The Interface between the Lexicon and Finiteness Marking in Specific Language Impairment

BY

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Abstract

Between the ages of 3- and 8-years the inconsistent omission of finiteness markers has been established as a clinical marker for Specific Language Impairment (SLI). This pattern of omission mirrors a normal stage of development where typically developing children also inconsistently omit finiteness markers. Unlike typical language learners, finiteness marking by children with SLI may never reach the level achieved by typical adults. Whether or not there are identifiable factors that significantly contribute to omission errors during this stage of variability is unknown. A goal of this research is to identify factors that contribute to errors of omission and then to apply this knowledge to the development of effective assessment and intervention techniques for children with SLI. This research considered the potential effect of the lexicon because lexical abilities are often noted as compromised for children with SLI. Specifically, this study examined whether the lexical representations of verbs explained variability in finiteness marking during the preschool period for children with SLI and for typically developing children.

Study 1 examined the effect of neighborhood density (i.e., the number of words that are phonologically similar to a given word) on the variable production of a finiteness marker (i.e., third person singular) in sentence imitation and spontaneous elicitation tasks by 20 children with SLI (4- and 5-year olds) and 20 children developing typically (3-year olds). The results showed that children with normal language development made fewer errors for dense compared to sparse words suggesting that the representation of words and finiteness influence one another during normal development. On the other hand, children with SLI were equally likely to make omission errors on dense and sparse verbs highlighting potential differences in the degree to which finiteness marking is influenced by the lexicon for preschoolers with SLI.

An additional critical issue for children with SLI is to identify effective methods for triggering growth in finiteness marking during this stage of variability. No studies have considered how manipulating lexical characteristics of the verbs used to treat a specific finiteness marker might impact growth. Study 2 therefore compared the pre-post exposure difference in third person singular use when presented with a set of dense verbs or a set of sparse verbs. Results showed that children exposed to sparse verbs showed a learning advantage compared to children exposed to dense words. These results provide preliminary evidence that the lexicon can be harnessed to trigger change in finiteness marking for children with SLI.

The combined results of the two studies suggest that the quality of lexical representations interacts with the representation of finiteness to differentially impact production and growth. Differences in neighborhood density effects across groups (i.e., SLI and typical development) are highlighted. Neighborhood density effects that vary by language modality for children with SLI are also discussed.

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TABLE OF CONTENTS

Chapter I: Introduction

Approximately 7% of the population of English speaking kindergarten children in the United States shows a profile of language ability consistent with Specific Language Impairment (SLI; Tomblin et al., 1997). Recent genetic evidence suggests that SLI is a heritable, developmental language disorder (Rice, Smith, & Gayan, in press; Tomblin, 2009). The earliest identified diagnostic indicator of SLI is late language emergence. According to a recent epidemiological study, late language emergence at 24-months is significantly associated with family history of late language emergence, male gender, number of children in the family, and neurobiological growth (i.e., percentage of expected birth weight, gestation age less than 37 weeks). However it is not associated with certain parental variables (e.g., mother's education, parental mental health, socio-economic status; Zubrick, Taylor, Rice, & Slegers, 2007). Despite pronounced difficulty with language learning following late language emergence, children with SLI are otherwise healthy. Specifically, intellectual disabilities (e.g., fragile X syndrome), hearing impairments, or other conditions are not identified as causal factors and subsequently are not associated causes of the profile of existing language delays. While the long-term outcomes (e.g., post-secondary education choices, career placement) of individuals with SLI in the United States have yet to be released, a recent study from the United Kingdom reported that the majority of teenagers with SLI received some form of special education throughout their secondary education years (Durkin, Simkin, Knox, & Conti-Ramsden, 2009), and that earlier language and literacy skills were significantly related to success in secondary education (Conti-Ramsden, Durkin, Simkin, & Knox, 2009).

Diagnosis of SLI is in part accomplished through a process of exclusion. Children scoring more than one standard deviation below the mean (i.e., standard score below 85) on a test of nonverbal intelligence are excluded from the definition of SLI (i.e., presence of an intellectual disability; Leonard, 1998; Tomblin et al., 1997) as are children with hearing impairments and children with developmental delays or known developmental/neurological differences (e.g., seizure disorders, genetic syndromes; Leonard, 1998). Accurate identification of SLI through the process of exclusion (i.e., low nonverbal IQ, hearing impairment, neurological impairment) is relatively straightforward. Defining the precise linguistic profile (i.e., inclusionary criteria) for children with SLI on the other hand is not. The broad definition of SLI used by some researchers (i.e., late language emergence followed by significant delays in language comprehension and/or expression) invites individual differences within the language profile and diagnostic classification systems also allow for such differences. One example is the EpiSLI system, a classification system that was developed to diagnose language impairment and was used in a large epidemiologic study of SLI (Tomblin, Records, & Zhang, 1996). This diagnostic system yields five language composite scores obtained by evaluating comprehension and production across three language domains: vocabulary (i.e., picture identification and oral vocabulary), grammar (i.e., grammatical understanding, grammatical completion, and sentence imitation) and narrative abilities (i.e., narrative comprehension and narrative recall). According to the EpiSLI classification system, children who show two or more composite scores below -1.25 standard deviations are diagnosed as having a language disorder. Thus, under a similar classification scheme, children with SLI may show a variety of linguistic profiles allowing for a heterogeneous set of strengths and weaknesses across language domains (i.e., vocabulary, grammar, narrative ability) and modality (i.e., comprehension and production). Bishop and Hayiou-Thomas (2008) reported the following as some of the many different diagnostic criteria used across studies of individuals with SLI: 1) a clinical concern about speech and language development; 2) presence of treatment for speech or language concern; and 3) parent report of speech or language difficulty. Other researchers have required poor performance on nonword repetition tasks, but more recently it has been noted that this criterion does not apply to all children with SLI and so it is not as widely used (Bishop & Norbury, 2006; Whitehouse, Barry, & Bishop, 2008). All the same, these varying methods for diagnosing SLI have resulted in a great deal of heterogeneity in terms of associated linguistic profiles.

Despite the heterogeneity within linguistic profiles for SLI, Rice and Wexler (1996) highlighted the importance of identifying a clinical marker for researchers and clinicians. They stated that identifying a clinical marker would allow researchers and clinicians to identify a clear way in which the language of children with SLI is different from typically developing children. From a research standpoint, identification of a clinical marker should reduce the potential variability in terms of identifying a common, core impairment among variable patterns of linguistic strengths and weaknesses. From a clinical standpoint, children who show a particular clinical marker may be more quickly and easily identified as requiring further evaluation and subsequent intervention. The late onset and subsequent delayed growth in a set of grammatical morphemes (i.e., walks, walked, is hungry, is walking) that mark finiteness has been identified as the clinical marker for English speaking children with SLI between the ages of 3- and 8- years (e.g., Bedore & Leonard, 1998; Conti-Ramsden, Botting, & Faragher, 2001; Rice & Wexler, 1996). A recent study suggests that certain elements of finiteness might continue to hold as a clinical marker for school-age children and adolescents with SLI (Rice, Hoffman, & Wexler, 2009).

Clinical Marker/Core Impairment for SLI

Finiteness in typical language development. Finiteness is an obligatory property of English clauses. It involves marking tense (e.g., present versus past tense) and agreement (e.g., person and number) on verbs through the addition of a set of grammatical morphemes (i.e., "I am hungry" versus "she is hungry"; Quirk, Greenbaum, Leech, & Svartvik, 1985). Finiteness in English is marked in the following contexts with the following morphemes: the *third person singular present tense* (Abby walks), *past-tense* (Abby walked), copula *BE* (Abby is happy), auxiliary *be* (Abby is walking) and auxiliary *DO* (Does Abby walk?). English verbs can be finite (Abby walked) or nonfinite (Abby is going to walk), where the finite form is marked for tense and subject-verb agreement. Note that finiteness is marked on both lexical (i.e., third person singular as in walks and past tense as in walked) and on non-lexical BE and DO auxiliary verb forms (i.e., copula and auxiliary be and do). In the adult grammar, finiteness marking is obligatory to correctly realize tense and agreement. In other words, a sentence like “Abby play outside” is never grammatical for an adult English speaker since the verb is one that requires finiteness marking, and in this particular example, it appears as nonfinite.

An interesting phenomenon occurs with respect to the typical acquisition of finiteness; while preschool children are acquiring finiteness they inconsistently use nonfinite verbs in finite clauses (e.g., "Abby walk to school" instead of "Abby walks to school"; Wexler, 1998). In this way, the omission of the third person singular finiteness marker on a lexical verb like “walk” is typical for a preschool child. Preschool children occasionally omit all finiteness markers in this same way so that another typical, nonfinite verb in a finite clause would be “Abby walking” where the auxiliary BE verb form is omitted. Wexler (1998) referred to the time when children use sentences like this as the Optional Infinitive (OI) stage. During the OI stage finiteness marking appears to be "optional" for the child in that both finite and nonfinite verbs are acceptable in clauses that require finiteness marking. Finiteness may be optional because its representation is incomplete or still emerging for the child. An important element of the OI stage is that typically developing children do not make overt agreement errors even when they inconsistently use finiteness markers. For example, sentences like "they walks" are not observed during the OI stage. The fact that children do not make overt agreement errors suggests that knowledge of finiteness is emerging during this stage, rather than faulty. The OI stage is a normal stage of grammatical development for preschool children and between the ages of 3- and 4- years, and optional omission of finiteness errors is observed without concern.

Finiteness in SLI. Understanding the OI stage of normal language development is highly relevant for the study of SLI. Rice et al. (1995) hypothesized that children with SLI would also experience the OI stage of grammatical development and perform similarly to younger typically developing children. One important difference that Rice and her colleagues hypothesized was that the optional use of finiteness markers would be far protracted in time compared to the brief stage observed during normal language development. Rice et al. explored the optional omission of finiteness markers in 5-year-olds with SLI. The use of finiteness markers in a younger group of typically developing children ranging in age from 2;6 to 3;4 (mean age = 2;11) and a group of typically developing 5-year old children matched in chronological age to the SLI group was also examined. The younger group of typically developing children had comparable sentence length, as measured by mean length of utterance (MLU) from a spontaneous language sample, to children in the SLI group. All children participated in a language sample and completed probes designed to elicit the finiteness markers subject to vulnerability during the OI stage (i.e., third person singular, past tense, copula BE and auxiliary BE and DO). In probes and during spontaneous speech, children with SLI produced nonfinite forms of lexical verbs (e.g., walk) and omitted BE and DO verb forms (e.g., she __ walking) significantly more frequently than children matched for chronological age or younger typically developing children matched on MLU. Chronologically age matched children were at or near ceiling levels on finiteness marking (i.e., making almost no omission errors). Younger, typically developing children were much less accurate than children in the chronologically age matched group, but they were still more accurate compared to children with SLI. The higher accuracy of finiteness markers among younger typically developing children highlighted the extended nature of the OI stage in SLI. Even though children with SLI had equivalent MLUs to the younger normal group, their finiteness marking continued to lag behind children who were two years younger. Consistent with Wexler's hypothesis regarding the absence of agreement errors during the OI stage, children with SLI did not produce errors in agreement (e.g., they walk*s*). Rice et al. (1995) concluded that the results confirmed Wexler's OI model and supported an Extended Optional Infinitive (EOI) model for SLI. An important component of the EOI model is that children with SLI have knowledge of the properties of finiteness, but the knowledge that these properties are obligatory, rather than optional, may be incomplete. Children with SLI in the EOI stage therefore have an immature grammar in terms of finiteness. This immature grammar is realized through the occasional correct use of finiteness markers but absence of overt agreement errors.

The presence of the EOI stage for children with SLI motivated subsequent lines of inquiry designed to identify a clinical marker for SLI. Rice et al. (1995) identified an area of grammatical development that was particularly compromised in children with SLI, despite the similarity to a known phase of grammatical development for typically developing children. In a follow-up study to Rice et al. (1995), Rice and Wexler (1996) sought to replicate this important finding with a different sample of children with the goal of indentifying a clinical marker. The ages of children were the same across these two studies (i.e., 5-year olds with SLI, chronological age matches, and 3-year olds with normal language). Similar to Rice et al. (1995), performance on finiteness markers from spontaneous language samples and elicitation probes was measured. Additionally, Rice and Wexler (1996) measured performance on a group of comparison grammatical morphemes. The comparison grammatical morphemes included morphemes bound to lexical verbs and nouns as well as free standing grammatical morphemes. Importantly, the comparison morphemes were not finiteness markers (i.e., prepositions *in* & *on*, present progressive *ing*, and plural *s*). Consistent with Rice et al. (1995), children with SLI performed significantly more poorly than children in either of the typically developing groups (i.e., chronological age matches and younger children) for use of finiteness. Importantly, group differences were not observed for non-finiteness comparison morphemes. Based on these findings, difficulty with finiteness markers (i.e., past tense, third person singular, copula BE, and auxiliary BE and DO) was identified as the clinical marker for SLI, as opposed to difficulty with all grammatical morphemes (e.g., plural –s, present progressive –ing). A number of other researchers have replicated the finding that children with SLI show marked difficulty with finiteness marking confirming the hypothesis that this is a clear area of impairment consistently observed across children with SLI despite other potential variable linguistic abilities. (e.g., Bedore & Leonard, 1998; Conti-Ramsden et al., 2001; Grela & Leonard, 2000; Leonard, Eyer, Bedore, & Grela, 1997)

The combined results of Rice et al. (1995) and Rice and Wexler (1996) highlighted delays in finiteness as the clinical marker for SLI. However, the course of emergence and mastery over time in finiteness marking for both typically developing children and children with

SLI was still unknown. Rice, Wexler, and Hershberger (1998) explored the time course of finiteness marking for typically developing children from 2;6 to 8;9, and for children with SLI from 4;6 to 8;8. Similar to Rice et al. (1995) and Rice and Wexler (1996), growth in finiteness marking was measured on probes designed to elicit specific structures (i.e., third person singular, past tense, copula BE and auxiliary BE and DO verbs), and during spontaneous language samples. Several important findings emerged from this longitudinal study. In line with Wexler's (1998) OI hypothesis for normal language development, the younger typically developing children who started the study at 3 years and were in the OI stage moved out of the OI stage by 4 years. This confirmed the brevity of the OI stage during normal language development. For children with SLI, the presence of the EOI stage hypothesized by Rice and Wexler (1996) was confirmed in that children with SLI had not yet mastered finiteness marking by 8-years of age. In fact, children with SLI never showed a rapid growth spurt in finiteness marking to make up for their late start. Similar to Rice and Wexler (1996) this protracted growth period was not observed for comparison grammatical morphemes like the plural -s. Even though plural –s (e.g., cat<u>s</u>) has the same phonetic structure as the third person singular finiteness marker (e.g., kick<u>s</u>), children with SLI did not show difficulty mastering the plural –s. This confirmed prior hypotheses that only the set of grammatical morphemes marking finiteness (in English), rather than all grammatical morphemes, are challenging for children with SLI.

A final important element of the EOI stage for children with SLI is that significant difficulty with finiteness marking is not limited to production. In fact, similar patterns of optional omission of finiteness markers are also observed in receptive tasks, such as grammaticality judgment. Here, children with SLI incorrectly accept nonfinite verbs in finite clauses as grammatically correct (e.g., "He need a tissue" is judged as acceptable). Children's performance on grammatically judgment tasks indicates that the significant difficulty producing finiteness markers is attributable to deficits in linguistic knowledge rather than articulatory deficits (Rice, Wexler, & Redmond, 1999).

Children with SLI have an underlying grammar that behaves similarly to younger children with typical development, but operates on a different time scale. That time scale is significantly extended and does not include rapid growth spurts to make up for late emergence of finiteness markers (Rice, 2004). The current state of the literature provides the knowledge of the time course for the emergence and mastery of finiteness marking. One area of uncertainty is why children in the EOI stage, and children in the OI stage, are inconsistently successful at finiteness marking. There is a great deal of literature suggesting several possible linguistic deficits for children with SLI that could potentially explain their significant difficulty with finiteness. However, few research studies have considered whether the optional omission of finiteness markers can be predicted by other aspects of language known to present challenges for children with SLI. Specifically, do weaknesses in other linguistic areas interact with the significant delays in finiteness marking for children with SLI? Examining this area may serve as a window into understanding why children in the EOI/OI stage mark finiteness inconsistently. The lexicon represents one possible area that could serve as a limiting factor for finiteness marking. Specifically, are there aspects of the lexicon that might contribute to children’s inconsistent use of finiteness markers?

The Lexicon in SLI

During the preschool period continuing into the school-age years, lexical ability is one area that has received a great deal of attention and it is widely noted as compromised for many children with SLI. Topics of interest include the age of first word acquisition, vocabulary growth, performance on novel word learning, and word representation in the lexicon (e.g., semantic, lexical). On average, typically developing children produce their first words around their first birthday and begin combining words into sentences around 2 years. When children do not meet these expectations, the concern is that their language may be delayed. In fact, a vocabulary of fewer than 50 words or no word combinations by 2 years (i.e., "later talker") has been established as one of the earliest indicators of a language impairment (Rescorla & Achenbach, 2002). Children with SLI are late to acquire their first words. The presence of late talking (i.e., delayed emergence of first words) combined with delays in receptive vocabulary presents an even greater risk for SLI (Thal, Reilly, Seibert, Jeffries, & Fenson, 2004).

Once word acquisition is underway for children with SLI, delays in this domain do not cease. Differences are noted in terms of the types of words used by children with SLI and the rate at which new words are learned. Verbs appear to be particularly challenging for children with SLI (e.g., Eyer et al., 2002; Kelly & Rice, 1994; Rice, Buhr, & Nemeth, 1990; Watkins, Rice, & Moltz, 1993; Windfuhr, Faragher, & Conti-Ramsden, 2002). Young children with SLI are known to overuse high frequency General All Purpose (GAP) verbs in their spontaneous speech (e.g., do, want, make, put, work). The use of GAP verbs results in reduced lexical diversity during spontaneous speech compared to typically developing children (Conti-Ramsden & Jones, 1997; Goffman & Leonard, 2000; Leonard, Miller, & Gerber, 1999; Rice & Bode, 1993; Watkins, Kelly, Harbers, & Hollis, 1995). Rice and Bode (1993) regarded GAP verbs as desirable to children with SLI because these verb types are frequent in the language input, consist of a simple phonetic form, and importantly they are non-specific in terms of their syntactic and semantic characteristics (e.g., a GAP verb like "do" can be used to refer to multiple action meanings). One reason that many verbs are believed to be so difficult for children with

SLI is that they are weakly represented in the lexicon because of the features related to finiteness that they encompass (Rice, Oetting, Marquis, Bode, & Pae, 1994).

Preschool children with SLI also appear to have difficulty learning and comprehending new words during short-term word learning tasks. Although children with SLI are able to learn new words, they consistently require more exposures to the new word in order to comprehend its meaning compared to typically developing children (Dollaghan, 1987; Eyer et al., 2002; Horohov & Oetting, 2004; Oetting, Rice, & Swank, 1995; Rice, Buhr, & Oetting, 1992; Rice et al., 1990; Rice et al., 1994; Watkins et al., 1995). Lexical delays that persist beyond the preschool years manifest themselves in different aspects of vocabulary, like knowledge of word meaning (i.e., semantics; McGregor & Appel, 2002; McGregor, Newman, Reily, & Capone, 2002) and the ability to accurately retrieve words (Lahey & Edwards, 1999). McGregor et al. (2002) examined stored semantic knowledge in school-age children with SLI via drawing tasks. Children with SLI created drawings that contained significantly less detail than drawings created by typically developing children. McGregor et al (2002) took this to mean that the semantic representations of words are less complete for children with SLI. During word learning tasks, children with SLI also require more semantic cues than typically developing children for accurate word comprehension (Alt & Plante, 2006; Alt, Plante, & Creusere, 2004). Poor representations can in turn affect the ease with which children are able to retrieve words for picture naming tasks (e.g., Lahey & Edwards, 1996, 1999).

In summary, children with SLI are late to learn words, use fewer different word types, require additional exposure to learn and comprehend new words, and once words are learned, they contain less detail in their stored representations which in turn can affect retrieval ease. It is unknown exactly how the above described lexical difficulties might interact with delays in finiteness marking, particularly during the EOI stage. Recall that finiteness is linked with verbs in English. Specifically, the representation of finiteness is realized by the production of finiteness markers attached to a verb (i.e., morphological endings for third person singular and past tense). Therefore, factors that influence retrieval of the verb may account for variability in finiteness marking. In this way, optional omission of finiteness markers might be related to any number of verb properties (e.g., word frequency, semantic features, or verb representations). Difficulties with various lexical abilities entertain the potential for a cyclical pattern of impairment between co-occurring difficulties in finiteness marking. One possibility for children with SLI is that difficulty with finiteness marking interferes with verb learning and these weak verb representations further impact the emergence and mastery of finiteness marking. This potential pattern of interaction motivates studies aimed at uncovering the potential interface between the lexicon and finiteness marking.

The Interface between the Lexicon and Finiteness

The potential interface between the lexicon and finiteness has been entertained, but typically only in studies where the goal was to investigate either finiteness marking *or* lexical abilities. The primary way in which this potential interface has been explored is through correlation analyses between MLU and vocabulary size (e.g., Dixon & Marchman, 2007; Hadley & Holt, 2006; McGregor, Sheng, & Smith, 2005). In some studies the size of the lexicon has been found to predict the onset of grammatical structures in the early stages of normal language acquisition (Marchman & Bates, 1994; McGregor et al., 2005). However, the interaction between the lexicon and finiteness has not been consistently observed in young children at risk for SLI (Hadley & Holt, 2006) or in older children already diagnosed with SLI (Rice, Redmond, & Hoffman, 2006). On the contrary, a relationship between size of the lexicon and grammar, but not finiteness marking in particular, was observed in a group of late talkers from 2;0 to 5;6 (Moyle, Weismer, Evans, & Lindstrom, 2007). Inconsistent findings may be attributable to a variety of issues. One issue is that studies reporting a relationship explored vocabulary and general grammatical development, not finiteness in particular (i.e., the core grammatical deficit for SLI). The other issue relates to how lexical abilities were measured. Studies commenting on the lexicon-grammar interface traditionally have used current vocabulary, or product-based measures of the lexicon (i.e., standardized receptive vocabulary tests). Global measures like these may not be sensitive to detecting relationships in older children. The fine grained properties of words that are not typically tapped by receptive vocabulary tests might be more telling of potential interactions. For example, recall that older children with SLI have less detailed stored semantic representations of words (e.g., Alt & Plante, 2006; Alt et al., 2004; McGregor, Friedman, Reilly, & Newman, 2002). Semantic representations of words might not be tapped by forced-choice tasks like traditional receptive vocabulary tests (i.e., identifying the correct picture out of four choices). Different types of word representations are generally found to influence language performance and so they might also influence variability in finiteness. Based on this, it is clear that alternative measures of the lexicon, like representations, should be considered to further explore the lexicon-finiteness interface. One characteristic thought to index the quality of lexical representations is neighborhood density.

Neighborhood density. Neighborhood density is the number of words that are phonologically similar to a target word, based on a one sound substitution, addition, or deletion (Luce & Pisoni, 1998). Words that are phonologically similar to many other words (i.e., neighbors) are referred to as *dense* and words with few phonologically similar neighbors are referred to as *sparse*. Neighborhood density has been found to affect language processing in children (Garlock, Walley, & Metsala, 2001; Metsala, 1997; Storkel, 2004a). Specifically, words with dense neighborhoods are thought to have more complete and segmentally detailed lexical representations than words with sparse neighborhoods (De Cara & Goswami, 2003; Storkel, 2002, Metsala & Walley, 1998). Children are able to make more sophisticated similarity judgments of dense words and can better manipulate word parts in phonological awareness tasks. Dense neighborhoods create lexical competition so that recognition and retrieval is slowed for dense compared to sparse words (e.g., Garlock et al., 2001; Mainela-Arnold, Evans, & Coady, 2008; Metsala, 1997; Newman & German, 2002). However, facilitative effects for dense words are observed in working memory and short-term word learning tasks in typically developing children (De Cara & Goswami, 2003; Roodenrys, Hulme, Lethbridge, Hinton, & Nimmo, 2002; Storkel, 2001). Neighborhood density is an attractive candidate for studying the lexicon-finiteness interface because it represents finer grained properties of the word form (i.e., the lexical representation) that might not otherwise be tapped by other lexical measures (e.g., receptive vocabulary tests). Since children with SLI may have weak lexical representations of verbs, examining the effect of neighborhood density may provide further insight into those representations and whether or not they contribute to variability in finiteness marking during the EOI stage. Likewise, examining neighborhood density effects on finiteness marking for typically developing children in the OI stage would inform whether or not interactions are similar across typical and impaired language development.

Neighborhood Density and Finiteness Production

For typically developing children, dense and sparse verbs have different representations and accordingly they are processed differently. If lexical representations interact with the incomplete/emerging representation of finiteness during the OI stage, differences in using finiteness markers would be predicted for dense and sparse verbs. The OI stage is an ideal developmental stage to explore this possibility since incomplete/emerging representations of finiteness are realized by inconsistent omission errors. Therefore, if there is an interaction between representations of verb forms and representations of finiteness, typically developing children would be predicted to be more successful at applying finiteness rules to root verbs that are more robustly represented (i.e., dense verbs). Knowledge of the obligatory properties of finiteness would therefore be even more suppressed when the root form of the verb contains a less detailed lexical representation (i.e., sparse verbs). These predictions for the interface between lexical representations and the representation of finiteness are in line with the findings that dense words generally facilitate language production (De Cara & Goswami, 2003; Roodenrys et al., 2002; Thomson, Richardson, & Goswami, 2005).

Since dense words do not always facilitate performance across language tasks and the effect of neighborhood density on finiteness is unknown, an equally likely possibility is that sparse words would facilitate the production of finiteness markers. This would be the case if applying the rules of finiteness is less difficult for words with less complete representations (i.e., sparse words). Since less complete representations are likely to be volatile they might be more amendable to the changes associated with using the finite form of a verb.

The effect of neighborhood density in preschool children with SLI has not yet been examined and so predictions are more speculative for this population. Similar to typically developing children, errors of omission represent incomplete/emerging, rather than faulty, representations of finiteness for children with SLI in the EOI stage. In this way, if children with SLI also have complete representations for dense words and incomplete representations for sparse words, the same pattern of predictions made for typically developing children would also be applied to children with SLI.

On the other hand, if dense and sparse words are not differentially represented as they are for typically developing children, no particular advantage would be expected for one verb type over another. This prediction is equally likely given that children with SLI are already hypothesized to have overall weak verb representations. Furthermore, neighborhood density effects in preschool children have not yet been tested and so no effect might also indicate that words are not organized by similarity neighborhoods like they are for typically developing children.

Lexical representations and finiteness production (study 1). The present study addresses whether or not the optional omission of finiteness markers made by children in the EOI/OI stage of language development can be explained by the lexical representation of the root form of verbs used during the production of finiteness markers (i.e., neighborhood density). Study 1 of this research will examine the influence of neighborhood density on the use of one of the English finiteness markers (i.e., third person singular) by typically developing children and children with SLI during two tasks designed to measure current production abilities (i.e., sentence imitation and spontaneous elicitation). Study1 will serve as a test of the influence of the lexicon on finiteness, by using a potentially more sensitive measure of the lexicon (i.e., lexical representations). Study 1 will address the following question:

1. Does the neighborhood density of a verb (dense versus sparse) affect the inconsistent omission of a finiteness marker (i.e., third person singular) by children in the EOI/OI stage (i.e., typically developing 3-year-olds and 4- and 5-year-olds with SLI)?

Neighborhood Density and Growth in Finiteness

Uncovering the nature of interactions between the lexicon and use of finiteness markers is important for understanding children's current production ability. However, an additional critical issue for children with SLI is how to accelerate growth in finiteness marking. Rice et al (1998) reported that by 8-years, children with SLI have yet to master finiteness marking and grammatical judgments of BE and DO question forms remain impaired into adolescence (Rice et al., 2009). There is essentially no evidence that children with SLI outgrow delays in finiteness to catch up to their peers (Rice, 2009). An additional critical line of inquiry for young children with SLI is whether growth in finiteness can be jumpstarted by training, or intervention techniques.

Research aimed at exploring intervention techniques for children with language delays is an area that has received very little attention. Research in this area has largely focused on identifying the most effective ways to present linguistic structures during intervention (e.g., Camarata et al., 1994; Connell & Stone, 1992; Leonard, 1981). One common strategy that has been studied is conversational recasting (e.g., Camarata, Nelson, & Camarata, 1994). In conversational recasting the clinician expands a child's less complex utterance (e.g., child says "He play", examiner says "He plays with a truck"). Focused stimulation provides concentrated exposures of specific linguistic structures (e.g., words) to children, and modeling involves giving the correct structure to the child (e.g., clinician says "here are two cat<u>s</u>" while showing a child two cats). These intervention strategies have been developed because children with language delays are known to produce less complex structures and require additional exposures to structures to demonstrate learning. We also know though that children with SLI have significant difficulties with finiteness marking yet very few investigations have focused on how this might be factored into the intervention process.

A recent intervention study with children who have SLI focused on accelerating growth in finiteness markers (Leonard, Camarata, Brown & Camarata, 2004). One group of children received intervention focused on the third person singular structure (e.g., she kicks) while another group received intervention focused on auxiliary BE forms (e.g., she is kicking). Although children showed some growth as a result of intervention, it was slight given the intensity of the study (i.e., from 0% at baseline to 40% after 96 sessions). Additionally, there was no evidence of generalization to other finiteness markers. The modest gains in finiteness marking and limited evidence supporting effective intervention strategies suggest the need for a paradigm shift in intervention research in this area. Currently we have some knowledge that methods of delivering intervention targets to children might differentially affect growth (e.g., modeling), but clearly additional avenues need to be explored. The impact of manipulating specific linguistic factors during intervention might be a new and worthwhile endeavor. The lexical characteristics of the verbs used to teach finiteness might be one promising area to explore.

The idea of manipulating specific linguistic factors during language intervention is not new to other clinical populations. In fact, manipulating linguistic factors of the treatment targets appears to influence growth in sound learning for children with phonological delays. Specifically, the relationship between neighborhood density and growth in sound production during intervention has been investigated. Studies that have explored this issue have found that although children are more accurate at initially producing a target sound in a dense word (Gierut & Morrisette, 1998; Gierut & Storkel, 2001; Morrisette, 1999), over time there is an advantage to treating sounds in sparse words and treatment of sounds in dense words leads to minimal, if any, sound change (Gierut et al., 1999; Morrisette & Gierut, 2002). It is argued that complete lexical representations are resistant to change. Moreover, since sparse words are recognized and retrieved faster, over time faster processing allows children to better perform additional levels of analysis (i.e., correct sound production by children with phonological delays). No study has examined whether neighborhood density has a parallel influence on finiteness. For intervention aimed at triggering growth in finiteness, children would need to retrieve the root form of the verb and apply an additional level of analysis (i.e., finiteness) to correctly produce a finiteness marker. In this way, growth might be differentially triggered for dense and sparse verbs.

Lexical representations and growth in finiteness (study 2). The second issue in this research is whether or not growth in finiteness can be accelerated for a small group of children (i.e., n = 6) in the EOI stage through a brief (i.e., 6-week) pre-post controlled exposure exploratory study. Acceleration will be targeted by providing concentrated exposures to a finiteness marker using either dense *or* sparse verbs to present the structure. Therefore, Study 2 will examine whether or not the lexicon plays a role in accelerating growth of the third person singular finiteness marker by children with SLI in the EOI stage. Study 2 was designed to provide preliminary evidence to determine whether or not examining the effect of neighborhood density on finiteness growth in a larger scale intervention study is worthwhile. In this way, Study 2 will serve as a platform for subsequent studies aimed at accelerating growth in finiteness. Study 2 will address the following research question:

1. Does manipulating the neighborhood density of a verb (dense versus sparse) presented in a finite clause (i.e., third person singular) during a controlled exposure task result in different rates of change for the production of third person singular over time for children with SLI?

This is the first study to consider the effect of neighborhood density on growth over a short period of time in finiteness and as a result, there are three equally logical predictions for this research. Based on the results of Morrisette and Gierut (2002) in the domain of phonology, the sparse condition is predicted to be the favorable condition for triggering growth in third person singular. Because sparse words have less complete representations, children might be more willing to transition out of using nonfinite forms of the verb in finite contexts. Additionally, since sparse words are recognized and processed more easily than dense words, repeated exposure to finiteness with sparse verbs might allow children to better focus on learning the obligatory property of finiteness.

If the neighborhood density effects on growth in finiteness differ from those in phonology, the dense condition would be predicted as the favorable condition. In this way, the complete representations of dense words would first facilitate production within the exposure sessions. The complete representations of dense words would then interact with the incomplete representation of finiteness to guide the child into performing additional linguistic analyses (i.e., finiteness marking). Repeated correct productions of the third person singular finiteness marker would thereby trigger growth faster than the sparse condition. Likewise, words with complete lexical representations might be ready for the changes associated with more consistent use of finite forms.

A final possibility is that presenting repeated exposure to the third person singular structure would not differentially trigger change for dense or sparse verbs. As discussed above, the effect of neighborhood density has not been explored for preschool children with SLI and so the representation of dense and sparse words is unknown. The above predictions assume that dense words and sparse words have different representations for children with SLI. However, if dense and sparse verbs are similarly represented (i.e., equally complete or equally incomplete), there would be no reason to believe that learning the property of finiteness would be jumpstarted by one particular condition.

Chapter II: Study 1

Study 1 asked the following research question: **(1)** Does the neighborhood density of a verb (dense versus sparse) affect the inconsistent omission of a finiteness marker (i.e., third person singular) by children in the EOI/OI stage (i.e., typically developing 3-year olds and 4- and 5-year old children with SLI)? This research question was addressed via performance across two production tasks (i.e., sentence imitation and spontaneous elicitation) that required children to attempt a production of the third person singular finiteness marker. Both tasks included an equal number of dense and sparse verbs inflected with the third person singular finiteness marker so that accuracy (i.e., dependent variable) could be compared across dense and sparse verbs (i.e., independent variable: neighborhood density).

Method

Participants. Two groups of children participated in this research: 1) children with Specific Language Impairment (SLI) and 2) typically developing children (TD). The SLI group included 7 females and 13 males (n = 20) and the TD group included 12 females and 8 males (n = 20). Children were recruited from the following areas in Kansas: 1) Lawrence; 2) Kansas City; and 3) Iola. The mean age of children in the SLI group was 4;9 (*Range*: 4;0 – 6;1; *SD*: 8 months) and the mean age of children in the TD group was 3;3 (*Range*: 2;11 – 3;11 months; *SD*: 4 months). All participants were required to be monolingual native English speakers and speak the standard dialect of English as determined by parent report. The following exclusionary criteria typically used in the diagnosis of SLI were applied to all children in this study: 1) normal nonverbal intelligence as evidenced by a standard score at or above 85 on the *Reynolds Intellectual Assessment Scale* (RIAS; Reynolds & Kamphaus, 2003) ; 2) normal hearing as determined by a standard screening (ASHA, 1997); 3) no evidence of cognitive, neurological impairment, or other developmental delay as indicated by parent report.

Since the main research question addressed children's inconsistent errors of the third person singular finiteness marker during the EOI/OI stage, it was critical that all participants (SLI and TD) show optional use of the third person singular finiteness marker (i.e., 20 – 80%) on the *Rice/Wexler Test of Early Grammatical Impairment* (TEGI; Rice & Wexler, 2001) *or* during a spontaneous language sample. In other words, if participants met all of the inclusionary criteria discussed above, but showed perfect use of the third person singular finiteness marker, they were excluded from participation in the study. Optional use of the third person singular finiteness marker on both of these measures is shown in Table 1. An older group of children equivalent in chronological age to children in the SLI group was not included in this study because this group of typically developing children would not be in the OI stage of language development (i.e., ceiling performance for production of finiteness markers) and so the inclusion of this group is not appropriate for answering the research questions.

To be included in the SLI group, all children had to show delayed expressive language ability as measured by Mean Length of Utterance (MLU; Leadholm & Miller, 1992) and delayed expressive grammatical ability as determined by an elicited grammar composite lower than the criterion score for the child's age on the *Rice Wexler Test of Early Grammatical Impairment* (TEGI; Rice & Wexler, 2001). The elicited grammar composite of the TEGI averages criterion scores from four separate probes measuring use of the following finiteness markers: 1) 3rd person singular (e.g., she jump*s*), 2) past tense (both regular, as in she climb*ed*, and irregular, as in she *rode*), 3) copula and auxiliary BE in statements and questions (e.g., she *is* thirsty; *is* the kitty resting?; the kitty *is* jumping) and 4) auxiliary DO in questions (e.g., *Does* the kitty like juice?).. The criterion scores for the TEGI are reported in Table 1.

All children who completed the TEGI had to pass a phonological probe prior to administration. The phonological probe assessed the production of /s z t d/ in the word final position. Correct production of these four sounds is crucial to be able to accurately assess production of the finiteness markers included on the TEGI. A passing score on the phonological probe of the TEGI is 4 out of 5 correct productions for each of the four sounds tested. Distortions of /s/ and /z/ are counted as correct productions on the TEGI phonological probe (e.g., dentalized productions of s and z). Children's receptive vocabulary development was assessed via the *Peabody Picture Vocabulary Test, 4th Edition* (PPVT-4; Dunn & Dunn, 2007), receptive grammatical ability was assessed via the Grammaticality Judgment probe of the TEGI (Rice & Wexler, 2001) and phonological inventory was assessed by performance on the *Goldman Fristoe Test of Articulation, 2nd Edition* (GFTA-2; Goldman & Fristoe, 2000). Performance on all remaining standardized measures of language ability for children in the SLI group is reported in Table 2.

In the SLI group only, children's receptive vocabulary ability, receptive grammatical ability, and phonological inventory were left free to vary because only the core impairment of delayed expressive grammatical ability (i.e., finiteness) was most pertinent to the research questions. Since these three areas were left free to vary, ability was variable within the SLI group (i.e., some children scored within normal limits while others scored below age expectations). It is important to note that although some children scored below age expectations on the GFTA-2, the primary errors made by children were /s, z, r, and l/ distortions. These are later acquired sounds and are often in error by children within the age group tested (Smit, Hand, Freilinger, Bernthal, & Bird, 1990).

To be included in the TD group, all children also had to pass the phonological probe of the TEGI to assess production of word final /s z t d/. However, children in the TD group had to show: 1) age appropriate expressive language performance as measured by MLU (Leadholm & Miller, 1992) and age appropriate expressive grammatical ability as determined by an elicited grammar composite at or above the criterion score for the child's age on the TEGI (Rice & Wexler, 2001), 2) age appropriate receptive vocabulary development as measured via the PPVT-4 (Dunn & Dunn, 2007), and 3) age appropriate phonological inventory as assessed by the GFTA-2 (Goldman & Fristoe, 2000). Receptive grammatical ability could not be assessed for children in the TD group because the grammaticality judgment probe of the TEGI is only appropriate for children 4-years and older. The TD group was matched to the SLI group on raw vocabulary, as measured by the PPVT-4 (Dunn & Dunn, 2007), $t(30.7) = 1.67$, $p = .105$, and Mean Length of Utterance (MLU), from a spontaneous language sample, $t(38) = .298$, $p = .768$. The criterion scores for the TEGI are shown in Table 1 and performance on all remaining standardized measures of language ability for children in the TD group is reported in Table 2.

Table 1

Mean, SD, and Range of TEGI Scores and Spontaneous 3rd Person Singular Accuracy

	SLI Group (n = 20)	TD Group (n=20)
[a]Spontaneous 3rd Sing.	35 (24) 0 - 81	63 (20) 33 - 100
[b]3rd Sing. Probe	32 (22) 0 - 70	53 (15) 20 – 78
[b] Past Probe	23 (20) 0 - 61	50 (18) 11 – 75
[b] BE Probe	51 (26) 0 - 100	79 (17) 44 – 100
[b] DO Probe	15 (24) 0 – 80	61 (32) 0 – 100
[b]Elicited Grammar Composite	30 (15) 12 - 59	61 (9) 49 – 83
[c]Dropped Marker	.57 (.19) .25 – 1.0	NA
[c]Dropped –ing	.59 (.25) 0 – 1.0	NA
[c]Agreement	.62 (.20) .38 – 1.0	NA

[a] Third person singular % correct during a spontaneous language sample
[b] TEGI criterion scores represent % correct
[c] TEGI grammaticality judgment A' (A prime) values

Table 2

Mean, SD, and Range of Participant Characteristics

	SLI Group (n = 20)	TD Group (n =20)
Age	4;9 (0;8) 4;0 – 6;1	3;3 (0;4) 2;11 – 3;11
[a]MLU-Words	3.72 (.67) 1.84- 4.77	3.65 (.74) 2.21-5.83
[a]PPVT-4 Raw Score	74 (20) 45-105	65 (12) 52-93
[b]PPVT-4 SS	96 (11) 76-118	114 (10) 100-138
[c]GFTA-2 SS	90 (13) 64-110	104 (12) 85-124
[d]RIAS SS	111 (16) 89-14	118 (14) 92-140

[a]Group Matching Variable: SLI and TD groups did not differ significantly
[b]Peabody Picture Vocabulary Test, 4th Edition Standard Score
[c]Goldman Fristoe Test of Articulation, 2nd Edition Standard Score
[d]Reynolds Intellectual Assessment Scale Standard Score

Stimuli

The stimuli included 30 verbs selected either from the *MacArthur Communicative Development Inventory* (CDI; Fenson et al., 1993) or from a database of words compiled by the Word and Sound Learning Laboratory. Words were chosen from these two sources to ensure that they would be familiar to all participants. Familiarity was verified through the administration of a receptive vocabulary probe created specifically for this study. In this probe, the target verb was pictured with two other foils: 1) a verb that shared the same first sound as the target verb (Target verb = kick; Foil sharing same first sound = kiss) and 2) a verb with a different first sound as the target verb but the same argument structure (e.g., Target verb = kick; Foil sharing same transitive argument structure = push). The examiner said the target verb in the nonfinite form (e.g., "kick") and asked the child to point to the corresponding picture. To be included in the study, all children had to achieve at least 80% accuracy on the vocabulary probe.

Selected verbs were chosen based on the neighborhood density of their nonfinite form (e.g., kick, rather than kick**s**). Neighborhood density of each root verb was calculated using a program designed to identify the number of words differing from the target verb by a one sound substitution, addition, or deletion. This calculator draws upon a child database of words (Storkel & Hoover, under review). Words were assigned to dichotomous categories of 'dense' (M= 15, SD = 6, *range* = 7 - 26) or 'sparse' (M = 7; SD = 4; *range* = 1 - 12). A word length sensitive calculation of neighborhood density was obtained where dense and sparse values were not overlapping within a given word length. The number of neighbors of verbs in the dense condition differed significantly from the number of neighbors of verbs in the sparse condition, $t(28) = 4.4$, $p < .001$.

To ensure that the stimuli in the dense and sparse conditions differed only in number of neighbors, additional factors were balanced. Phonotactic probability, or the likelihood of occurrence of a sound sequence, has a high positive correlation with neighborhood density making it difficult to tease apart individual effects of neighborhood density (Storkel, 2004b; Vitevitch & Luce, 2004). In order to separate the effects of neighborhood density from phonotactic probability, words in the dense and sparse conditions with similar segment averages (i.e., likelihood of occurrence of individual sounds; M dense = .06; M sparse =.05, $t(28)= 1.5$, p

= .142) and similar biphone averages (i.e., likelihood of occurrence of two adjacent sounds; *M* dense =.005; *M* sparse = .005, $t(28) = .410$, $p = .685$) were chosen. Word frequency (*M* dense = 2.98; *M* sparse = 3.02, $t(27) = -.33$, $p = .747$) was also balanced across conditions. Every attempt was made to balance the syllable structure, verb argument structure (transitive versus intransitive), and final allomorph resulting from the third person singular morpheme (s versus z versus schwa + z) across dense and sparse conditions while still maintaining a significantly different number of neighbors and balanced phonotactic probability estimates. See Appendix A for a full description of all of the verb stimuli in Study 1.

After selecting verbs based on neighborhood density and controlling for these other factors, sentences were constructed around the verbs, resulting in 15 sentences with a dense verb in the finite third person singular form, and 15 sentences with a sparse verb in the finite third person singular form. Sentences in the dense and sparse conditions were matched in the number of words (dense = 6.3; sparse = 5.4), number of morphemes (dense = 6.3; sparse = 6.4), and number of syllables (dense = 6.1; sparse = 5.93). The same set of agents and objects/locations were presented in the sentences across dense and sparse conditions when possible. All agents and objects/locations were taken from the *CDI* (Fenson et al., 1993) to ensure that they would be known by the participants. Appendix B illustrates this sentence matching procedure.

Sentence Imitation Task

The previously described 30 sentences were recorded in a sound proof chamber by a female native speaker of Standard American English and were then digitized and edited using the Computerized Speech Laboratory Software. The duration of each sentence was measured using the Computerized Speech Laboratory software and sentence durations were not significantly different across dense and sparse conditions, $t(28) = -.36$, $p = .722$. Sentence recordings were presented to a naïve group of adult listeners to verify that every word in the sentence was identified as the intended target. After all stimuli were verified, a program was written for experimental control software (i.e., Direct RT; Jarvis, 2006). This experimental control software presented the entire set of 30 sentences automatically. The order of sentence presentation was randomized by the experimental control software.

Children were seated in front of a laptop computer that was connected to speakers and running the Direct RT software. The task followed the standard procedure for sentence imitation tasks. Children passed a training cycle where they learned how to repeat sentences prior to hearing the 30 experimental stimuli. At the beginning of this training cycle the examiner provided the following instructions to the child:

> *We are going to play a listening game. I am going to say some words and then I want you to say the exact same words. Let's practice. I will say "The ball is red". Now you say it.*

The examiner provided positive feedback (e.g., *That's right! You said all of the words that I said*) to the child after he or she repeated each sentence. The examiner required the child to successfully repeat four sentences before administering the experimental task. All children in both groups easily passed this training cycle. After completing the training cycle, the examiner gave the following set of instructions to the child:

> *Now we're going to listen to a lot of words. This time, the computer is going to say the words, but I still want you to say exactly what you hear.*

Each sentence in the sentence imitation task was preceded by the pre-recorded phrase "*I will say*" and followed by the pre-recorded phrase "*Now you say it*". These phrases were used to help the child understand that they would hear a sentence and then say that exact same sentence. This procedure was motivated by pilot testing that showed some very young children tended to begin their sentence production prior to the end of the stimulus presentation. Children typically completed the task in approximately eight to twelve minutes.

Spontaneous Elicitation Task

A second production task was created to further capture the effect of neighborhood density on children's accuracy of production of the third person singular finiteness marker. For the second production task, illustrations corresponding to the previously described 30 sentences were created. The same female speaker used in the sentence imitation task recorded an audio script intended to elicit the 30 target sentences described above in response to the presentation of corresponding illustrations. The equipment set up was identical to the sentence imitation task. Direct RT was programmed in the same manner so that all 30 illustrations were randomly presented to the child with their corresponding audio script. Children were required to pass a training cycle, where they learned to produce a sentence targeting the third person singular finiteness marker in response to a corresponding photograph. At the beginning of this training cycle the examiner provided the following instructions to the child:

> *We are going to play a game where you look at a lot of pictures. I will tell you something about the picture and then I want you to tell me something about the picture. Let's practice.*

The examiner showed the child a picture of a person performing an action on an object (e.g., a man kissing a baby). The examiner then said the following:

> *Here is a man and this is a baby. The man's job is to kiss the baby. Now you tell me what the man does everyday at his job. Everyday he*_____

The intended target response in this instance was "kisses/kiss the baby" or "he/the man kisses/kiss the baby". If the child correctly responded in one of these two ways, the examiner provided performance related feedback (e.g., *that's right, the man kisses the baby*). If the child produced a different structure (e.g., *the man kissed the baby*) he or she was re-prompted in the appropriate way (e.g., *Tell me what the man does right here).* All children completed four training items before the experimental items were presented. After completing the training cycle, the examiner gave the following set of instructions to the child:

> *Now we're going to look at a lot of pictures. This time, the computer is going to tell you something about each picture, but I still want you to tell me something about the picture too.*

After training, the pre-recorded audio scripts and corresponding illustrations intended to elicit the 30 target sentences were randomly presented on the laptop by Direct RT. The exact same script presented via live voice during the training cycle was pre-recorded and used with all 30 items during the spontaneous elicitation task.

Scoring. The examiner glossed productions from the audio recordings of both tasks and scored the child's responses using a standard scoring system. For the sentence imitation task, scorable responses included a response where 1) the subject of the sentence was present, 2) the target verb was present, and 3) the third person singular finiteness marker was attempted (i.e., correct production of the third person singular was not required). If any one of these three criteria were not met, the sentence was not scored. Production of the subject was critical because the presence of the subject makes the third person singular finiteness marker obligatory in English. The production of the target verb was critical because it was tied to the neighborhood density independent variable. A production attempt for the third person singular finiteness marker was required because it was the dependent variable for all analyses.

After the presence of the subject, target verb, and third person singular attempt was determined, the examiner scored each sentence as correct or incorrect for the third person singular production. Sentences were scored as correct when the child produced the subject, used the target verb and correctly used the third person singular finiteness marker (i.e., "*the woman* *kicks the ball*”). Sentences were scored as incorrect when the child used the subject, produced the target verb, and *attempted* the third person singular finiteness marker but did *not* correctly produce it. In this way, only sentences that contained the subject, the target verb, and an attempt (either correct or omitted) at the third person singular structure were analyzed. For these sentences, the proportion correct of the third person singular finiteness marker was computed for dense versus sparse verbs. The proportion correct was calculated by summing the number of correct scores and dividing that sum by the total number of correct and incorrect scores. Unscorable sentences were not included in the calculation of third person singular accuracy.

For the spontaneous elicitation task, scoring was completed in the same way with one difference. For the spontaneous elicitation task, the pre-recorded audio script always provided the subject of the sentence. For this reason, items were never excluded from the calculation of third person singular accuracy because of an omitted subject. However, items were excluded if 1) the child did not attempt the third person singular structure and 2) if a different verb was used. For instances where the child used a non-target verb, the examiner re-prompted the child in the following way:

> *Listen carefully. The woman’s job is to kick the ball. Now you tell me what the woman does everyday at her job. Everyday she*_____

Participants were only allowed one re-prompt per item. In most instances, children produced a non-target verb because they were not paying attention during the administration of the item. However on some occasions, children continued to use a non-target verb even after receiving the re-prompt. In these instances, the item was not scored and therefore was not used in the calculation for third person singular accuracy.

Procedures

Study 1 data were collected across four 45-minute sessions. All sessions were audio and video recorded. Sessions were scheduled once per week for four consecutive weeks. Sessions took place at the child's preschool/school, in their home, or at the Speech and Hearing Clinic at the University of Kansas. During the first session, children completed a hearing screening, the phonological, third person singular, and past-tense probes of the TEGI, and the PPVT-4. During the second session all children completed the Study 1 receptive vocabulary probe to ensure that they knew the words presented in the Sentence Imitation and Spontaneous Elicitation tasks. Additionally, all children completed the Be/Do probe of the TEGI and the nonverbal intelligence test (i.e., RIAS). During the second session, children in the SLI group also completed the grammaticality judgment probe of the TEGI. During the third session, children completed the sentence imitation task, the spontaneous elicitation task, and the GFTA-2. The order of the sentence imitation and spontaneous elicitation tasks was counterbalanced across participants.

The fourth session was used to collect a 30-minute play-based spontaneous language sample. The goal was to obtain at least 150 complete and intelligible utterances. While most children produced at least 150 utterances during the 30-minute interaction, some children produced far fewer utterances either because they were shy or because they preferred to manipulate the toys rather than talk about them. The number of complete and intelligible utterances collected during the 30-minute interaction did not significantly differ between the SLI (M =208, SD = 70, $Range$ = 40 – 363) and TD (M = 206, SD = 82, $Range$ = 24 – 354) groups, $t(38) = .068$, $p = .946$. The examiner collected all spontaneous language samples using a standard set of toys that were age-appropriate for children in both groups (i.e., house and farm set with small people, animals, vehicles, and other related objects).

During the 30-minute sample, the examiner tried to elicit the finiteness markers that are represented on the TEGI, but greater emphasis was placed on eliciting the third person singular finiteness marker. Recall that children were required to show optional use of the third person singular finiteness marker on either the TEGI or during the spontaneous language sample (see Table 1). Accuracy of the third person singular finiteness marker was based only on complete and intelligible utterances for obligatory contexts in the phrase (i.e., the presence of the third person singular subject was required to count the utterance toward total accuracy). All 40 samples were transcribed, entered into the Systematic Analysis of Language Transcripts program (SALT) and coded following the conventions for grammar coding set forth in the SALT manual. Mean length of Utterance in words (MLU-W) was generated by the SALT program and was based on only fully complete and intelligible utterances.

Reliability

Scoring reliability was completed on 20% of the sample for each group (n = 4 cases per group) for the sentence imitation task and the spontaneous elicitation task. For the two tasks, a second judge was asked to transcribe all of the child's responses. After transcription, the reliability judge was asked to score each sentence as either 1) correct, 2) omission, or 3) un-scorable based on the scoring procedures described above. Interjudge reliability for the sentence imitation task was 97% (*SD* = 2%, *Range* = 94 – 100%) for the SLI group and 92% (*SD* = 2%, *Range* = 90 – 95%) for the TD group. Interjudge reliability for the spontaneous elicitation task was 95% (*SD* = 2%, *Range* = 92 – 97%) for the SLI group and 95% (*SD* = 4%, *Range* = 90 – 100%) for the TD group. Language sample transcription reliability was also computed for 20% of the sample from each group (n = 4 cases per group). For language sample transcription reliability the reliability judge transcribed 10 minutes of the 30-minute sample for each child and coded the child's utterances according to the conventions detailed in the SALT manual. Two types of agreement were calculated between the examiner and the reliability judge: 1) word agreement and 2) grammar coding agreement. Interjudge reliability for word agreement was 90% (*SD* = 4%, *Range* = 85 – 94%) for the SLI group and 90% (*SD* = 3%, *Range* = 86 – 94%) for the TD group. Interjudge reliability for the grammar coding agreement was 89% (*SD* = 2%, *Range* = 87 – 91%) for the SLI group and 89% (*SD* = 2%, *Range* = 88 – 91%) for the TD group.

Study 1 Results

The purpose of Study 1 was to determine whether the neighborhood density of a verb (dense vs. sparse) affected the ability to correctly produce the third person singular finiteness marker by children with SLI and younger typically developing children (TD) in the optional infinitive stage. The dependent variable was the proportion correct production of the third person singular finiteness marker in obligatory contexts from the sentence imitation and spontaneous elicitation tasks. Study 1 data were analyzed using a 2 group (SLI vs. TD) x 2 neighborhood density (dense vs. sparse) x 2 task (sentence imitation vs. spontaneous elicitation) mixed ANOVA. The comparisons of interest were the main effect of neighborhood density and the interaction between group and neighborhood density. To interpret significant interactions involving group, the effect of neighborhood density on third person singular production accuracy for dense versus sparse words was explored separately for each group.

The main analysis showed significant main effects of neighborhood density, $F(1, 38) = 27.83$, $p < .001$, $\eta_p^2 = .423$ and group, $F(1, 38) = 11.66$, $p < .01$, $\eta_p^2 = .235$. The main effect of task was not significant, $F(1, 38) = 1.55$, $p = .221$, $\eta_p^2 = .039$. The significant main effects of neighborhood density and group were qualified by a significant interaction between neighborhood density and group, $F(1, 38) = 11.23$, $p < .01$, $\eta_p^2 = .103$ and between task and group, $F(1, 38) = 4.36$, $p < .05$, $\eta_p^2 = .103$. Since both of the significant interactions involved group, a follow up 2 neighborhood density x 2 task ANOVA examining the effect of neighborhood density on third person singular production in production tasks was conducted separately for each group.

The results of the follow-up 2 neighborhood density x 2 task ANOVA for the SLI group showed only a significant main effect of task, $F(1, 19) = 5.64$, $p < .05$, $\eta_p^2 = .229$ in that overall accuracy for the sentence imitation task was higher (*M* = 46%, *SD* = 26%, *SEM* = 6%) than overall accuracy on the spontaneous elicitation task (*M* = 31%, *SD* = 28%, *SEM* = 6%), $t(19) = 2.4$, $p < .05$. Neither the main effect of neighborhood density, $F(1, 19) = 2.64$, $p = .120$, $\eta_p^2 = .122$, nor the interaction between task and neighborhood density were statistically significant, $F(1, 19) = .006$, $p = .939$, $\eta_p^2 = .000$. Figure 1 shows the third person singular accuracy by task with accuracy for dense verbs represented by the striped bars and accuracy for sparse verbs represented by the solid bars. In the sentence imitation task children with SLI were equally accurate on the third person singular structure for dense (*M* = 48%, *SD* = 29%, *SEM* = 6%) and sparse (*M* = 45%, *SD* = 25%, *SEM* =6%) verbs. Likewise, in the spontaneous elicitation task children with SLI showed no difference in third person singular accuracy for dense (*M* = 33%, *SD* = 29%, *SEM* = 6%) and sparse (*M* = 30%, *SD* = 29%, *SEM* = 6%) verbs. In other words, the omission errors made by children with SLI in this study were not related to the neighborhood density of the root word form.

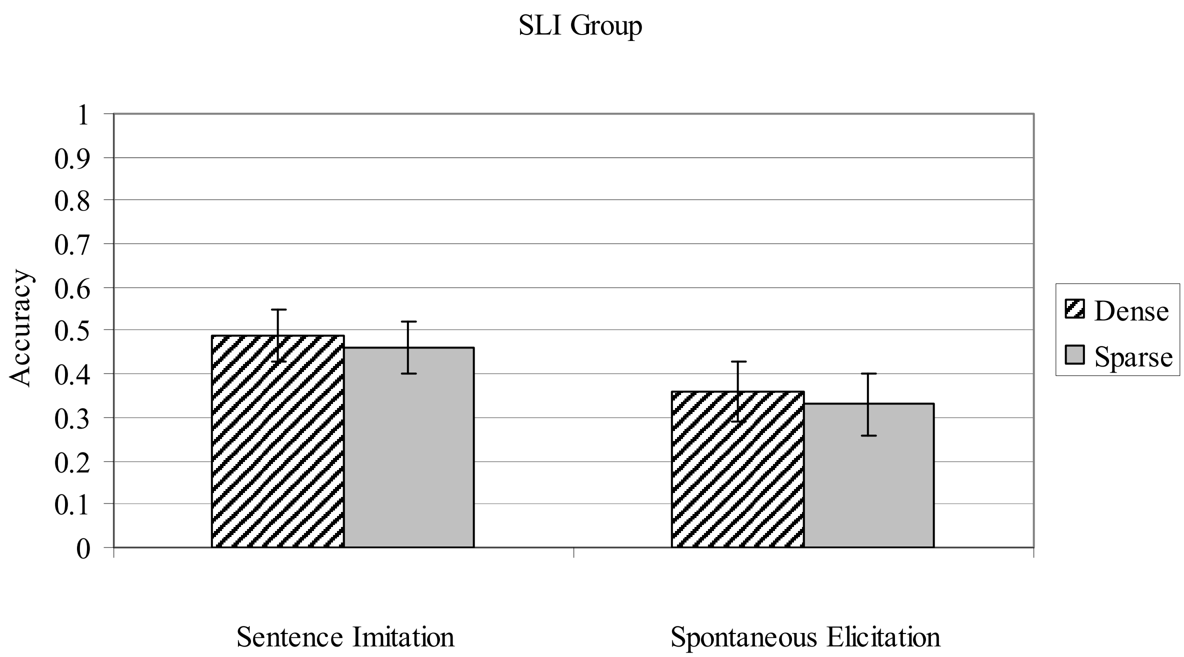

Figure 1. Third Person Singular Accuracy in Production Tasks for the SLI Group

In terms of the TD group, the 2 neighborhood density x 2 task follow-up ANOVA showed that the main effect of neighborhood density was significant, $F(1, 19) = 28.64$, $p < .001$, $\eta_p^2 = .601$. Neither the main effect of task, $F(1, 19) = .351$, $p = .561$, $\eta_p^2 = .018$, nor the interaction between neighborhood density and task were significant, $F(1, 19) = .192$, $p = .666$, $\eta_p^2 = .010$. Figure 2 shows the third person singular accuracy by task with accuracy for dense verbs represented by the striped bars and accuracy for sparse verbs represented by the solid bars. In the sentence imitation task, third person singular accuracy was significantly higher for dense verbs (*M* = 65%, *SD* = 27%, *SEM* = 6%) compared to sparse verbs (*M* = 50%, *SD* = 15%, *SEM* = 3%). Likewise, in the spontaneous elicitation task, third person singular accuracy was significantly higher for dense verbs (*M* = 68%, *SD* = 24%, *SEM* = 5%) compared to sparse verbs (*M* = 55%, *SD* = 22%, *SEM* = 5%). In other words, the omission errors made by children in the

TD group were affected by the neighborhood density of the root verb form with more omission errors on sparse verbs than on dense verbs.

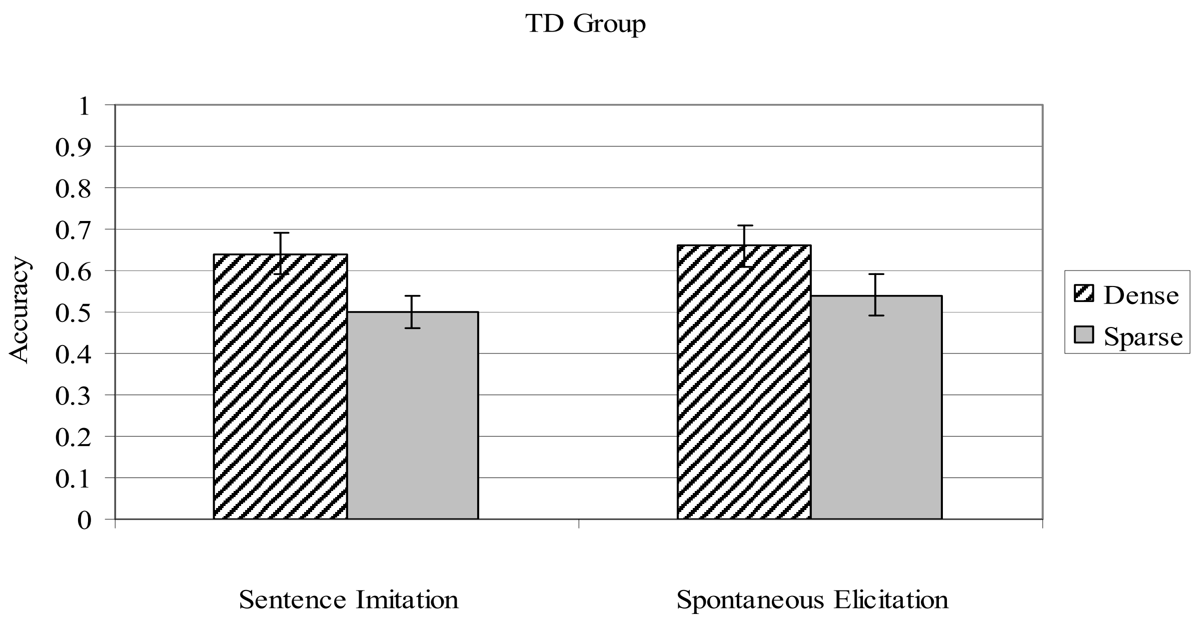

Figure 2. Third Person Singular Accuracy in Production Tasks for the TD Group

Group Difference Exploratory Analyses

Exploratory analyses were conducted to better understand the lack of significant neighborhood density effects for children with SLI. The purpose of the exploratory analyses was to rule out the following possible explanations for the lack of neighborhood density effect on third person singular omission errors: 1) heterogeneous performance within the SLI group (i.e., more errors on dense words for some children with SLI, but more errors on sparse words for other children with SLI) and 2) floor effects in the data.

If it is the case that some children with SLI made significantly more omission errors on dense words while others made significantly more omission errors on sparse words, the group analysis would result in a non-significant effect of neighborhood density. To rule out this possibility, difference scores were computed for all children in the SLI group. Because children in the TD group showed greater third person singular accuracy for dense verbs, difference scores were computed by subtracting sparse third person singular accuracy from dense third person singular accuracy. In this way, a positive difference score would indicate performance that matched children in the TD group (i.e., greater third person singular accuracy for dense verbs). A negative difference score would indicate performance that was the opposite as children in the TD group (i.e., greater accuracy for sparse verbs). A difference score of 0 would indicate that children showed no difference in their third person singular accuracy for dense and sparse verbs (i.e., no neighborhood density effect).

Figure 3 shows the frequency of sentence imitation difference scores for all 20 children in the SLI group. As shown in Figure 3, the majority of children in the SLI group (n = 13) showed essentially no difference in third person singular accuracy for dense and sparse verbs (M = .03, SD = .14). Five children in the SLI group showed positive difference scores that were between 11% and 40% indicating that a small group of children showed a pattern similar to the TD group. Additionally, two children showed a negative difference score that was less than -10%, indicating better performance for sparse verbs.

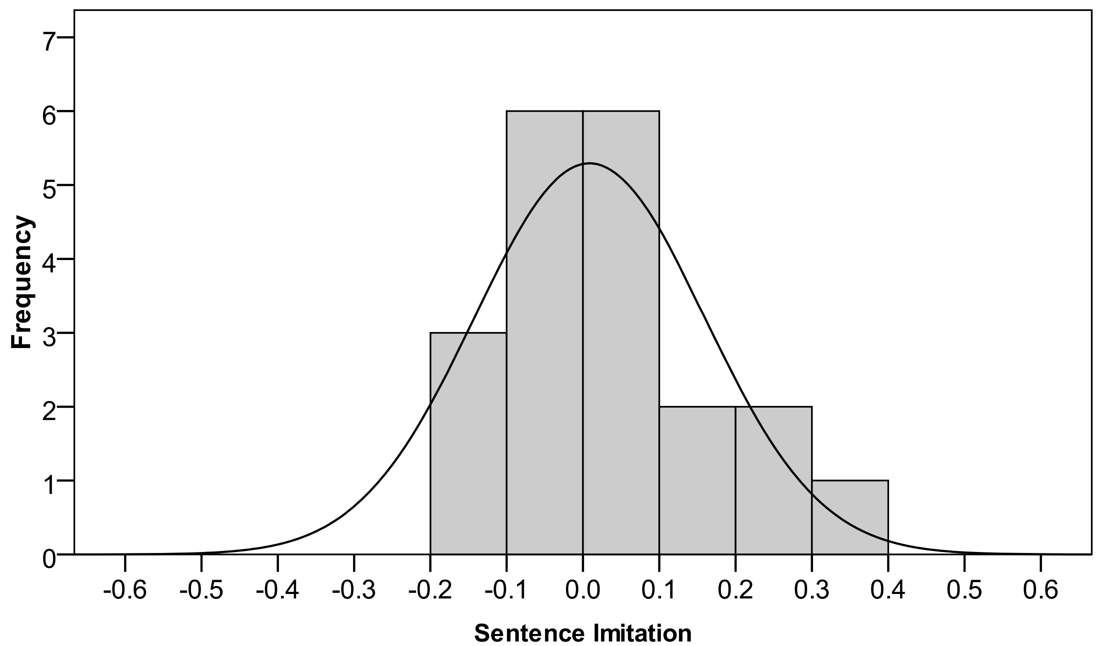

Figure 3. Sentence Imitation Difference Scores for the SLI Group

Figure 4 shows the frequency of spontaneous elicitation difference scores for all 20 children with SLI and a similar pattern is observed. In the spontaneous elicitation task, the majority of children with SLI (i.e., 14 out of 20 children) showed no difference in accuracy for dense and sparse verbs (*M* = .03, *SD* = .097). Five of the children in the SLI group showed positive difference scores that were between 15% and 25% indicating that a small group of children showed a pattern similar to the TD group. Likewise, one child showed a difference score of -13% indicating better performance for sparse verbs for this child.

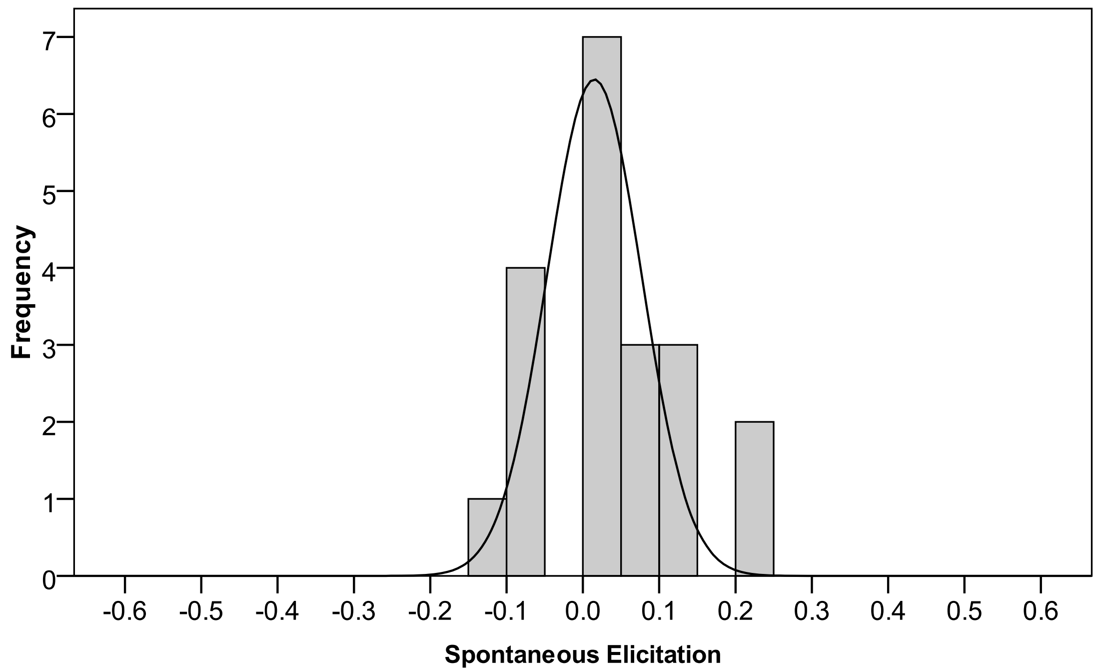

Figure 4. Spontaneous Elicitation Difference Scores for the SLI Group

In general, the pattern of effects was almost exactly opposite that of children in the TD group and this is shown in Table 3. Specifically, the majority of children in the SLI group showed no difference for dense and sparse verbs while the majority of children in the TD group showed a dense advantage. Very few children in either group showed a sparse advantage.

Table 3

Summary of Neighborhood Density Effects by Group

	Sentence Imitation		Spontaneous Elicitation	
	SLI	TD	SLI	TD
Dense Advantage	25%	70%	25%	70%
	(n = 5)	(n = 14)	(n = 5)	(n = 14)
Sparse Advantage	10%	15%	5%	15%
	(n = 2)	(n = 3)	(n = 1)	(n = 3)
No Difference	65%	15%	70%	15%
	(n = 13)	(n = 3)	(n = 14)	(n = 3)

Floor effects could also explain the lack of neighborhood density effect in the SLI group. Specifically, the main effect of neighborhood density in the SLI group could fail to reach significance because performance was too low across the task to uncover neighborhood density effects (i.e., 1 or 2 correct responses overall). Additionally, since the main effect of group was significant in the main ANOVA, it was important to examine a subset of the SLI group that was more closely matched in overall accuracy.

To address floor effects and the main effect of group in the sentence imitation task, a subset of children from each group was selected to achieve better matching on third person singular accuracy across the two groups. The effect of neighborhood density was re-examined in the sentence imitation task only for children whose accuracy was at least 30%. This criterion eliminated five children from the SLI group and three children from the TD group. A 2 neighborhood density x 2 group ANOVA showed a significant main effect of neighborhood density $F(1, 30) = 14.15$, $p < .01$, $\eta^2 = .320$ that was qualified by a significant interaction between group and neighborhood density, $F(1, 30) = 5.42$, $p < .05$, $\eta^2 = .153$. The group by neighborhood density interaction was explored by comparing third person singular accuracy for dense and sparse verbs separately for each group using paired samples *t* tests. Consistent with the main ANOVA, children in the TD group were significantly more accurate on the third person singular structure with dense rather than sparse verbs, $t(16) = 4.19$, $p < .01$. Also, consistent with the main ANOVA, children in the SLI group showed no difference in third person singular accuracy on the sentence imitation task for dense and spare verbs, $t(14) = 1.1$, $p = .303$.

Similarly, to address floor effects and the main effect of group in the spontaneous elicitation task, the effect of neighborhood density was re-examined only for children whose overall accuracy was at least 30%. In the spontaneous elicitation task, this criterion eliminated ten children from the SLI group and only one child from the TD group. A 2 neighborhood density x 2 group ANOVA showed only a significant main effect of neighborhood density $F(1, 27) = 7.8$, $p < .05$, $\eta^2 = .224$. Although the group by neighborhood density interaction was not significant, $F(1, 27) = 3.12$, $p = .08$, $\eta^2 = .104$, it was explored because it approached significance (the lack of significance was most likely due to the lack of power). The third person singular accuracy for dense and sparse verbs was compared separately for each group using paired samples *t* tests. Consistent with the main ANOVA, children in the TD group were significantly more accurate on the third person singular structure with dense rather than sparse verbs, $t(18) = 3.44$, $p < .01$. Also consistent with the main ANOVA, children in the SLI group showed no difference in third person singular accuracy on the spontaneous elicitation task for dense and spare verbs, $t(9) = .938$, $p = 373$.

The combined results from these analyses indicate that the lack of neighborhood density effect for the SLI group was not the result of overall poor performance across the two tasks. The main effect of group was no longer significant when a more closely matched subset of the groups was examined. Even when excluding children with very low accuracy from the analysis, no difference in the use of the third person singular structure for dense and sparse verbs was observed for children in the SLI group.

Chapter III: Study 2

The research question for Study 2 was: (1) Does presenting dense versus sparse verbs (i.e., manipulating neighborhood density) during a 6-week controlled-exposure learning paradigm differentially affect the rate of production for the third person singular finiteness marker over time for children with SLI (i.e., pre- versus post-exposure accuracy)? This research question was addressed by comparing pre- and post-exposure performance on a sentence imitation and spontaneous elicitation task that included dense and sparse verbs presented during 12-sessions of controlled exposure to the third person singular finiteness marker. Additionally, pre- and post-exposure performance was compared on the two production tasks from Study 1 (i.e., sentence imitation and spontaneous elicitation) to assess generalization of the effects of controlled exposure (i.e., generalization to unexposed verbs).

Method

Participants. A subset of children in the SLI group who participated in Study 1 also participated in Study 2. All children who qualified for Study 1 were eligible and invited to participate in Study 2. Reasons for not participating in Study 2 included: 1) availability and time on the part of the family, 2) space restrictions, and 3) approval restrictions from participating school districts (i.e., one district only approved recruiting children for Study 1). Parents of six children with SLI from Study 1 were willing and able to have their child commit to several weeks of consistent attendance and therefore gave permission for their child to participate in Study 2. Table 4 shows how the Study 2 participants compared to the children who only participated in Study 1.

Table 4

Mean, SD, and Range of Participant Characteristics Compared for Study 1 and 2 vs. Study 1 only

	Study 1 & 2 (n = 6)	Study 1 only (n = 14)
Chronological Age	4;5 (0;8) 4;0 – 5;6	5;0 (0;8) 4;2 – 4;8
TEGI Grammar Composite	19% (5%) 12 – 26%	35% (15%) 12 – 59%
TEGI 3rd Singular Probe	25% (25%) 0 – 70%	35% (21%) 0 – 70%
Spontaneous 3rd Singular	28% (11%) 15 – 45%	37% (27%) 0 – 81%
MLU in Words	3.38 (.79) 1.84 – 3.97	3.8 (.58) 2.79- 4.77
PPVT-4 Standard Score	96 (8.8) 84 – 108	96 (12) 76 – 118
GFTA-2 Standard Score	92 (13) 74 – 110	89 (13) 64 – 110

Design. Study 2 was a pre-post exposure design. This design included 1) participation in a no-exposure phase prior to the exposure phase; 2) random assignment to an exposure condition (i.e., dense or sparse); and 3) replication of exposure effects through the assignment of multiple children to the same level of the independent variable. In this study, an effect was considered meaningful if it was similarly observed across all children in the same condition and if it differed from the pattern observed during the pre-exposure period. Data from each of these three phases were plotted graphically and visually analyzed.

Stimuli. The stimuli for Study 2 included 12 verbs (i.e., 6 dense verbs and 6 sparse verbs). The procedure used to select verbs for Study 1 was used to select verbs as stimuli for Study 2. Similar to Study 1, knowledge of the Study 2 stimuli was verified by asking children to complete a receptive vocabulary probe created specifically for this study. The exact same format used for Study 1 was used for the Study 2 receptive vocabulary probe. To be included in Study 2, all children had to achieve at least 80% accuracy on the Study 2 vocabulary probe.

Following the Study 1 procedures, the 12 selected verbs were chosen based on the neighborhood density of their nonfinite form (e.g., spin, rather than spin**s**). Neighborhood density of each root verb was calculated using the same program described in Study 1 (Storkel & Hoover, under review). For Study 2, words were assigned to dichotomous categories of ‘dense’ (M= 13, SD = 6, *range* = 6 - 20) or ‘sparse’ (M = 6; SD = 3; *range* = 3-11). The number of neighbors of verbs in the dense condition differed significantly from the number of neighbors of verbs in the sparse condition, $t(10) = 2.5$, $p < .05$.

To ensure that the Study 2 stimuli in the dense and sparse conditions differed only in number of neighbors, the same additional factors that were matched across dense and sparse conditions for Study 1 were also matched across dense and sparse conditions for Study 2. Dense and sparse verbs did not differ significantly on positional segment average (*M* dense = .05; *M* sparse =.05, $t(10) = .97$, $p = .356$), biphone average (*M* dense =.0055; *M* sparse = .0048, $t(10) = .491$, $p = .634$), or log word frequency (*M* dense = 3.24; *M* sparse = 3.58, $t(10) = -.684$, $p = .522$). Likewise, every attempt was made to balance the syllable structure, verb argument structure (transitive versus intransitive), and final allomorph resulting from the third person singular morpheme (s versus z versus schwa + z) across dense and sparse conditions while still maintaining a significantly different number of neighbors and balanced phonotactic probability estimates. A full description of the Study 2 verbs is in Appendix C.

Following the Study 1 procedures, sentences were constructed around the 12 verbs, resulting in six sentences with a dense verb in the finite third person singular form, and six sentences with a sparse verb in the finite third person singular form. Sentences in the dense and sparse conditions were matched in the number of words (dense = 6; sparse = 6), number of morphemes (dense = 7; sparse = 7), and number of syllables (dense = 7; sparse = 6.7). The same set of agents was used in the sentences across dense and sparse conditions. Appendix D illustrates the sentence matching procedure for Study 2. The previously described 12 sentences were recorded by the same speaker who recorded the Study 1 sentence stimuli and they were digitized and edited using the same software described in Study 1. Sentence durations were not significantly different across dense and sparse conditions, $t(10) = .348$, $p = .735$. Additionally, all 12 sentences were presented to the same group of naïve listeners used for Study 1 who correctly verified that every word in the sentence was identified as the intended target.

Procedures

A 12-session controlled exposure learning paradigm was used for Study 2. As parents gave consent for children to participate in Study 2, they were randomly assigned to one of two possible conditions: 1) controlled exposure to dense verbs or 2) controlled exposure to sparse verbs. Thus, neighborhood density was a between subjects independent variable. Three children were assigned to the dense exposure condition and three children were assigned to the sparse exposure condition. The controlled exposure conditions were conducted on a fixed-time criterion, where each child completed two 30-minute sessions a week for 6 weeks, totaling 12 sessions per child. All sessions were video-and audio-recorded. The average time to complete 12 sessions was 6.5 weeks for the dense condition and 6.5 weeks (Range = 6 – 8 weeks) for the sparse condition (Range = 6 – 7 weeks).

Controlled Exposure Activities

Children completed twelve 30-minute sessions of concentrated and controlled exposure to the third person singular finiteness marker. All sessions took place in the child's home. During these sessions, children received auditory exposure through the examiner's productions of the third person singular structure and through their own third person singular production attempts. The controlled exposure activities were designed around a set of 6 verbs (i.e., dense *or* sparse) that were presented in the third person singular context. All of the procedures in terms of the number of auditory exposures, production prompts, activities and materials used were identical across the dense and sparse exposure conditions. The only difference between the two conditions was the set of verbs presented (i.e., dense versus sparse).

Within each session, children received 72 exposures to the third person singular finiteness marker (i.e., 864 total exposures for each child in Study 2). These exposures were accumulated over the course of each session through the following activities: 1) a story read by the examiner (i.e., 24 examiner productions), 2) picture guided story re-tell (i.e., 12 production attempts), 3) direct imitation (i.e., 12 examiner productions and 12 production attempts, and 4) elicited imitation (i.e., 12 production attempts).

Each session began with the examiner reading a story that featured two characters (i.e., a girl named Zoe and a boy named Max). The same two characters were featured in every story and were engaged in a variety of adventures across stories (i.e., snow day, zoo trip, farm trip, school trip, circus trip, and beach trip). The stories set the stage for all subsequent imitation requests and production prompts elicited during the session. Six story scripts were created and each story was read for two sessions. The stories were created by embedding the six target verbs (i.e., dense or sparse) into a script that set up the third person singular context. Each target verb was presented with the third person singular structure four times during the story.

Illustrations that corresponded to each story script were created by the same artist who created the Study 1 illustrations for the spontaneous elicitation task. Each story consisted of eight illustrations. The first illustration corresponded to the story's introduction and the last illustration corresponded to the story's conclusion. The introduction and conclusion scripts were identical across the dense and sparse conditions. The six intermediate illustrations were used to present each of the six target verbs (i.e., dense or sparse). Each verb within a condition was assigned to one illustration per story. The same six intermediate illustrations were created so that they could be used across dense and sparse conditions (i.e., the illustrations were non-specific). That is, the six intermediate illustrations featured the characters posed in a neutral context (e.g., in the school story, the dense verb "crash" and the sparse verb "laugh" were both assigned to a scene where Zoe and Max were on a playground). The eight illustrations per story were embedded into power point presentation. During the story, the child viewed the illustrations on a laptop computer while the examiner read the story script live voice.

The story gave each child 24 exposures to the third person singular structure (i.e., 4 exposures with each of the six verbs). After the examiner read the story, the child completed five short activities/tasks that prompted a production of the third person singular structure with each target verb several times.

The first task was a picture guided story retell where the child was prompted to re-tell the story using picture cards for assistance. During this task, the child had two opportunities to attempt a production of the third person singular structure with each verb (i.e., 12 total third person singular exposures). The second task used was an elicited production task. For this task, the child was allowed to choose one of five games (i.e., candy land, cootie, hi-ho cheery-o, ants-in-the-pants, and memory) to play while the examiner elicited a set number of production attempts of the third person singular structure. The examiner used the same production prompts regardless of the games chosen by the child. The games were used only as reinforcement for the child (i.e., they were allowed to take a turn after every production attempt regardless of how they responded). During this task, the child was given one attempt to produce the third person singular structure with each verb. This elicited production task was completed twice during each session so that the child was able to choose and play two games during each session. Completing this task twice resulted in 12 additional production attempts to the third person singular structure (i.e., one attempt per verb in each round of the task).

In addition to the elicited production tasks, the child was given additional production practice on the third person singular structure with each target verb via direct imitation (e.g., say "Zoe laughs at the horse"). During this task, the child was given one attempt to produce the third person singular structure with each verb. The direct imitation task was also completed two times within each session. The completion of two rounds of the direct imitation task resulted in 12 additional production attempts to the third person singular structure (i.e., one attempt per verb in each round of the task) as well as 12 auditory additional exposures to the third person singular structure that were produced by the examiner while she provided the sentence to be imitated (i.e., one production per verb in each round of the task). The cumulative number of exposures provided within each 30-minute session across the child's production attempts and the examiner's productions was 72 (i.e., 36 productions by the examiner and 36 production attempts by the child).

Children were invited to participate in this study because their production accuracy for the third person singular structure was delayed. Therefore, many of the production attempts resulted in omission errors (e.g., "Zoe **laugh_** at the horse") or unscorable responses (e.g., "I don't know" "She laughing"). When the child did not correctly produce the third person singular structure because of these reasons, the number of exposures to the third person singular was reduced. To guard against this reduction in exposures and to ensure that all children received the same number of exposures across each session and across the dense and sparse conditions, the examiner recasted every production attempt that did not result in a production of the third person singular structure with the target verb. In these instances, the examiner provided the correct target structure for the child. For example, if the child said "Zoe **laugh** at the horse" the examiner said "Listen carefully, Zoe **laughs** at the horse". Additionally, since the presence of a subject is required for a third person singular obligatory context, if the child produced a response that did not include the subject, the examiner asked the child to try their response again, but to start with "he" or "she".

For all activities within a session, the child's productions were scored using the same scoring procedure as Study 1. The child was given a score of '1' for each production of the target verb where the third person singular finiteness marker was correctly used. A score of ‘2’ was given for all productions of the target verb where the third person singular structure was omitted. A score of ‘3’ was assigned to all other production responses (i.e., any other response besides correct productions and omissions of the third person singular). These scores were marked on a data sheet during the session so that the examiner could keep track of the number of exposures presented during the session. The total accuracy of the third person singular productions on target verbs was calculated for each treatment session. Accuracy was calculated by dividing the sum of responses across all activities that were scored as ‘1’ by the sum of all responses scored as ‘1’ or ‘2’ (i.e., correct third person singular productions/total third person singular opportunities). Scores of ‘3’ were ignored in computing third person singular accuracy.

Measures of Learning

Pre-exposure measures. Prior to the first controlled exposure session, each child completed a pre-exposure testing period. As children were enrolled in the dense and sparse conditions for Study 2, they were randomly assigned to three, four, or five pre-exposure testing conditions with one child from each neighborhood density condition being assigned to each pre-exposure condition. The purpose of the pre-exposure period was to establish the true effect of the exposure sessions on third person singular accuracy as opposed to maturation. To determine whether changes observed during the exposure period were attributable to the exposure sessions, a pattern of no change in at least two consecutive sessions or a decrease in accuracy was required prior to beginning the exposure phase of the study.

To monitor accuracy of the third person singular structure during the pre-exposure period, two versions of the sentence imitation and spontaneous elicitation tasks from Study 1 were used: 1) a version that used the Study 2 verbs (i.e., exposed verbs) and 2) the previously described Study 1 version (i.e., unexposed verbs). The use of these two versions allowed for 1) measurement of growth for third person singular with the verbs presented during the controlled exposure sessions and 2) measurement of growth for third person singular with a set of verbs that were *not* presented during the controlled exposure period. The purpose of this procedure was to be able to determine whether observed changes in the third person singular were only observed for verbs explicitly presented during the exposure period or whether observed changes were also generalized to a new set of verbs. Recall that the Study 1 version of the production tasks included both dense and sparse verbs. So by using the Study 1 version of the two production tasks a measure of within- and across-density generalization comparisons was also available to determine whether generalization was only extended to verbs that matched the neighborhood density of the exposure condition or whether generalization was extended to all verbs (dense and sparse) regardless of the exposure condition. Generalization of third person singular changes to dense and sparse verbs would indicate more widespread change since children were only exposed to either dense or sparse verbs during the controlled exposure sessions.

Post-exposure measures. In the session immediately following the 12th controlled exposure session, children completed the Study 2 version of the sentence imitation and spontaneous elicitation tasks. The post-exposure administration of this task served as the dependent measure for the third person singular accuracy for the set of verbs that were presented during the controlled exposure sessions. In the same session, children also completed the Study 1 version of the sentence imitation and spontaneous elicitation tasks. The post-exposure administration of the Study 1 tasks served as the dependent measure for the third person singular accuracy for a set of verbs that were not presented during the controlled exposure paradigm (i.e., generalization measure). In addition to completing the sentence imitation and spontaneous elicitation tasks for the exposed and unexposed verbs, children also completed the TEGI after their 12^{th} exposure session.

Study 2 Results

The purpose of Study 2 was to determine whether the neighborhood density of a verb presented during 12 sessions of controlled exposure differentially affected growth in the third person singular finiteness marker. All six children received 12 sessions of concentrated and controlled exposure to the third person singular finiteness marker. Three children were exposed to the third person singular finiteness marker with a set of dense verbs and three children were exposed to the third person singular finiteness marker with a set of sparse verbs.

Production of Third Person Singular in Exposed Verbs

The first measure of learning was the accuracy of the third person singular finiteness marker from the production prompts during each controlled exposure session. Third person singular accuracy was calculated for each session. Individual participant graphs were constructed plotting accuracy for all 12 exposure sessions (see Figures 5 – 10). Visual analysis of these data was used to compare the rate of change in third person singular.

In addition to third person singular exposure session accuracy, the difference in pre- versus post-exposure third person singular accuracy on the Study 2 production tasks was also compared across the dense and sparse exposure conditions. To determine the average pre-exposure session accuracy, the third person singular accuracy obtained across all pre-exposure sessions for both sentence imitation and spontaneous elicitation was averaged. In this way, there was one pre-exposure third person singular accuracy score that was calculated for the Study 2 verbs. To determine the average post-exposure session accuracy, the third person singular accuracies obtained from the Study 2 version of sentence imitation and spontaneous elicitation were averaged to obtain one post-exposure session accuracy score. The average pre-exposure accuracy score was then subtracted from the average post-exposure accuracy score. These scores were compared across the dense and sparse conditions. The purpose of this comparison was to determine whether one exposure condition (i.e., dense or sparse) yielded a greater amount of pre-post change for third person singular accuracy for the verb items presented during the exposure sessions.

Figures 5 – 7 show 1) the accuracy for the pre-exposure period, represented by the “P” points, 2) accuracy for the exposure sessions, represented by the “E” points, and 3) accuracy from the post-exposure test point, represented by the “PE” point, for the three participants who were assigned to the dense condition.

As shown in Figure 5, Child 47, who was exposed to dense verbs, showed a relatively flat pattern of accuracy, with little variability across sessions (*M* session accuracy = 9%; Range of session accuracy = 3% - 17%). His accuracy during exposures sessions was never higher than the average of his third person singular accuracy during the pre-exposure phase (i.e., 19%). In fact, the difference between his post-exposure session accuracy to pre-exposure was negative (i.e., -19%) meaning that Child 47 showed no improvement in his use of the third person singular finiteness marker over the course of the 12 exposure sessions.

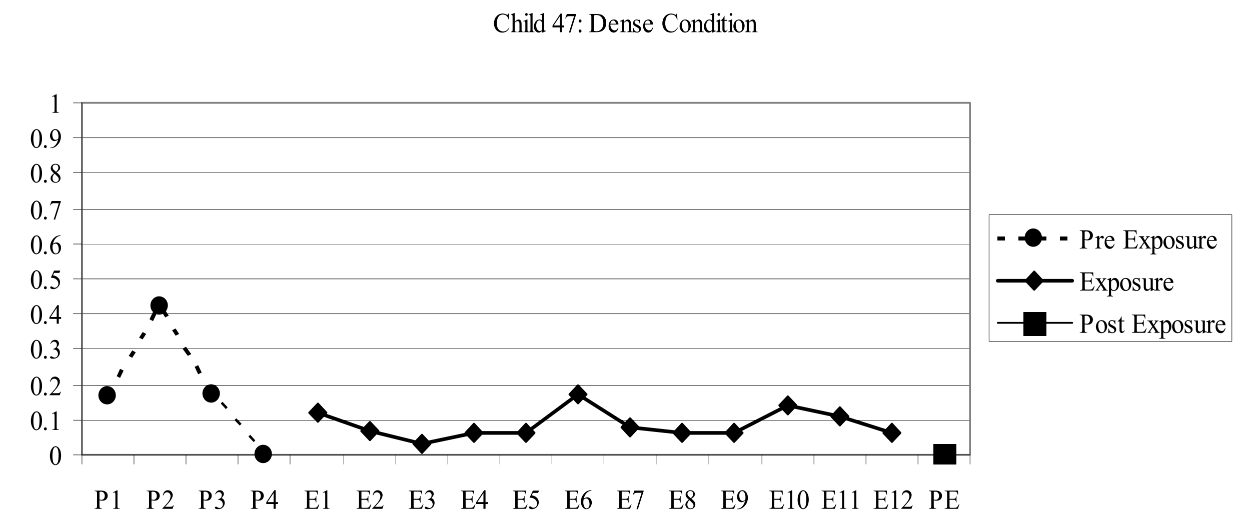

Figure 5. Accuracy Data for Dense Verbs Presented during Exposure for Child 47

The other two children who were exposed to dense verbs showed a different pattern of accuracy during the exposure sessions. As shown in Figure 6, Child 48's session accuracy was characterized by variability (*M* session accuracy = 32%, Range of session accuracy = 6% - 64%) and her exposure accuracy was higher than her average pre-exposure accuracy for 6 out of 12 exposure sessions. However, Child 48 showed no difference in her third person singular accuracy from the pre- to post-exposure time point (i.e., -3%).

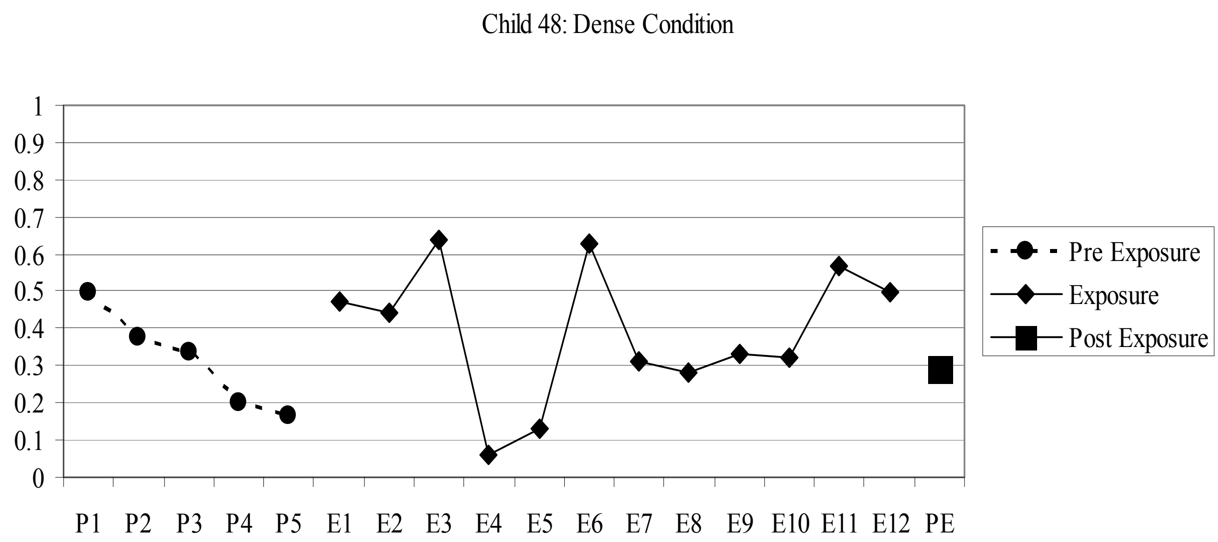

Figure 6. Accuracy Data for Dense Verbs Presented during Exposure for Child 48

As shown in Figure 7, Child 53 showed similar variability in her exposure session accuracy (*M* session accuracy = 66%, Range of session accuracy = 50% to 100%) and her exposure accuracy was higher than her average no-exposure accuracy for 5 out of 12 exposure sessions. Child 53 showed a positive difference in her third person singular accuracy from the pre- to post-exposure time point (i.e., a 21% increase) and she was the only child in the dense condition who showed improvement in her use of the third person singular finiteness marker.

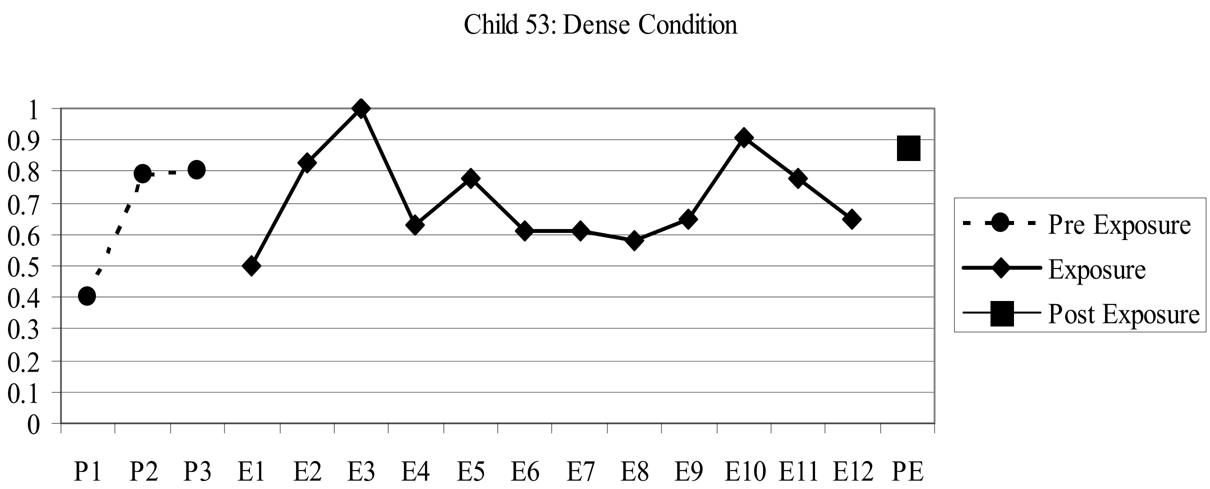

Figure 7. Accuracy Data for Dense Verbs Presented During Exposure for Child 53

Figures 8 – 10 show 1) accuracy for the pre-exposure period, represented by the "P" points, 2) accuracy for the exposure sessions, represented by the "E" points, and 3) accuracy from the post-exposure test point, represented by the "PE" point, for the three participants who were assigned to the sparse exposure condition.

As shown in Figure 8, Child 45, who was exposed to sparse verbs, showed a relatively stable pattern of accuracy characterized by an increase in accuracy through the ninth exposure session. After session 9, Child 45 was inconsistent in his accuracy across the remaining three sessions (*M* = 45%; *Range* = 27% - 77%). Noteworthy is that for 12 out of 12 exposure sessions, his third person singular accuracy was higher than the average accuracy achieved during the pre-exposure phase. Likewise this improvement was maintained at the post-test, with an average third person singular accuracy of 71%. The difference between his post-exposure session accuracy and pre-exposure session accuracy was positive (i.e., 48%) indicating that Child 45 showed improvement on his use of the third person singular finiteness marker over the course of the 12 exposure sessions.

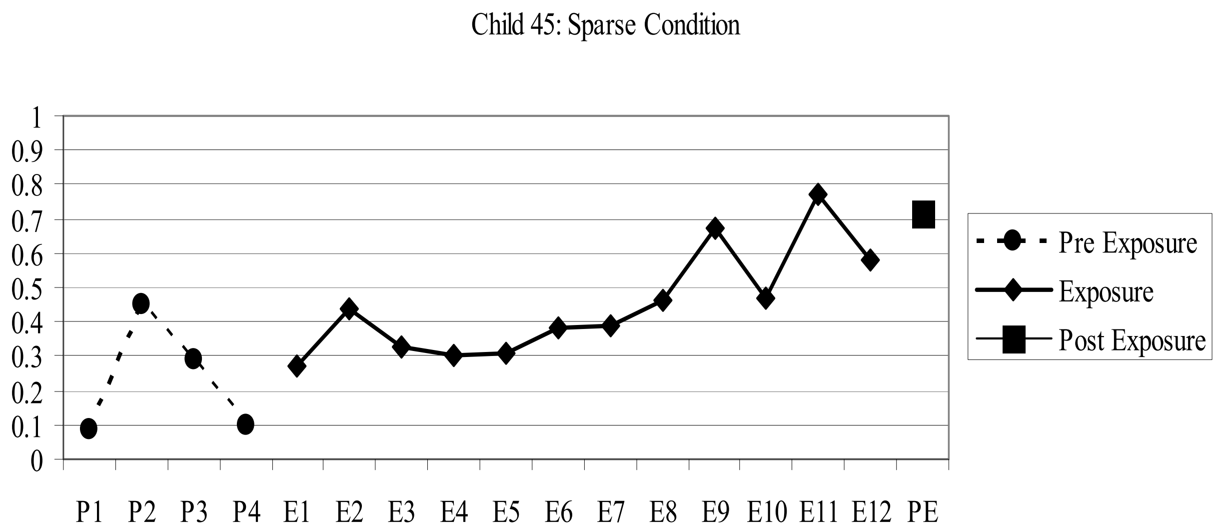

Figure 8. Accuracy Data for Sparse Verbs Presented during Exposure for Child 45

Child 49, shown in Figure 9, demonstrated a somewhat similar pattern of accuracy over time in that his rising accuracy was relatively stable through the seventh exposure session while afterwards it was characterized by inconsistency (*M* = 46%, *Range* = 32% - 66%). Child 49 showed a higher third person singular accuracy compared to his average pre-exposure accuracy for 9 out of 12 exposure sessions. Child 49 had a positive difference between his post-exposure session accuracy and pre-exposure accuracy (i.e., 25%) also indicating improvement on his use of the third person singular finiteness marker.

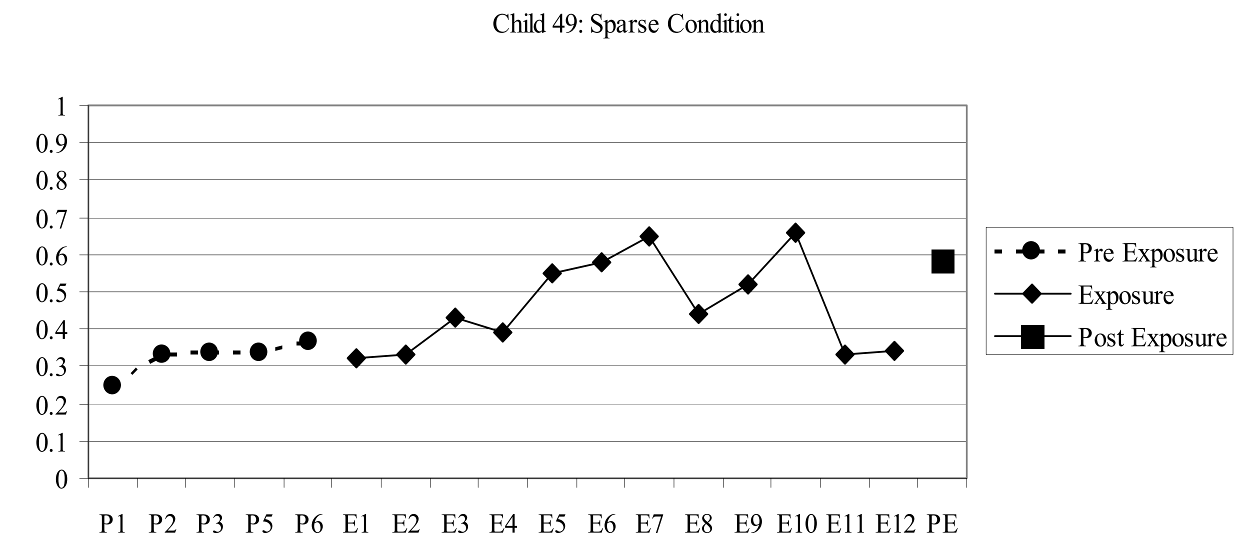

Figure 9. Accuracy Data for Sparse Verbs Presented during Exposure for Child 49

Figure 10 shows the exposure session accuracy for Child 54. Child 54 showed a relatively stable rising pattern of accuracy for the first four sessions. After the fourth session his accuracy was characterized by a series of rises and falls indicating inconsistency (*M* = 63%, *Range* = 30% to 79%). However, even though Child 54 was inconsistent in his third person singular accuracy across the sessions, he showed higher third person singular accuracy compared to his average pre-exposure accuracy for 11 out of 12 exposure sessions. Consistent with Child 45 and Child 49, Child 54 showed a positive difference in his third person singular accuracy from the pre- to post-exposure time point (i.e., 42% increase).

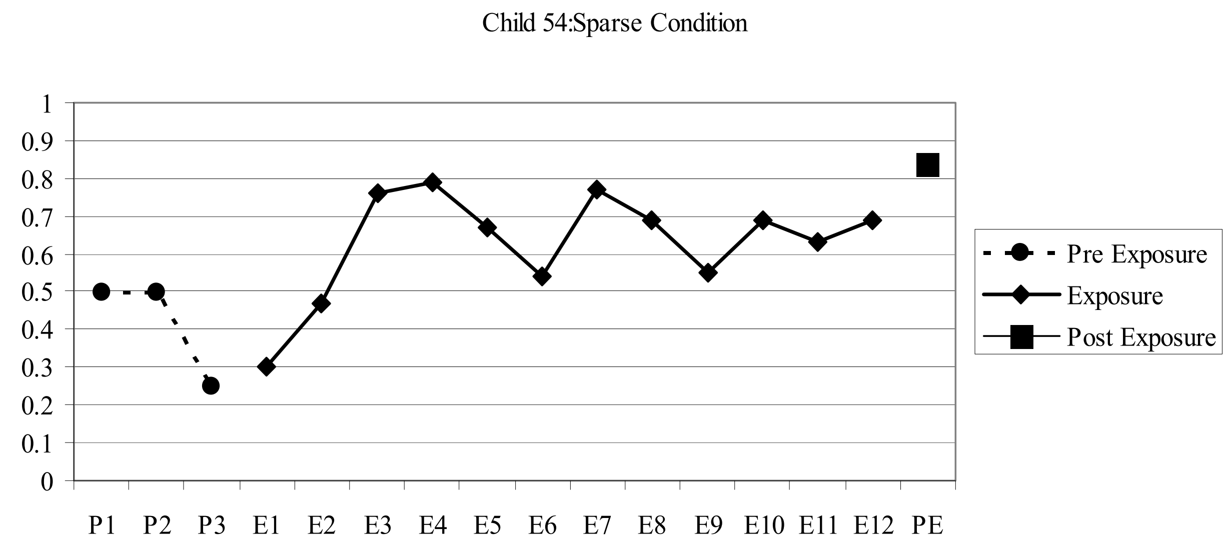

Figure 10. Accuracy Data for Sparse Verbs Presented during Exposure for Child 54

Table 5 shows a summary of the exposure session data for all six children. For children in the dense condition, the average number of sessions where accuracy was higher than the average pre-exposure accuracy was 3.7, with a range of 0 to 6 sessions. The average amount of pre-post change for the dense condition was -3%, ranging from -19% to 21%. For children in the sparse condition, accuracy during the exposure sessions was higher than the accuracy during the pre-exposure phase for an average of 10.7 sessions, ranging from 9 to 12 sessions. The average amount of pre-post change for the sparse condition was 38.3%, with a range of 25% to 48%. Exposure to sparse verbs appeared to improve the production of third person singular finiteness marker more than exposure to dense verbs.

Table 5

Exposure Accuracy Summary across Conditions

	[1]Dense Exposure	[1]Sparse Exposure	[2]Dense Exposure	[2]Sparse Exposure
	Exposure % > Pre Exposure %	Exposure % > Pre Exposure %	Pre/Post % Difference	Pre/Post % Difference
Child 47	0		-19%	
Child 48	6		-3%	
Child 53	5		21%	
Child 45		12		48%
Child 49		9		25%
Child 54		11		42%
Mean	3.7	10.7	-3%	38.3%
Range	0 - 6	9 - 12	-19% - 21%	25% - 48%

Note: [1] Refers to the number of exposure sessions where accuracy was higher than the average pre-exposure accuracy; [2] Refers to difference between the average pre-exposure third person singular accuracy and the average post-exposure accuracy for exposed verbs.

Production of Third Person Singular in Un-Exposed Verbs

A second measure of learning that was examined for Study 2 was the difference in pre- versus post-exposure third person singular accuracy on the Study 1 production tasks (i.e., sentence imitation and spontaneous elicitation). The purpose of this comparison was to determine whether the exposure conditions resulted in improvement for third person singular with dense and sparse verbs that were not explicitly presented during the exposure sessions (i.e., generalization to un-exposed items). Differences in pre- versus post-exposure accuracy for the Study 1 production tasks were first collapsed across task (i.e., the average of sentence imitation and spontaneous elicitation) and then compared for children in the dense and sparse exposure conditions. Accuracy was collapsed across the Study 1 production tasks because the interaction between these tasks and neighborhood density was not significant for children with SLI in Study 1. In fact, there was no difference at all between dense and sparse verbs on either of these tasks in Study 1 for children with SLI.

Changes in the production of the third person singular finiteness marker from the pre-exposure phase to the post-exposure point were calculated for Study 1. Change was calculated by subtracting the average third person singular accuracy on the Study 1 verbs during the pre-exposure period from the post-exposure third person singular accuracy on the Study 1 verbs. Change was calculated in this way for verbs that were in the same neighborhood density condition as the verbs presented during exposure (i.e., within density generalization) and for verbs that were in the opposite neighborhood density condition as the exposure verbs (i.e., across density generalization). These two calculations provided a way to examine the extent of generalization of the third person singular structure to new verbs that were similar (i.e., within-density) to the exposure verbs and to new verbs that differed from those presented during the exposure condition (i.e., across-density).

Figure 11 shows the within- and across-density generalization data for the three children in the dense condition. For within-density generalization (i.e., change in un-exposed dense verbs), Child 47, represented by the first black bar, showed a 10% pre-post exposure change. Child 48, represented by the first striped bar, showed an 11% pre-post exposure change and Child 53, represented by the first light gray bar, showed a -2% pre-post exposure change. The pattern of across-density generalization (i.e., change in un-exposed sparse verbs) was similar with Child 47, represented by the second black bar, showing a 14% pre-post exposure change. Child 48, represented by the second striped bar, showed a 4% pre-post exposure change and Child 53, represented by the second light gray bar, showed a -4% pre-post exposure change. Each child in the dense condition showed a similar amount of within- and across-density generalization.

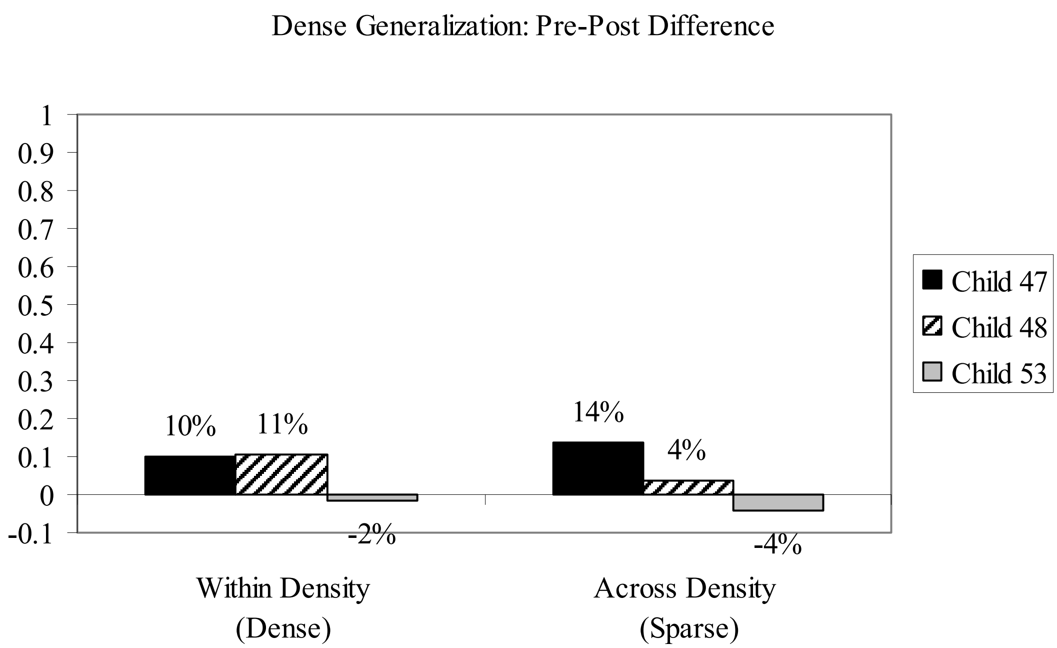

Figure 11. Within- and Across- Neighborhood Density Generalization for the Dense Condition

Figure 12 shows the within- and across-density generalization data for the three children in the sparse condition. For within-density generalization (i.e., change in un-exposed sparse verbs), Child 45, represented by the first black bar, showed an 11% pre-post exposure change. Child 49, represented by the first striped bar, showed a 43% pre-post exposure change and Child 54, represented by the first light gray bar, showed a 3% pre-post exposure change. The pattern of across-density generalization (i.e., change in un-exposed dense verbs) was similar with Child 45, represented by the second black bar, showing a 16% pre-post exposure change. Child 49, represented by the second striped bar, showed a 45% pre-post exposure change and Child 54, represented by the second light gray bar, showed a 22% pre-post exposure change. The amount of within- and across-density generalization was similar for Child 45 and Child 49, but Child 54 showed greater across-density generalization compared to within-density generalization.

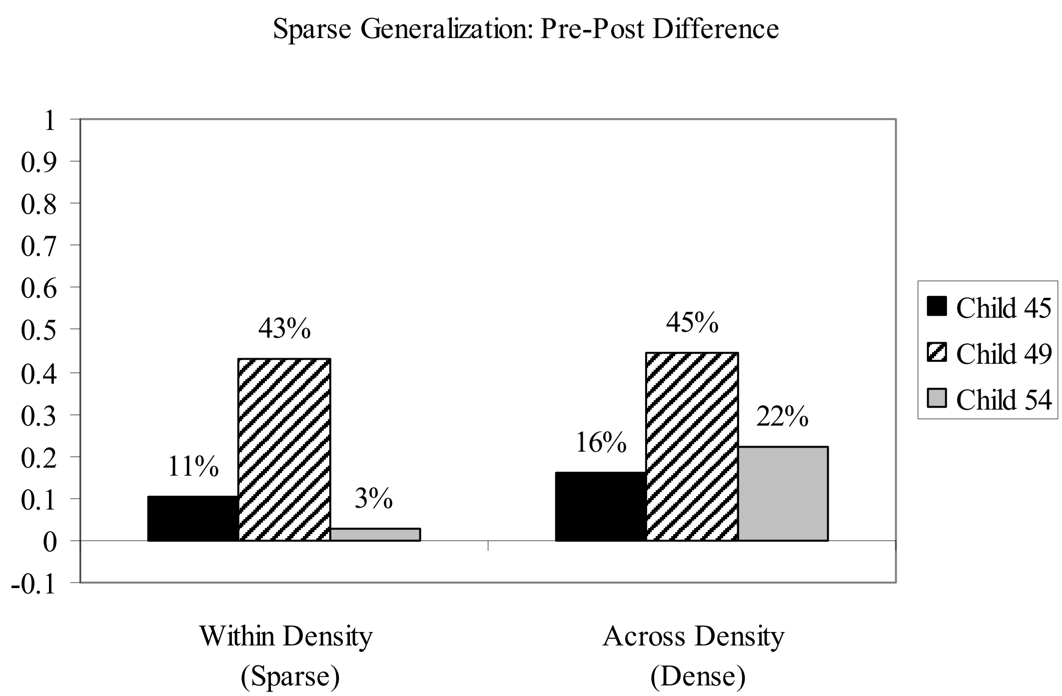

Figure 12. Within- and Across- Neighborhood Density Generalization for the Sparse Condition

Comparing across the dense and sparse conditions, all children appeared to make a relatively equivalent amount of within- and across-density change. However, the sparse condition showed a larger average within- density pre-post exposure difference (Mean difference = 19%, Range: 3% to 43%) compared to the dense condition (Mean difference = 6%, Range: -2% to 11%), but the ranges overlapped showing variability. On the other hand, the average across- density pre-post exposure difference for the sparse condition was larger (Mean difference = 28%, Range: 16% to 45%) than the dense condition (Mean difference = 4%, Range: 16% to

45%), but the ranges did not overlap. The within- and across-density generalization data agree with the exposure data in that the sparse condition seemed to result in greater pre-post exposure third person singular change.

Neighborhood Density Effect Post-Exposure

The results of Study1 showed that third person singular accuracy for children with SLI was not affected by the neighborhood density of the verb (i.e., dense versus sparse), yet there was a dense advantage for typically developing children. Since children who participated in Study 2 were given repeated exposure and practice with the third person singular structure, one question might be whether or not they began to perform similarly to younger typically developing children by showing a neighborhood density effect with third person singular production being more accurate for dense rather than sparse verbs. This question was addressed by comparing performance across dense and sparse verbs for the Study 1 production tasks at the end of the controlled exposure period.

Figure 13 shows the differences in dense and sparse verbs for the sentence imitation task (Dense: *M* = 59%, *SD* = 21%, *SEM* = 12%; Sparse: *M* = 52%, *SD* = 7%, *SEM* = 4%) and spontaneous elicitation task (Dense: *M* = 30%, *SD* = 27%, *SEM* = 16%; Sparse: *M* = 31%, *SD* = 27%, *SEM* = 16%) for the three children in the dense condition. Figure 14 shows the differences in dense and sparse verbs for sentence imitation task (Dense: *M* = 69%, *SD* = 18%, *SEM* = 10%; Sparse: *M* = 67%, *SD* = 14%, *SEM* = 8%) and spontaneous elicitation task (Dense: *M* = 53%, *SD* = 22%, *SEM* = 12%; Sparse: *M* = 46%, *SD* = 43%, *SEM* = 25%) for the three children in the sparse condition. For the children who participated in the dense and sparse controlled exposure conditions, there did not appear to be a consistently higher third person singular accuracy for dense compared to sparse verbs in either of the two production tasks following the exposure period. The completely overlapping error bars for dense and sparse verbs in both tasks confirm this and also indicate variability across children with each condition. In other words, it did not appear to be the case that the children in either of the exposure conditions began to perform more like their younger typically peers by showing a clear neighborhood density effect for the Study 1 production tasks.

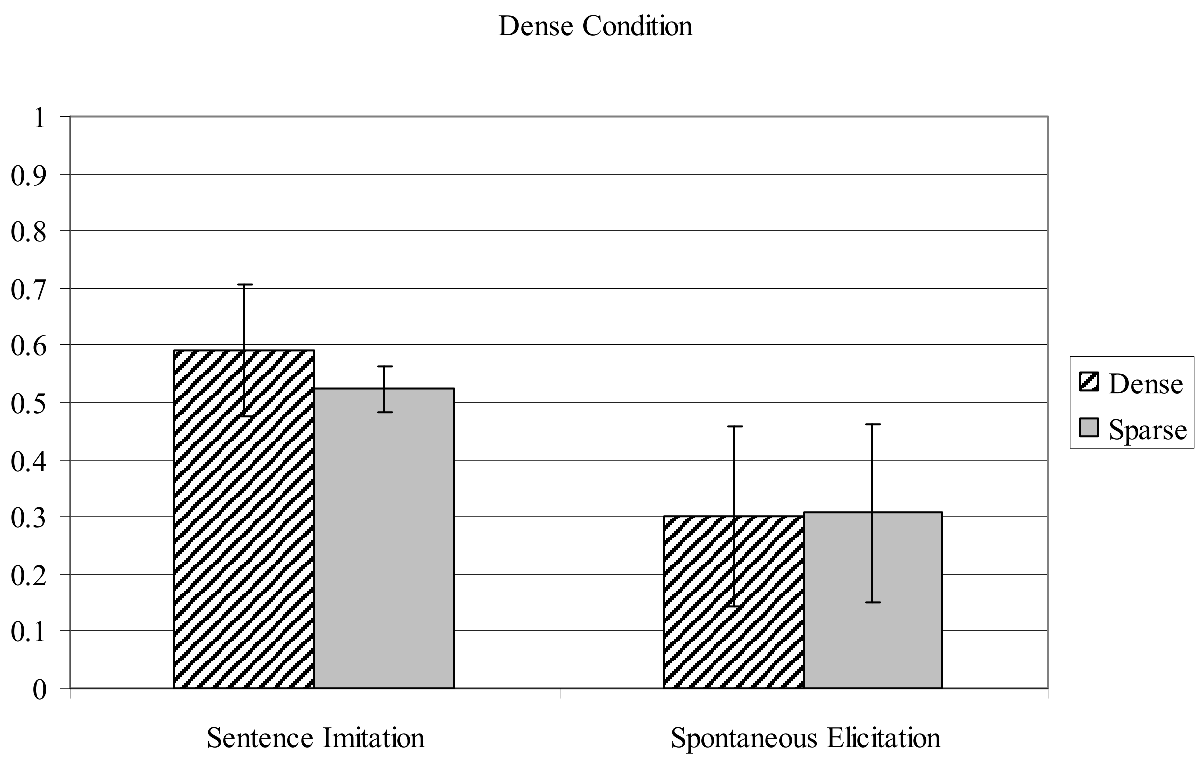

Figure 13. Dense versus Sparse Accuracy for Study 1 Tasks Post-Exposure for the Dense Condition

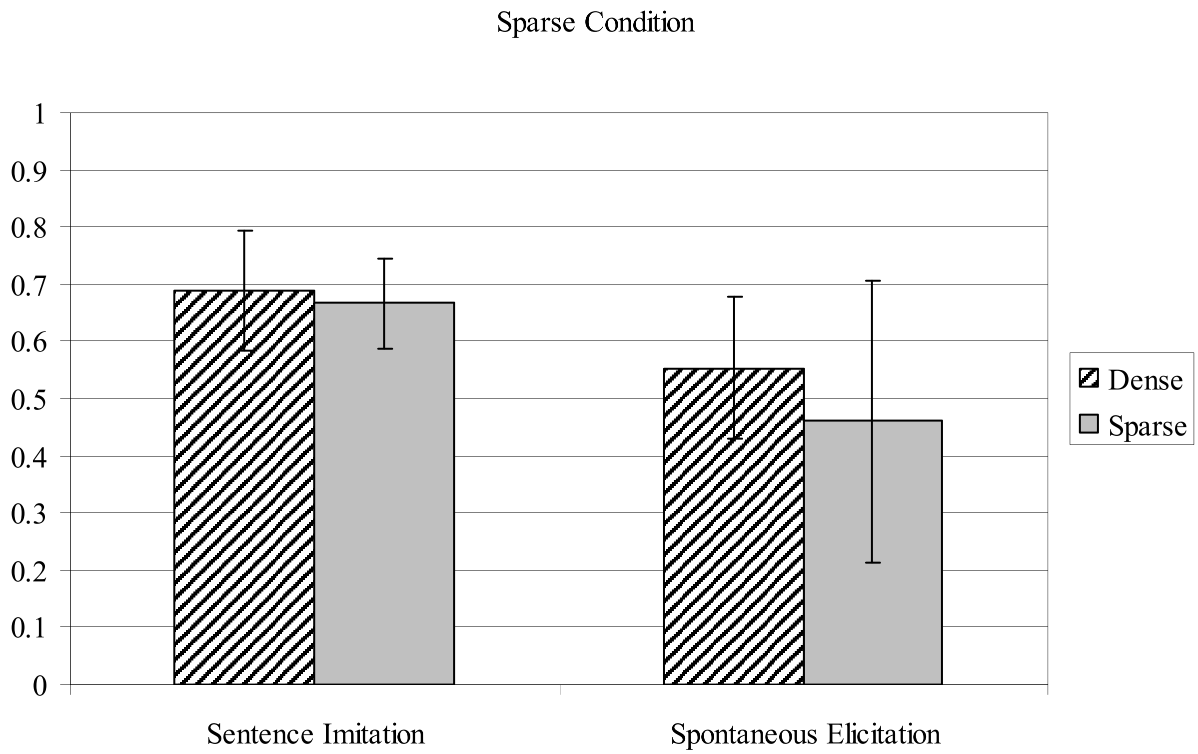

Figure 14. Dense versus Sparse Accuracy for Study 1 Tasks Post-Exposure for the Sparse Condition

Post-Exposure TEGI Scores

After the 12th exposure session, all children completed the TEGI and the pre-post difference scores for all four probes and the elicited grammar composite were compared across the dense and sparse conditions. As shown in Table 6, these differences were quite modest for both conditions. Both conditions showed the greatest pre-post difference on the third person singular probe (Dense: 10%; Sparse: 15%) with no pre-post difference on the DO probe. Children in the Dense condition showed a 7% pre-post difference on the BE probe, a 1% difference on the past tense probe and the pre-post difference of their elicited grammar composite was 4%. Children in the Sparse condition showed an 11% pre-post exposure difference on the past tense probe, a 3% difference on the BE probe and the pre-post difference of their elicited grammar composite was 7%. The pre-post differences for the third person singular probe, past tense probe, and elicited grammar composite were higher for children in the sparse condition compared to children in the dense condition. However, these differences were not as striking as the pre-post differences for the exposure and generalization data.

Table 6

Pre-Post Exposure Difference Scores for the TEGI

	Dense Pre/Post TEGI Difference	Sparse Pre/Post TEGI Difference
3rd Sing.	10%	15%
Past	1%	11%
BE	7%	3%
DO	0%	0%
Grammar Composite	4%	7%

Chapter IV: General Discussion

This research explored the lexicon-finiteness interface during the Extended/Optional Infinitive (EOI/OI) stage of language development for 4- and 5-year olds with SLI and younger typically developing children. The goal of Study 1 was to examine the interface for current finiteness *production* abilities in children with SLI and their typically developing peers. The research question was: *Does the neighborhood density of a verb affect the inconsistent omission of a finiteness marker by children in the EOI/OI stage*? The results indicated that neighborhood density contributed to optional finiteness marking for typically developing children, but not for children with SLI. The goal of Study 2 was to examine the lexicon-finiteness interface, but as it relates to *growth* for children with SLI. The research question was: *Does manipulating the neighborhood density of a verb presented in a finite clause during a controlled exposure task result in different rates of growth for the production of third person singular over time?* The results offered preliminary evidence that neighborhood density differentially impacts the amount and type of growth for the third person singular finiteness marker during a controlled exposure learning task.

Study 1: Lexical Representations and Production

Study 1 tested the hypothesis that lexical representations, indexed by neighborhood density, are one factor that contributes to optional omission of finiteness markers (i.e., third person singular). The results showed that children in the TD group were significantly more likely to make omission errors on sparse compared to dense verbs in two different production tasks. On the other hand, neighborhood density did not have a similar impact on production for the SLI group. In particular, children with SLI made an equal number of third person singular omission errors on dense and sparse verbs in both production tasks.

Omission errors by TD children. The neighborhood density effect observed in Study 1 points to an interaction between different types of linguistic representations (i.e., lexical and finiteness) where the completeness of representations affects performance. Specifically, the representation of dense verbs (i.e., segmentally detailed and complete) appears to converge with the representation of finiteness to promote a favorable context for using the third person singular structure. If a representation of a word is to influence the production of a finiteness marker, why would the *lexical* representation matter? To realize finiteness in a main declarative sentence, the child must apply tense and agreement features to the representation of a verb. In English, using the finite form of the verb in a main declarative sentence is obligatory (e.g., plays, runs, sleeps). Children in the OI stage do not seem to know that using the finite form of the verb in this context is obligatory and this is illustrated by their occasional use of the nonfinite form (e.g., she play). Despite the lack of negative evidence from adults in response to children's optional infinitives, children in the OI stage carry on with this pattern until around the age of 4 years when finiteness emerges as obligatory in their grammar. This pattern suggests that the adult state is achieved through the process of maturation, or a biologically driven mechanism (e.g., Guasti, 2002; Wexler, 2003). In terms of how this stage interfaces with the lexicon to facilitate correct productions, the level of linguistic analysis required to apply tense and agreement features to the representation might be less difficult when a root form of the verb already has a complete representation. Dense words are hypothesized to have complete representations based on children's ability to make more segmentally detailed similarity judgments and their ability to better manipulate smaller word parts in phonological awareness tasks compared to sparse words (De Cara & Goswami, 2003; Storkel, 2002).

For young children in the OI stage, the representation of finiteness is incomplete, or emerging, as indexed by optional omission errors. If different representations interact during the OI stage, an expected prediction would be poorer performance for the interaction between two representations that are incomplete (i.e., finiteness during the OI stage with a sparse verb). On the other hand, when the interaction involves two representations and one of them is complete (i.e., finiteness marking during the OI stage for dense words), better performance is expected. This was the case for Study 1; when the incomplete representation of finiteness converged with incomplete lexical representations (i.e., sparse words) performance was more likely to falter. In this way, representations of dense words seem to serve as a bootstrap into finiteness marking where dense verbs facilitate the addition of tense and agreement features to a verb in a main declarative sentence. Importantly, a complete representation of a word entails more than just a complete lexical representation, but when all other factors are held constant as they were in this study, the word with the more complete *lexical* representation allowed children to narrow in on finiteness. Additionally, one might expect that finiteness would be supported as other elements of the word's representation stabilize (e.g., semantic representation, phonological representation). Future studies testing the influence of other aspects of a word's representation would likely flesh out this relationship.

Working memory is an alternative explanation for the benefits gained from dense words during language production tasks for children in the TD group. Dense words and nonwords are repeated more accurately than sparse words and nonwords during working memory tasks and for that reason they are thought to be easier to hold in working memory than sparse words (Roodenrys & Hinton, 2002; Thomson et al., 2005; Thorn & Frankish, 2005). Roodenrys and Hinton (2002) concluded that stored lexical representations in long term memory affect the reconstruction of the word form (i.e., real word or nonword) during repetition. Since dense real words and nonwords are phonologically similar to many other stored lexical representations and since stored dense representations are more segmentally detailed, the reconstruction process is better supported for dense real words and nonwords compared to sparse.

The Study 1 results can also be explained under the framework proposed by Roodenrys and Hinton (2002). Specifically, both Study 1 tasks required children to listen to a target verb embedded in a sentence, hold it in working memory and immediately repeat it while realizing finiteness. Not only was reconstruction of the verb form required, but also the application of morphosyntactic rules for using the third person singular finiteness marker. If the support that dense words receive during the reconstruction process persists further to the interface of those words with other aspects of language production, the third person singular finiteness marker would be affected and supported. Specifically, children were able to rely more on their knowledge of finiteness because the reconstruction of the verb form was better supported. This explanation hypothesizes that finiteness marking might be improved when working memory demands are low for children in the OI stage. This explanation does not assume finiteness marking requires in-tact working memory ability. It suggests that working memory (i.e., the process of reconstructing and repeating a verb form) might be one contributing factor to omission errors in these particular production tasks. This explanation is speculative and requires testing in a study designed to address working memory performance. An additional test of this hypothesis would examine finiteness in tasks not requiring the child to use a specific target verb (e.g., tasks where scoring is not tied to a specific verb).

Omission errors by children with SLI. While children in the TD group made fewer omission errors for dense verbs, there was no difference between dense and sparse verbs for children with SLI. Given that neighborhood density effects are so widely documented in typically developing children and adults it is somewhat surprising that children with SLI in this study were not affected by density (e.g., Coady & Aslin, 2003; De Cara & Goswami, 2003; Garlock et al., 2001; Luce & Pisoni, 1998; Storkel, 2004a; Storkel, Armbruster, & Hogan, 2006). One reason for the lack of a neighborhood density effect in this group is that young children with SLI are not able to harness the normal benefits gained from the organization of the lexicon. Recall that a host of lexical abilities (e.g., word learning, word retention, naming) are challenging for preschoolers with SLI (e.g., Dollaghan, 1987; Eyer et al., 2002; Gray, 2003; Lahey & Edwards, 1996; Lahey & Edwards, 1999). An additional area of vulnerability might very well be the degree to which dense and sparse neighborhoods are able to support language processing, especially finiteness marking. Specifically, if the organization of the lexicon is somehow different for children with SLI (e.g., overall size of dense and sparse neighborhoods) normal benefits might not be available. It could be the case that a minimum threshold of “denseness” is required for lexical representations to support finiteness production and the children in this study might not have met that threshold yet. In fact, it has been argued that early in development phonological neighborhoods are sparsely populated and that only with development do they become more densely populated; with this development representations become more detailed (Charles-Luce & Luce, 1990, 1995). If the children with SLI in this study had relatively smaller dense neighborhoods than typically developing children, neighborhood density effects would not be expected.

A related explanation for the lack of density effects in Study 1 is that children with SLI can eventually harness the benefits gained from the lexicon in various language processing tasks. In fact, the only other known study examining neighborhood density in school-age children with

SLI supports this explanation (Mainela-Arnold et al., 2008). In this study, real words differing in neighborhood density and word frequency were presented to children between the ages of 8;5 and 12;3 in a gating task. Gating tasks present small increments of a word to a child until the child correctly identifies the target word. The point at which the child correctly recognizes the word is then measured. Performance on this task interacted with neighborhood density and word frequency, but not with group. Specifically, word recognition was supported by high frequency words that also had sparse neighborhoods and by low frequency words that also had dense neighborhoods. This study showed that older children with SLI can show neighborhood density effects, which supports the idea that effects could be tied to the overall denseness of similarity neighborhoods in preschoolers with SLI (Charles-Luce & Luce, 1990, 1995). While the pattern of density and frequency effects did not differ between groups, children with SLI took longer to show the neighborhood density effect. Another possibility is neighborhood density effects are not necessarily tied to development, but instead might reflect the need for children with SLI to experience repeated exposures to perform similarly to typically developing peers (Rice et al., 1994). If this is the case, the Study 1 tasks would be not ideal for invoking a neighborhood density effect since they only provided one exposure per verb.

Since Mainela-Arnold et al. (2008) examined neighborhood density effects on word recognition another possibility is that neighborhood density benefits are circumscribed to tasks that are purely lexical in nature (e.g., a gating task), as opposed to the tasks in this study that also relied on finiteness marking abilities. Specifically, lexical representations, invoked by manipulating neighborhood density, might not interact with the representation of finiteness for children with SLI. One reason that representations might not interact for children with SLI is that the particular vulnerability in finiteness marking is resistant to support from lexical representations. The same constraints described above regarding the nature of finiteness during the OI stage apply to children with SLI in the EOI stage. However, children with SLI take even longer to learn that adding tense features to a verb representation is required in main declarative sentences and they omit tense features to an even greater extent than children in the OI stage. Even though both groups of children were in the EOI/OI stage, the TD group was on a normal trajectory to mastering finiteness. Even after restricting the Study 1 analysis to a group of children with SLI who were more closely matched in third person singular accuracy to the TD group, neighborhood density effects were still not observed. This refutes the possibility that neighborhood density effects are related to overall accuracy. The results of the sub-analysis showed that neighborhood density effects on finiteness appear to be driven by the presence of language impairment.

Incomplete lexical representations emerged as a potential limiting factor in finiteness marking for children in the TD group. Nevertheless, they did not prove to be a limiting factor for children with SLI. This leaves the potential for other limiting factors to be considered for optional omission errors in children with SLI. A recent study identified a phonological factor that seems to limit finiteness marking for children in the EOI stage. Leonard, Davis, and Deevy (2007) examined the effect of phonotactic probability (i.e., the likelihood of occurrence of individual sounds and sound sequences) on past tense production with novel verbs by preschool children with SLI and younger typically developing children. They found that all children were more likely to make past tense omissions when the novel word consisted of rare sound sequences, as opposed to common sound sequences. In other words, children with SLI who already had a difficult time with the past tense structure to begin with had even more difficulty with the structure when the root verb consisted of rare sound sequences (Leonard, Davis, &

Deevy, 2007). Likewise, a study including typically developing children in the OI stage showed that third person singular omission errors were even greater when the verb used had a phonologically complex ending (e.g., drives, eats), as opposed to a phonologically simple word ending(e.g., blows, cries). Both of these potential limiting factors were examined in children in the OI stage, similar to the children in this study. Finally, recall that Mainela-Arnold et al. (2008) found the effect of neighborhood density on word recognition to interact with word frequency. Phonotactic probability and syllable structure were balanced across the dense and sparse conditions in this study and so was word frequency. Therefore, it seems more likely that other limiting factors, besides neighborhood density alone, contribute to finiteness as opposed to the idea that finiteness does not interface with other language areas. If any of these factors had been manipulated across the dense and sparse conditions, they may have emerged as the limiting factor for children with SLI in this study. Future studies addressing limiting factors in finiteness might need to consider how multiple factors interface to especially support or hinder production.

Study 2: Lexical Representations and Growth

Study 2 provides evidence that lexical representations play a role in *growth* in finiteness for children with SLI. The results from this study showed preliminary evidence that receiving concentrated and controlled exposure to the third person singular finiteness marker with sparse verbs might be more favorable than receiving exposures with dense verbs. Why would the sparse condition emerge as favorable for triggering growth in a finiteness marker? One goal of the repeated exposure learning task was for the child to begin to transition out of overusing the nonfinite form (e.g., *she walk to the store) of verbs in the finite context (she walks to the store). To transition out of this stage, children need to begin to more consistently apply tense features to the verb representation. For children with SLI, this transition is expected to be protracted even during tasks designed to trigger growth given their particular difficulty applying tense features to verbs compared to younger typically developing peers. The transition from using the nonfinite form (i.e., tense features omitted) to the finite form (i.e., tense features applied) was more acceptable for sparse words which have less segmentally detailed representations. Normally incomplete representations are viewed as detrimental to language performance in children. Specifically, having a complete lexical representation of a word helps children make more detailed similarity judgments and manipulate smaller parts of words in phonological awareness tasks (De Cara & Goswami, 2003; Storkel, 2002). However, for this study the goal was to trigger change (i.e., consistently applying tense features to a verb in a main declarative clause), not to facilitate production. Lexical representations thus appear to influence different modalities in different ways (i.e., production versus triggering change for learning). Since sparse words have a volatile lexical representation from the start they might be more susceptible to the changes associated with finiteness marking (i.e., using the finite form versus the nonfinite form in the appropriate syntactic context). In this case, incomplete lexical representations would be the better indicator of change. Complete representations would be more resistant to the transition from nonfinite to finite uses because the representation is more entrenched in the lexicon from the start. It is important to note that this interpretation assumes children with SLI represent dense and sparse words in a similar manner to typically developing children. Based on the Study 1 results, this explanation requires additional testing to determine the precise nature of phonological neighborhoods for children with SLI. However, given that neighborhood density effects have been observed to change by context (e.g., Luce & Pisoni, 1998; Vitevitch & Luce, 1998), the Study 2 results could represent neighborhood density effects that change by context (i.e., production vs. growth) for children with SLI.

Dense words have been found to facilitate word learning and production and this is also consistent with the Study 1 results for typically developing children (De Cara & Goswami, 2003; Storkel, 2002; Thomson et al., 2005; Vitevitch, 2002b; Vitevitch & Sommers, 2003). However, recognition is better for sparse words (Garlock et al., 2001; Luce & Pisoni, 1998; Mainela-Arnold et al., 2008; Metsala, 1997). The sparse advantage observed in recognition can be applied to the sparse condition emerging as favorable in Study 2. Broadly defined, word recognition is the process by which a listener uses linguistic information to access words in the lexicon. During this process, words are accessed by matching speech input to known lexical patterns (Dollaghan, 1998). Recognition is slowed when there are multiple lexical representations activated with an auditory presentation of a word. In terms of neighborhood density, when a listener encounters a dense word, the number of activated lexical representations will be much higher than when a sparse word is encountered. This is why lexical competition effects are greater for dense words and processing is slowed. When accessing a dense word the listener must sift through several possibilities to accurately process the target word (Luce & Pisoni, 1998; Storkel & Morrisette, 2002).

How would the idea of lexical competition and word recognition be applied to Study 2 when traditional methods of tapping word recognition or comprehension were not used? Half of the exposures to the finite forms of the target verbs were spoken by the examiner, and of these auditory exposures, over half (i.e., 24 out of 36) were presented in a story context that set the stage for all of the child’s productions. Additionally, children were instructed to listen carefully to each story so that they could later talk about the story (i.e., imitation and production attempts). In this way, essentially half of each exposure session required the child to listen to the target verb set presented in both finite and nonfinite contexts. In other words, children were repeatedly hearing and thinking about target words that they would later attempt to use with tense and agreement features in main declarative sentences during production tasks. During each story, two nonfinite forms of each target verb were presented in direct contrast to the finite forms (e.g., Zoe is going **to make** a snowman. First, she **makes** the body."). Nonfinite forms were also used in the production prompts for story re-call and elicited production (e.g., Look at this picture, Zoe is going **to make** the snowman's body. Now you tell me what Zoe does). Presumably each auditory exposure to the target verbs, in either the finite or nonfinite form, activated other similar lexical representations for the child. In line with models of spoken word recognition, greater competition effects were always apparent for the children in the dense condition (Luce & Pisoni, 1998). Since children were exposed to either dense or sparse verbs throughout the entire exposure period (i.e., 12 sessions), from the moment the exposure phase began, children in the sparse condition were at a processing advantage because the potential for lexical competition effects was reduced.

Word recognition alone does not account for the Study 2 results instead the interface between word recognition and repeated production practice with the third person singular structure is a more complete account of the results. Words that are less vulnerable to lexical competition effects, like sparse words, have been noted to reduce the overall linguistic processing load for children in learning tasks like those in Study 2 (Gierut, Morrisette, & Champion, 1999; Morrisette & Gierut, 2002). The accuracy score for each exposure session in Study 2 was based on only production attempts made by the child. So the sparse condition emerged as favorable because children in that condition were more successful at their production attempts. Successful production attempts involved applying tense and agreement features to a target verb in a main declarative sentence. Since each elicited production attempt was preceded by an auditory exposure of the word, the child had to retrieve and reconstruct their version of the target word form and then reconcile the context for finiteness (i.e., using tense features). When the processing load associated with retrieving and reconstructing the word form was lightened, the child was able to devote their attention to finiteness. This processing advantage likely contributed to children's success with using tense features on the verb representation. Additionally, the child was also asked to directly imitate sentences that included the target verbs already in the finite form (e.g., Say "Zoe makes a snowman"). In these instances, since it was easier to recognize sparse words, the child might have been more likely to notice that the word was also in its finite form, which might facilitate maintaining the finite form in production. This explanation is consistent with one that Morrisette and Gierut (2002) offered for explaining the differences in sound change that were influenced by the neighborhood density of words used during treatment for children with phonological delays. Specifically, Morrisette and Gierut (2002) found that treating sounds in sparse words lead to greater change than treating sounds in dense words. Morrisette and Gierut acknowledged that the initial differences in processing dense and sparse words resulting from lexical competition effects likely allowed the child to make more sophisticated linguistic analyses (i.e., correct sound production) of sparse words over time in a more efficient manner. Relevant to this study, the finer grained analyses required for correct productions were the use of the third person singular finiteness marker (i.e., applying tense features to the target verbs).

Triggering Growth in Finiteness

The results of Study 2 provide preliminary evidence that lexical organization/representations can influence change in finiteness marking for children with SLI. The goal of Study 1 was to consider whether or not there are factors related to the exposure input (i.e., neighborhood density) that can trigger observable changes (i.e., using finiteness markers). In order to determine whether this goal was achieved, two things must be considered: the amount as well as the extent of changes observed during Study 2. Determining the extent of change should help reconcile exactly what the child learned as a result of the exposure period. The following are possibilities: 1) children only learned how to use third person singular with the exposure words; 2) children only learned how to use third person singular with all words that matched their exposure condition; 3) children learned how to use third person singular with all words; 4) children learned that finiteness is obligatory and so they learned to consistently use tense features with the verb representation when it was in a main declarative sentence. These four possibilities represent a spectrum of local to widespread change.

Since the exposure period was brief (i.e., 6-weeks) it was not expected that striking widespread changes in finiteness marking would be observed. This was confirmed by the modest pre-post difference in TEGI scores. However, improvement in third person singular was not restricted to treated verbs nor was it restricted solely to verbs matching the neighborhood density of the exposure condition. This extent of generalization refutes the first two possibilities where learning would be restricted to either treated verbs or to a particular neighborhood density condition. Refuting the first two possibilities indicates that all children generalized some of what they learned about the obligatory nature of the third person singular structure during the exposure period to other verbs (i.e., that the third person singular tense feature needs to be applied in certain contexts). However, the amount of generalization for children in the sparse condition seemed more apparent even though the overall amount of change was small. As discussed above, presenting the third person singular structure with sparse words might have made the obligatory property of finiteness on a verb in a main declarative sentence more obvious as a result of reduced lexical competition. On the other hand, repeated practice with less stable representations that were more amendable to syntactic change might have triggered more consistent use of third person singular tense features with other verbs. The results from Study 2 are encouraging in that they motivate a more intensive version of the study (i.e., more exposure sessions for a longer period of time). A more intense version of the study would determine if the effect of the sparse condition observed here can be replicated across a larger group of children, including no treatment controls, and whether or not learning can eventually extend to other finiteness markers.

Neighborhood Density Effects for Children with SLI

A final point of discussion is to reconcile the difference in neighborhood density effects observed across Study 1 and Study 2 for children with SLI. Children with SLI in Study 1 did not show differences in their use of third person singular finiteness marking for dense and sparse verbs. In this way, the fact that an exposure condition in Study 2 emerged as favorable is surprising. Why would the same children who showed no difference for dense and sparse verbs in Study 1 be influenced by neighborhood density in Study 2? The differences in the Study 1 and Study 2 designs help to narrow the field of possible explanations for the lack of a neighborhood density effect in Study 1.

After considering the sparse advantage in Study 2, two explanations seem to be most promising. The first explanation offered for Study 1 that seems promising is that density effects on finiteness marking vary by modality for children with SLI (i.e., production versus growth). This explanation follows the idea that neighborhood density exerts different effects on production versus word recognition in children in adults (Luce & Pisoni, 1998). Specifically, a dense advantage is observed in production (De Cara & Goswami, 2003; Roodenrys et al., 2002; Thorn & Frankish, 2005; Vitevitch, 2002b) while a sparse advantage is observed for word recognition (Garlock et al., 2001; Mainela-Arnold et al., 2008; Vitevitch, 2002a). The second equally promising explanation is that children with SLI are able to eventually show a neighborhood density effect, but that the study 1 tasks were insufficient in tapping that effect. Specifically, children with SLI are known to require additional exposures to learn new words (Rice et al., 1994), and although older children with SLI showed a sparse advantage in a word recognition study, they required more time to show the advantage compared to typically developing children (Mainela-Arnold et al., 2008). Study 1 and Study 2 tapped different language processes (i.e., production versus learning). Repeated exposures (i.e., 144 exposures to each verb over the course of 12 sessions) were built into the context of Study 2 whereas Study 1 only offered two exposures per target word (i.e., 1 exposure per production task). The differences between Study 1 and Study 2 might be best reconciled through a combination of these two explanations. Specifically, neighborhood density effects on finiteness marking for children with SLI are dependent on modality (i.e., production versus learning) and exposure (i.e., single versus repeated).

Summary and Conclusions

The combined results of Study1 and Study 2 support a general model of language development where different types of linguistic representations converge to influence one another for production and learning. This research considered the lexicon as a potential limiting factor in children's production of a finiteness marker during the EOI/OI stage. In Study 1 lexical representations appeared to converge with the incomplete representation of finiteness to support correct productions for typically developing children. The effect of the lexical representations on finiteness production tasks was less clear for children with SLI. Specifically, children with SLI did not show the same convergence of lexical representations and finiteness in Study 1.

Neighborhood density did not appear to support or suppress omission errors. The combined results of Study 1 and Study 2 show that the lexicon-finiteness interface might differ by language modality (i.e., production versus learning) for children with SLI. Specifically, neighborhood density effects might only be observed in certain contexts (e.g., learning) or only with repeated exposures. The results also indicate that the lexicon finiteness interface might be different altogether for children with SLI. Specifically, children with SLI might not be able to harness the lexicon during certain language tasks compared to typically developing children. Future studies will continue to hone in on the precise limiting factors involved in finiteness abilities for children with SLI in order to further characterize the nature of their linguistic limitations. The results of Study 2 showed that manipulating neighborhood density during repeated exposure to the third person singular finiteness marker resulted in different amounts of change in finiteness following an exposure period. The results of Study 2 provide preliminary evidence that manipulating the properties of the linguistic input to the child might result in observable changes in learning. Specifically, certain words appear to be more amenable to change than others with repeated exposure. These studies motivate a series of investigations aimed at identifying the precise role of the lexicon and other linguistic factors in grammatical development for children with normal language development and for children with SLI. Understanding the precise factors that might limit finiteness will be needed to plan future intervention studies for children with SLI.

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Appendix A

Characteristics of the Verb Stimuli for Study 1

Dense Condition

Verbs	# of Phon.	# of Neigh.	Segment Avg.	Biphone Avg.	Log Freq.	Syll. Shape	Argument Struc.	Final sound
Bite	3	26	.06	.0033	3.0	CVC	Transitive	s
Hide	3	21	.05	.0037	3.05	CVC	Intransitive	z
Kick	3	21	.08	.0079	3.34	CVC	Transitive	s
Ride	3	20	.05	.0032	3.95	CVC	Transitive	z
Read	3	19	.05	.0036	3.2	CVC	Transitive	s
Shake	3	16	.04	.0034	2.75	CVC	Transitive	s
Poke	3	14	.06	.0035	2	CVC	Transitive	s
Hug	3	14	.04	.0034	2.18	CVC	Transitive	z
Hold	4	12	.06	.0057	3.62	CVCC	Transitive	z
Slip	4	11	.06	.0047	2.56	CCVC	Intransitive	s
Break	4	10	.06	.0078	3.52	CCVC	Transitive	s
Spill	4	10	.05	.0048	2.9	CCVC	Transitive	z
Stack	4	10	.06	.0104	2.04	CCVC	Transitive	s
Sleep	4	7	.06	.004	3.51	CCVC	Intransitive	s
Slide	4	7	.06	.0038	3.1	CCVC	Intransitive	s

Sparse Condition

Verbs	# of Phon.	# of Neigh.	Segment Avg.	Biphone Avg.	Log Freq.	Syll. Shape	Argument Struc.	Final Sound
Walk	3	12	.04	.0039	4.01	CVC	Intransitive	s
Dig	3	12	.06	.0073	2.76	CVC	Transitive	z
Hop	3	12	.05	.004	2.51	CVC	Intransitive	s
Cook	3	11	.05	.0024	3.02	CVC	Transitive	s
Wipe	3	10	.04	.0021	2.91	CVC	Transitive	s
Knock	3	8	.05	.0038	3.1	CVC	Intransitive	s
Move	3	5	.03	.0014	3.43	CVC	Transitive	z
Build	4	5	.08	.0087	3.54	CVCC	Transitive	z
Taste	4	4	.06	.0093	2.41	CVCC	Transitive	s
Clean	4	5	.05	.0042	3.8	CCVC	Transitive	z
Swim	4	5	.05	.0038	3.07	CCVC	Intransitive	z
Crawl	4	4	.05	.0049	2.18	CCVC	Intransitive	z
Climb	4	3	.04	.0037	3	CCVC	Intransitive	z
Drop	4	1	.05	.0045	2.94	CCVC	Transitive	s
Scoop	4	5	.05	.0052	Missing	CCVC	Transitive	s

Appendix B

Characteristics of the Sentence Stimuli for Study 1

Dense Condition

Sentence	# of Words	# of Morphs.	# of Syll.
The woman pokes the bubble	5	6	7
The boy hides behind the tree	6	7	7
The boy bites the cookie	5	6	6
The dog sleeps under the bed	6	7	7
The girl rides the horse	5	6	5
The man breaks the dish	5	6	5
The man slides on the floor	6	7	6
The man spills the water	5	6	6
The woman kicks the ball	5	6	6
The woman holds the food	5	6	6
The teacher reads a story	5	6	7
The teacher slips in the hole	6	7	7
The girl hugs the doll	5	6	5
The girl stacks the box	5	6	5
The boy shakes the bottle	5	6	6

Sparse Condition

Sentence	# of Words	# of Morphs.	# of Syll.
The woman moves the ball	5	6	6
The boy climbs up the tree	6	7	6
The boy walks to the park	6	7	6
The dog crawls under the bed	6	7	7
The girl drops the doll	5	6	5
The man wipes the floor	5	6	5
The man digs a hole	5	6	5
The man builds a house	5	6	5
The woman cooks the food	5	6	6
The woman swims in the water	6	7	8
The teacher knocks on the door	6	7	7
The teacher cleans the dish	5	6	6
The girl hops on the couch	6	7	6
The girl tastes the cookie	5	6	6
The boy scoops the snow	5	6	5

Appendix C

Characteristics of the Verb Stimuli for Study 2

Dense Condition

Verbs	# of Phon.	# of Neigh.	Segment Avg.	Biphone Avg.	Log Freq.	Syll. Shape	Argument Struc.	Final Sound
Make	3	20	.05	.0044	4.79	CVC	Transitive	s
Peek	3	17	.06	.003	1.95	CVC	Intransitive	s
Take	3	17	.05	.0039	4.62	CVC	Ditransitive	s
Spin	4	8	.06	.0056	2.81	CCVC	Intransitive	z
Bumps	4	8	.06	.0092	2.89	CVCC	Transitive	s
Crash	4	6	.05	.0074	2.4	CCVC	Intransitive	schwa z

Sparse Condition

Verbs	# of Phon.	# of Neigh.	Segment Avg.	Biphone Avg.	Log Freq.	Syll. Shape	Argument Structure	Final Sound
Work	3	11	.04	.0025	3.71	CVC	Intransitive	s
Laugh	3	8	.04	.0025	3.24	CVC	Intransitive	s
Fix	3	5	.07	.0077	3.63	CVCC	Transitive	schwa z
Drive	4	4	.04	.0054	3.45	CCVC	Transitive	z
Step	4	3	.06	.009	3.44	CCVC	Intransitive	s
Give	3	3	.05	.0018	4.02	CVC	Ditransitive	z

Appendix D

Characteristics of the Sentence Stimuli for Study 2

Dense Condition

Sentence	# of Words	# of Morphs.	# of Syll.
The cat peeks through the door	6	7	6
The monkey spins around the room	6	7	8
The bear takes the blanket from the boy	8	9	9
The pig crashes into the barn	6	7	8
The farmer bumps the gate	5	6	6
The bird makes a nest	5	6	5

Sparse Condition

Sentence	# of Words	# of Morphs.	# of Syll.
The cat steps on the blanket	6	7	7
The monkey drives the bus	5	6	6
The bear gives the cup to the boy	8	9	8
The pig fixes the barn	5	6	6
The farmer works on the gate	6	7	7
The bird laughs at the toy	6	7	6