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## Do Word-Level Characteristics Predict Spontaneous Finiteness Marking in Specific Language Impairment?

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Do Word-Level Characteristics Predict Spontaneous Finiteness Marking  
in Specific Language Impairment?

A Thesis Presented

by

PATRICK S. WILSON

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Approved as to style and content by:

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Jill Hoover, Committee Chair

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Gwyneth Rost, Committee Member

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Jane A. Baran, Department Chair  
Department of Communication Disorders

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## ABSTRACT

### DO WORD-LEVEL CHARACTERISTICS PREDICT SPONTANEOUS FINITENESS MARKING IN SPECIFIC LANGUAGE IMPAIRMENT?

MAY 2015

PATRICK S. WILSON, B.S., TUFTS UNIVERSITY

M.A., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Professor Jill R. Hoover

The correct use of morphological suffixes in obligatory contexts reflects linguistic knowledge and competence of speakers. Grammatical knowledge is acquired during a child's period of primary language acquisition, and may be partial or incomplete due to normal linguistic variation found during acquisition, due to a child's level of progression through typical chronological development, or due to the presence of language disorders, like specific language impairment (SLI). In the current study, we ask whether characteristics of verbs make it more or less likely that children will correctly use an inflectional morpheme. The morphemes of interest in the current study were third person singular *-s* (3S) and past tense *-ed* (ED). Data for analysis were taken from a database of spontaneous language samples collected from 40 children (20 with SLI and 20 developing typically; Hoover, Storkel, & Rice, 2012). Spontaneous language samples were analyzed for the presence or absence of each morpheme in obligatory contexts. For each word item, the uninflected base word was additionally analyzed for a number of phonological and lexical variables. After comparing children with SLI to typically developing peers group differences emerged with respect to the effect of phonological

and lexical variables. Moreover, different variables were determined to predict the 3S and ED morphemes. The results are discussed highlighting relevant theoretical and clinical implications.

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# CHAPTER 1

## INTRODUCTION

### A. Specific Language Impairment

Specific language impairment (SLI) is a developmental condition marked by significant impairment in language ability not caused by hearing loss or overall cognitive deficits (for a review, see Leonard, 2014a). This condition can be subtle in its symptoms, but it is estimated to affect as much as 7% of the population (Tomblin et al., 1997) rendering it as one of the most common developmental conditions in children (Leonard, 2014a; Rice, 2013). SLI is a lifelong developmental disorder with possible genetic etiologies (Bishop, North, & Donlan, 1995; Rice, Smith, & Gayán, 2009), and its manifestations can be highly heterogeneous in the particulars of language symptomatology (Tomblin, Records, & Zhang, 1996). What is generally seen in the SLI population is a delay in language acquisition during early childhood; children affected by SLI seem to learn language significantly more slowly than typically developing peers. Moreover, early language deficits seem to have lasting effects for individuals with SLI seen as continued lifelong academic and social struggles (Beitchman et al., 1996).

The current study focuses on the spontaneous language skills seen in SLI during the preschool years with a focus on grammatical development. The goal is to examine the spontaneous language use of preschool children with SLI, making comparisons to typically developing children in order to examine language skills still under development. This can provide information about the factors that influence emerging grammatical skills

in SLI and about how similar these patterns may be to patterns observed in typical development.

The study of SLI has both clinical and theoretical implications. In treatment of children with SLI, it is hoped that advancing knowledge of this disorder may lead to more effective methods of intervention. Certainly, within the field of communication disorders, this goal drives much of the interest into this topic. However, beyond the potential for therapeutic improvements, there is also the potential for the study of individuals with SLI to lead to a greater understanding of typical language development and use. By comparing the SLI and typically-developing (TD) populations, more can be learned about the ways in which language is uniquely impaired by single cognitive disorders, or alternately is impaired in combination with other, interrelated domains (Leonard, 2014b). In other words, the study of SLI can help to shed light on the domain specificity of language itself.

The linguistic deficits indicative of SLI in a child may vary from individual to individual, with some children with SLI, for example, showing deficits specifically in the expressive or receptive use of language (e.g., Lahey & Edwards, 1996). While a number of deficits, including linguistic (e.g. Rice, Wexler, & Cleave, 1995; Paradis, Crago, & Genesee, 2005; Schuele, Haskill, & Rispoli, 2005), nonlinguistic (e.g., Dispraldo et al., 2013; Gabriel et al., 2013; Ebert & Kohnert, 2011), and academic (Freed, Lockton, & Adams, 2012; Conti-Ramsden, St Clair, Pickles, & Durkin, 2012; Dockrell, Lindsay, & Palikara, 2011), have been noted in children with SLI, a great deal of attention has centered on understanding lexical and morphosyntactic skills in the population. When

there is a disparity in early lexical ability caused by SLI, the effects are thought to be long-lasting, even into adulthood (Mawhood, Howlin, & Ruter, 2000). Children with SLI demonstrate poorer outcomes in early literacy measures (Boudreau & Hedberg, 1999). These literacy impairments follow students with SLI into their primary school years (Catts, 1993), and early literacy skills have been shown to predict a student's later reading skills as well (Adolf, Catts, & Lee, 2010). From the developmental profile of individuals with SLI, it can be seen that early lexical impairments caused by SLI can lead to significant language deficits in later years.

## **B. Verb Finiteness**

In addition to lexical delays, the other area of linguistic development that receives a great deal of attention is finiteness. In fact, a widely agreed upon marker of SLI is a demonstrated impairment in verb morphology, specifically in the marking of verb finiteness. Finiteness morphemes are used to mark grammatical properties that convey information about a verb. This information may pertain to tense (e.g., past tense, present tense, future tense) or agreement (e.g., first person, third person, singular). In English, when a verb is used in a sentence context denoting certain tense or agreement properties it is obligatory that it receive the corresponding finiteness marker. For example, the verb in the sentence *Patrick walks* requires an inflectional morpheme (-s) to serve as a finiteness marker when it is used to describe action that takes place in the present, performed in the singular third person, i.e. by one agent who is neither the speaker nor the listener.

In English, the set of finiteness markers includes bound inflectional morphemes, free-standing verbs and morphophonological verb stem changes. The third person singular present tense (3S) is marked with the morpheme *-s* (e.g., *He likes airplanes*). Past tense is marked in one of two ways: 1) regular past tense (ED) is marked with the inflectional morpheme *-ed* (e.g., *He liked airplanes*) and 2) irregular past tense is marked by morphophonological verb stem changes (e.g., *She drove a convertible*). Some grammatical forms, in statements and questions, express finiteness using lexical items (i.e., auxiliary and copula verbs) rather than morphological affixation. For example, *do* verbs (e.g., *Does he feel the need?*), copula (e.g., *He is a Navy pilot*), and other auxiliary verb forms (e.g., *He is wearing aviator sunglasses*). The plural form of the third person (e.g., *They play beach volleyball*), however, also carries tense and agreement properties, and therefore is a finite verb, although finiteness is not overtly marked. The bare stem of a verb without inflectional morphemes is the nonfinite form. Though nonfinite verbs may appear in sentences when combined with an auxiliary verb (e.g. *He will buzz the control tower*), a nonfinite verb never forms the main verb phrase of a sentence in correct, adult English (e.g., *\*He a good pilot* and *\*He play volleyball*, both lacking finiteness markers, are ungrammatical).

An individual's knowledge of verb finiteness is reflected in his or her accuracy of use of finiteness markers in obligatory contexts syntactically appropriate inflected forms, or as the accuracy of his or her use of auxiliary and copula *be* and of auxiliary *do*. For a young child, acquisition of this knowledge is important to later syntactic development, and delays in finiteness marking may constitute an impaired morphological foundation

for more complex forms of syntax such as relative clauses, for example. Finiteness markers have clinical significance because they have been shown to be particularly difficult for children with SLI, relative to other inflectional morphemes that are not related to finiteness, like plural *-s* for example (Rice & Wexler, 1996; Goffman & Leonard, 2000). Verb finiteness is the most sensitive predictor of SLI, more so than mean length of utterance (MLU), as measured by the average number of words spoken in a single utterance, or lexical diversity, as measured by the total number of unique words produced (Rice & Wexler, 1996; Goffman & Leonard, 2000).

### **C. Optional Infinitive Development**

According to the Optional Infinitive (OI) model of typical finiteness acquisition, children with typical speech and language skills undergo a stage of linguistic development in which they utilize finiteness markers only some of the time, even in obligatory contexts (Rice et al., 1995). Furthermore, the Extended Optional Infinitive (EOI) model specifically proposes a lower rate of use in children with SLI compared to typically-developing children, and importantly a trajectory of growth that significantly lags behind typically-developing children (Rice, Wexler, & Hershberger, 1998). Specifically, for typically-developing children, this period of inconsistent finiteness marking extends until the age of about 4, whereas children with SLI are seen to demonstrate a developmental delay in this area and persist in inconsistent marking in expressive language until the age of 7 or 8 (Rice et al., 1998), and well into the adolescent years on receptive measures (Rice, Hoffman, & Wexler, 2009). This

difference in the rate of learning more complex grammatical structures is a major distinction separating children with SLI from their typical peers.

Much of the early research supporting the EOI account focused exclusively on identifying the growth rates of finiteness markers expected for typical development and children with SLI (Rice et al., 1995; Rice et al., 1998). More recently, researchers have been building on the EOI account (Hoover et al., 2012; Leonard, Davis, & Deevy, 2007; Marshall & van der Lely, 2007), and early morphological variability in general, by asking whether there are specific properties of verbs that may render them more or less likely to be inflected during this optional state. In particular, a growing body of work shows that phonological and lexical properties of verbs influence the likelihood that a child will inflect a base word with the correct morphological marker. Properties that have been identified as important include coda complexity (Polite, 2011; Song, Sundara, & Demuth, 2009), phonotactic probability (Leonard et al., 2007; Marshall & van der Lely, 2007), utterance position (Mealings & Demuth, 2014), phonological neighborhood density (Hoover et al., 2012), and word frequency (Rispen & de Bree, 2014). We will discuss the emerging evidence for each variable in the paragraphs that follow.

#### **D. Word-Level Variables**

In a two part study, Song et al. (2009) reported evidence of phonological effects on the third person singular tense marker in typically-developing (TD) children between the ages of 1;3 and 3;6 (years; months). In particular, children were more accurate producing the third person singular *-s* during spontaneous speech when words had phonologically simpler codas (e.g., vowel coda, as in *sees*) compared to complex codas

(e.g., consonant coda as in *needs*) and when the word occurred in utterance-final position (e.g., *It rubs*) compared to utterance-medial productions (e.g., *It rubs the lotion*). In a second stage of analysis, Song et al. replicated these results in an elicited imitation task. Here, children were presented with pre-recorded sentences featuring the third person singular morpheme and prompted to repeat them. The results mirrored the patterns observed in spontaneous language, with higher third person singular accuracy in words with simple syllable codas and in the utterance-final position.

This sensitivity to phonological effects of coda complexity can be distinguished further by comparing performances of TD children and children with SLI (Marshall & van der Lely, 2007). In a controlled study of the effects of base word phonological complexity on finiteness marking among children aged 9;9 to 16;3, children with SLI demonstrated greater accuracy for phonologically simpler stem endings (consonant-final), compared to more complex endings (consonant blend-final), while typically-developing controls did not show such sensitivity. It is therefore notable that findings for the effect of phonological complexity on finiteness marking in SLI are somewhat mixed. Song et al. (2009) reported that TD children were sensitive to effects of phonological coda complexity, with higher accuracy for simpler codas, while Marshall and van der Lely (2007) found that TD children were not, but children with SLI were. These conflicting data can be reconciled by comparing the ages of the TD children who were sensitive to phonological effects—ages 1;3 to 3;6 (Song et al., 2009)—to the ages of the TD children who were not sensitive to them—ages 9;9 to 16;3 (Marshall & van der Lely, 2007). A pattern of language learning emerges from these studies in which TD children

utilize knowledge of phonology at an early age to facilitate finiteness marking, but discard that strategy as they mature and no longer need cues to mark finiteness in obligatory contexts.

This interpretation is substantiated by Leonard et al. (2007), who studied both TD and SLI populations' finiteness marking and found that lower phonotactic probability of base words decreased the likelihood of correct finiteness marking by children with SLI but not by TD children. The children in this study were divided into three groups: SLI (ages 4;6 to 6;6), TD matched for age (ages 4;5 to 6;8), and TD matched for MLU (ages 2;8 to 4;1). The participants were presented with non-word verb stimuli and prompted to inflect the novel verbs using the regular past tense *-ed*. Here it is significant that children with SLI were sensitive to phonotactic probability, while typically-developing children in either TD group seemingly are not. While these findings may seem to be at odds with Song et al. (2009) it is important to note that different measures of phonological complexity were considered (i.e., coda complexity vs. phonotactic probability).

These same phonological factors might influence inflectional morphology more generally, rather than affecting finiteness markers specifically. Polite (2011) reported similar influences of phonological complexity (i.e., coda complexity) on the likelihood of children with SLI and typically-developing peers correctly producing the regular plural *-s* morpheme in obligatory noun contexts. As a result, it may be concluded that phonological cues may influence morphological structures beyond ED and 3S, and affect even morphemes that mark grammatical content other than finiteness.

A related study considered whether there are utterance-level factors that affect finiteness marking in a way that is similar to phonological complexity and phonotactic probability. Sundara, Demuth, and Kuhl (2011) found that children within the OI timeframe are more likely to accurately perceive the grammaticality of finiteness markers and to use those markers in experimental settings when the target word occurs in utterance-final position. Mealings and Demuth (2014) similarly found that children are more likely to omit the third person singular *-s* morpheme when it appears in utterance-medial position as compared to utterance-final. This study employed a structured speech repetition task in a controlled experimental setting, and included typically-developing English speakers between the ages of 2;9 and 3;2. The children repeated 3- or 5-word utterances, and were scored on the accuracy of their use of the 3S morpheme. Regardless of the utterance length, affixation of the 3S morpheme was more accurate in utterance-final position. Utterance length, on the other hand, only affected accuracy when the target word was utterance-medial.

Taken together, it can be seen that word-level effects can play some kind of role in children's finiteness marking during the (Extended) Optional Infinitive stage. Phonological complexity influences third person singular (Song et al., 2009) and regular past tense (Leonard et al., 2007; Marshall & van der Lely, 2007). At the same time, utterance-level effects (i.e., an inflected word occurring in utterance-final position) influence finiteness marking in a similar way (Sundara et al., 2011; Mealings & Demuth, 2014). Across these studies of finiteness marking, effects on typical development and SLI appear to be mixed, with some showing that factors affect one or the other.

Lexical factors (i.e., factors that describe properties of the whole word form rather than individual sound segments) have also been identified as influencing finiteness in a way that is similar to phonological complexity/phonotactic probability. For example, neighborhood density, a measure of whole-word phonological similarity, is seen to influence the accuracy of TD children in the OI stage (ages 2;11 to 3;11) in affixing finiteness markers, with denser verbs (i.e., words that are phonologically similar to many others based on a single sound substitution) being more likely to be accurately affixed with the 3S morpheme, while children with SLI (ages 4;0 to 6;1) showed no sensitivity to this lexical factor (Hoover et al., 2012).

An investigation on the influence of word frequency was performed by Rispens and de Bree (2014) on three groups of Dutch children: one group with SLI (age eight) and two groups of typically-developing children (ages five and seven). All groups' accuracy at realizing the regular past tense morpheme was assessed, and the authors found an interaction between group and token frequency. Specifically, only the seven-year old typically-developing participants were found to produce the past tense more accurately for words of higher frequency, while the children with SLI and younger typically-developing children were not affected by this variable. This is consistent with Hoover et al. (2012) who also showed that finiteness marking by children with SLI was not affected by a lexical factor. Rispens and de Bree (2014) hypothesized that the effect of word frequency may be dependent on vocabulary size possibly explaining the lack of effect for SLI. Hoover et al. (2012) offered a similar hypothesis for lexical neighborhood

density such that the quality of lexical representations in children with SLI may not be robust enough to use lexical neighborhood density to facilitate finiteness marking.

### **E. Current Study**

As reviewed above, there is an emerging body of evidence highlighting the role of phonological, lexical, and utterance-level factors in the accuracy of finiteness marking in SLI and typical development. A limitation of this research, however, is that most studies have utilized tightly controlled, experimental tasks (Marshall & van der Lely, 2007; Mealings & Demuth, 2014; Sundara et al., 2011; Leonard et al., 2007; Hoover et al., 2012). Moreover, there is wide variability in the ages that have been studied, from 1;10 (Sundara et al., 2011) to 16;8 (Marshall & van der Lely, 2007) and mixed findings for SLI compared to typical development. What is less well known, though, is 1) how these variables influence children's spontaneous language while they are in the midst of the Optional Infinitive stage, or the Extended Optional Infinitive stage in the case of children with SLI, 2) whether 3S and ED are similarly or differentially affected by word level variables, and 3) how patterns of effects for typical development compare to SLI.

These gaps in the literature motivate the need for multivariate investigation of this phenomenon using spontaneous speech. The findings of Song et al. (2009), Sundara et al. (2011), and Mealings and Demuth (2014) provide good evidence that typically-developing children are sensitive to phonological and utterance-level influences on their realization of the third person singular morpheme. However, despite these studies begging comparison between typical and clinical populations, not all have incorporated

language-impaired children in their study of variable finiteness marking. The present study aims to address these limitations.

The current study examines the phonological variables of phonotactic probability and word-final sonority, as well as the lexical and utterance-level variables of word frequency, neighborhood density, and utterance position. These variables were analyzed as predictor variables in children's spontaneous production of 3S and ED. Phonological (e.g., phonotactic probability), lexical (e.g., neighborhood density), and utterance-level (e.g. utterance finality) factors were selected out of consistency with past investigations, but the current study also incorporates sonority, which represents a measure of syllable structure complexity that is novel to the analysis of finiteness marking. Across languages, patterns of sonority within a syllable typically comply with the Sonority Sequencing Principle (SSP; Clements, 1990), which states that it is phonotactically preferred for sonority to rise towards the nucleus of a syllable, and to fall towards the margins. Thus, during the onset of a syllable there should be a rise in sonority, and during the coda there should be a fall. Other structures are marked relative to this tendency. While sonority has not been considered in the study of finiteness markers, there is evidence from children with phonological disorders showing that children are sensitive to it in their language learning (Morrisette, Farris, & Gierut, 2006).

## **F. Research Questions**

In the current study, we asked three research questions:

- 1) Do phonological variables (phonotactic probability and sonority change) and lexical variables (neighborhood density and word frequency) predict finiteness marking?
- 2) Are the third person singular *-s* and regular past tense *-ed* differentially affected by the variables?
- 3) Are typically-developing children and children with SLI differentially affected by the variables?

The relatively late acquisition of the 3S morpheme makes it particularly well-suited for the current study, as typically-developing children are observed to produce errors on this morpheme around the ages of 3 and 4 years (Brown, 1973). ED serves as an ideal second morpheme for analysis, as it is also inflectional and also acquired at that developmental age.

Based on previous, related studies, we can make the following predictions for the current study. In terms of the phonological variables, we predict both the TD and SLI groups to demonstrate reduced accuracy in phonological contexts that are more complex (Song et al., 2009; Marshall & van der Lely, 2007; Leonard et al., 2007). In the case of our variables, phonological complexity is defined as a change in sonority that violates the Sonority Sequencing Principle (Clements, 1990), and as lower phonotactic probability (i.e., rare sound sequences). Thus, it is expected that all participants will have greater accuracy for word tokens in which the process of affixation creates a fall from a more sonorous phoneme at the end of the root word to a less sonorous phoneme at the

beginning of the *-s* or *-ed* morphemes, and that they will have greater accuracy for word tokens in which measures of phonotactic probability are higher.

One area in which the TD and SLI groups might be expected to differ in performance would be word frequency and neighborhood density. Based on the work of Rispens and de Bree (2014) and Hoover et al., (2012), it is anticipated that the TD group will show a sensitivity to lexical variables while the SLI group will not. If this hypothesis is supported by the data, then children's accuracy of finiteness marking in the TD group will be higher for words that occur more frequently (Rispens & de Bree, 2014). From Hoover et al. (2012), we predict that base words from dense lexical neighborhoods will be more likely to be correctly marked for finiteness in the TD group, though not in the SLI group.

The results from the current study have a number of important implications. From a theoretical perspective, the distinct cognitive demands of propositional versus elicited speech implicate different areas of strength and weakness that cannot necessarily be observed simultaneously by a task that only calls on one. By examining variable finiteness marking in unstructured child language, we can observe how a child's understanding of finiteness develops: whether it develops individually for morphological finiteness markers or as a general linguistic skill, and whether this developmental model differs in the case of specific language impairment. A multivariate investigation of these diverse variables also offers a more naturalistic representation of the behaviors as they are functionally utilized by children, who must appropriately manage any and all phonological, word-level, and utterance-level effects, and their interactions, in free

speech. Additionally, these issues carry clinical importance because they potentially call into question the validity of SLI diagnosis in cases where a child's performance on spontaneous versus elicited tasks may differ for morphological markers that convey strong diagnostic significance.

## CHAPTER 2

### METHODS

#### A. Participants

Language samples were analyzed from 40 English-speaking children who participated in a previous study of finiteness marking and specific language impairment (Hoover, Storkel & Rice, 2012). This set of participants consisted of two groups: 20 children with specific language impairment (SLI), and 20 children with typical language development (TD). The SLI group (ages ranged from 4;0 to 6;2, average 4;10) contained 7 females and 13 males, and the TD group (ages ranged from 2;11 to 3;11, average 3;3) contained 8 females and 12 males. Parents reported that all children were monolingual speakers of Standard American English (SAE).

A complete description of the inclusion and exclusion criteria for the participants are reported elsewhere (see Hoover et al., 2012). In general, though, typically-developing children were required to perform within normal limits on standardized tests of vocabulary (Peabody Picture Vocabulary Test, 4th Edition (PPVT-4; Dunn & Dunn, 2007), grammar (Rice-Wexler Test of Early Grammatical Impairment (TEGI; Rice & Wexler, 2001), and phonology (Goldman-Fristoe Test of Articulation, 2nd Edition (GFTA-2; Goldman & Fristoe, 2000), and show age-appropriate mean length of utterances. To be included in the SLI group, children were required to perform below age expectations on expressive grammatical performance measured by the TEGI (Rice & Wexler, 2001) and mean length of utterance (Leadholm & Miller, 1992) derived from a 30-minute spontaneous language sample between the child and an examiner. In the SLI

group, performance on standardized tests of receptive vocabulary and phonology was left free to vary because, across studies on SLI, the data show heterogeneous skills in these two areas with some children exhibiting delays, and others showing performance within normal limits on these measures. All children in the TD and SLI groups were required to pass a hearing screening (American Speech-Language-Hearing Association Guidelines; ASHA, 1997) and perform within normal limits on a standardized test of nonverbal cognition (Reynolds Intellectual Assessment Scales (RIAS); Reynolds & Kamphaus, 2003).

## **B. Language Transcripts**

The data used to answer the research questions consisted of 40 spontaneous language samples that were collected as part of a prior study (Hoover et al., 2012). The samples were obtained from an interaction between one child and one examiner. Interactions lasted for 30 minutes and involved unstructured play using age-appropriate toys (e.g. household items, farm animals, toy people, vehicles). Throughout the play activity, the examiner was actively targeting the elicitation of the third person singular –s morpheme in verbs, but children also used a variety of morphological markers.

Within the transcripts, some utterances containing the target inflectional finiteness markers were excluded before conducting the statistical analysis analysis. Specifically, inflected words that occurred in partially intelligible utterances were not counted, even if the word in question was intelligible. Likewise, inflected words, even if intelligible, that occurred in utterances that were abandoned by the speaker, were also excluded for analysis. If the obligatory context for a verb marked with finiteness was ambiguous, or if

the child failed to produce a subject, these utterances were also excluded for analysis. Finally, words that occurred within verbal mazes (fragments of utterances that were abandoned and restarted by the speaker) were excluded from analysis.

**Data Coding.** Transcripts were entered and coded using Systematic Analysis of Language Transcripts (SALT; Miller & Chapman, 1996) 2012 software, Instructional Version. In each transcript, word items were coded according to SALT's system of word codes and bound morpheme codes. Word tokens that were used by a participant in a context that obligated the use of an inflectional morpheme (e.g., verbs used in the third person in the present tense) were recorded as a base word plus a bracketed code. Specifically, correct use of the third person singular *-s*, and regular past tense *-ed* were annotated according to the specifications of the SALT program ([3S] and [ED]), and omissions of these words in obligatory contexts were recorded as: [\*3S], [\*ED].

Using SALT, we generated reports counting the number of times each participant used the inflectional morpheme in question as well as the number of times each morpheme was correctly used and omitted with a given word token. The accuracy of each inflectional morpheme was then generated for each subject. A second phase of data coding then occurred, where the accuracy of the morphemes in question was checked and verified by manually searching for each of the codes within a given transcript. During this second phase each item of data was also scored as occurring at the end of the child's utterance or not. These two passes through the transcript set served to confirm the accuracy of the data coding, and yielded an opportunity to correct any irregularities.

Words were coded as “correct” if they were affixed to the appropriate inflectional morpheme for its context (e.g., *walks* for *walk*) or “incorrect” if they were not marked for finiteness in the obligatory context (i.e., produced as a bare stem by the child in a context that obligates the use of a tense marker). In rare instances, a participant produced an overregularized form of a past tense verb by marking it with the *-ed* morpheme (e.g., *\*flied* for the base verb *fly*). These instances were coded as a correct production of the past tense. In one instance, a participant doubly marked an irregular past tense verb (*broke*) with an overregularized addition of the past tense *-ed* (*\*broked*). This was one isolated example that did not occur elsewhere in the database, and it was therefore excluded from analysis. Two other examples of overregularization without double-marking (i.e., *\*seed* for *saw* and *\*flied* for *flew*) were produced by two children in the SLI group and were preserved in analysis.

At the end of this data coding phase, a database was established that contained 913 data points. Each data point, representing an obligatory context for one inflectional morpheme, the base word, the type of inflectional morpheme, whether that inflectional morpheme was used correctly or not, and whether the word occurred utterance-finally or not. In other words, all correct and incorrect uses of each morpheme by each participant were included in the database as long as they were produced in an obligatory context. The morphemes investigated are summarized in Tables 1 and 2. The overall accuracy associated with each morpheme’s use within obligatory contexts is presented for each group in Table 3.

**Table 1.** Morpheme Types within the Typically-Developing (TD) Group

<b>Morpheme</b>	<b>Code</b>	<b>Occurrences within Data Set</b>	<b>Unique Words</b>
Third person singular	3S	395	75
Regular past tense	ED	59	37
<b>Total</b>		454	112

**Table 2.** Morpheme Types within the Specific Language Impairment (SLI) Group

<b>Morpheme</b>	<b>Code</b>	<b>Occurrences within Data Set</b>	<b>Unique Words</b>
Third person singular	3S	378	75
Regular past tense	ED	81	41
<b>Total</b>		459	116

**Table 3.** Accuracy of Finiteness Marking by Morpheme Type

<b>Morpheme</b>	<b>Group</b>	<b>Correct Productions</b>	<b>Errors (Omissions)</b>	<b>Accuracy</b>
3S	TD	250	145	63%
	SLI	138	240	37%
	Overall	388	385	50%
ED	TD	46	13	78%
	SLI	42	39	52%
	Overall	88	52	63%
Cumulative	TD	296	158	65%
	SLI	180	279	39%
	Overall	476	437	52%

One additional morpheme, regular plural *-s*, was originally considered and coded for the database, but ultimately excluded from the final analysis. While plural *-s* among nouns was considered as a control morpheme (i.e., an inflectional morpheme that does not mark finiteness) to investigate, and was coded in the data set, it was ultimately excluded from the broader analysis because participants tended to produce this

morpheme at a very high level of accuracy (99.5% accurate among the TD group, 95.0% accurate among the SLI group, 97.4% overall for both groups). Given that there was little variability in its use across the TD or SLI groups, it was determined that the S morpheme was reliably accurate for both the TD and SLI groups, and thus lacked sufficient variation in its realization to provide valuable data. These high levels of accuracy are unsurprising, given that plural –s is generally one of the earliest morphemes acquired (Brown, 1973).

For a similar reason, after coding utterance finality, we excluded it as a predictor in the analysis. The majority of 3S and ED morphemes in the SLI and TD groups were produced in the utterance-medial position. Children in the SLI group produced 61 utterance-final verbs in contexts that obligated finiteness marking, compared to 398 utterance-medial verbs in obligatory contexts (i.e., 87% utterance-medial). TD participants produced 46 utterance-final verbs in obligatory contexts, and 408 such verbs in utterance-medial position (i.e., 90% utterance-medial). Thus, both groups demonstrated similar and strong tendencies to produce the verbs under investigation in this study in medial position, and relatively few examples of utterance-final finiteness marking were found in the data.

### **C. Base Word Coding**

**1. Sonority.** Sonority was coded in the environment of the morphophonological boundary between the base word and suffix. Specifically, the sonority of the final phoneme of the base word (e.g., word final /d/ in *slides*) and the initial phoneme of the suffix (e.g., the /z/ used to produce third person singular in *slides*) were recorded.

Sonority was quantified based on a hierarchy first proposed by Selkirk (1984), in which

more sonorous phonemes (e.g., vowels, nasals, liquids and glides) are assigned lower numeric scores and less sonorous phonemes (e.g., stops, fricatives and affricates) are assigned higher numeric scores on an 8-point scale. According to this hierarchy, consonants are ranked, in order of decreasing sonority, as follows: liquids, glides, nasals, fricatives, stops. At the same time, voiceless consonants are ranked as less sonorous than voiced cognates.

The sonority value of the initial phoneme of the suffix was then subtracted from that of the final phoneme of the base word to yield a single value of “sonority change” for each word token. For example, a verb, like *pass* that ends in /s/ and is affixed with the past tense –ed suffix would take the allomorph /t/, as in the example *passed* (/pæst/) for *pass*. The voiceless fricative /s/ has a sonority value of 5, while /t/, a voiceless stop, has a sonority value of 7. Thus, the sonority difference for the word *passed* is  $5 - 7$ , or -2. The outcome of this sonority coding was a numerical score for each item of data, which represents the sonority difference of the morphophonological transition from base word to suffix. The maximum possible scores allowed within this coding system is 7 (a voiceless stop followed by a vowel, e.g., *swatted*), and the minimum possible score is -6 (a vowel followed by a voiced stop, e.g., *lied*).

Sonority changes that are lower (e.g., a negative sonority difference as in the word *lied*) form syllables that conform to the Sonority Sequencing Principle (Clements, 1990), because they form syllables that fall in sonority from the nucleus to the coda. Conversely, sonority changes that are higher (e.g., a positive sonority difference as in the word *walks*) violates the SSP by forming a syllable in which the sonority contour is high at the

nucleus, then drops to the voiceless stop /k/, then rises to the voiceless fricative /s/. The frequency of occurrence of each sonority change pattern is presented in Table 4.

**Table 4.** Sonority from Final Segment of Base Word to Initial Segment of Suffix

<b>Sonority Change</b>	<b>TD</b>	<b>SLI</b>	<b>Total</b>	<b>Example(s)</b>
7	2	1	3	<i>wanted</i>
6	1	3	4	<i>landed</i>
5	15	14	29	<i>washes</i>
4	1	2	3	<i>uses</i>
3	0	0	0	*
2	234	208	442	<i>helps</i>
1	0	0	0	*
0	37	39	76	<i>walked</i>
-1	29	45	74	<i>comes</i>
-2	18	19	37	<i>missed</i>
-3	15	24	39	<i>tells, opened</i>
-4	100	95	195	<i>flies, rolled</i>
-5	1	0	1	<i>figured</i>
-6	1	9	10	<i>tried</i>

Sonority changes for which there were no examples produced in the data set are marked by an asterisk (\*) in the Examples column of Table 4. These represent potential violations of the morphological affixation rules that were avoided by the participants. For example, a sonority change of 3 was not produced by any participant in the data set, but could have resulted from a base word with a nasal consonant in final position followed by a vowel-initial suffix. However, no verb ending in a nasal consonant would take the /əz/ or /əd/ allomorphs of the 3S or ED morphemes, as those are reserved for affixations that would result in a clash between two adjacent fricatives (e.g., *washes*) or two adjacent

alveolar stops (e.g., *waited*). The morphemes investigated in the current study never produce such a clash.

**2. Phonotactic Probability.** Words produced by participants were analyzed in order to determine their phonotactic probability. Phonotactic probability is a measure of the relative likelihood of individual speech sounds (positional segment frequency) and adjacent sound sequences (biphone frequency) in a particular language (Storkel & Hoover, 2010). Words that have relatively high phonotactic probabilities are considered to be “common” (e.g., the individual phonemes and adjacent phoneme pairs in the word *sit*) in the language and those that have relatively low phonotactic probabilities are considered to be “rare” (e.g., the individual phonemes and adjacent phoneme pairs in the word *thatch*) in the language.

To obtain positional segment and biphone frequency phonotactic probability values, each unique word was phonetically transcribed, converted to a computer readable transcription (Klattese) and entered into an online calculator (Storkel & Hoover, 2010) that derives values based on a corpus of 4,832 words used by children in kindergarten and first grade, their pronunciations, and their spoken word frequencies. From this corpus, we calculated multiple measures of phonotactic probability, including averages of the word’s individual segment probabilities (segment mean) and biphone probabilities (i.e., biphone means; adjacent phonemes in the words), as well as the probability of the final phoneme and the final biphone in the word.

**3. Lexical Variables.** The same online calculator and word corpus were used to retrieve word frequency and neighborhood density values. Word frequency is defined as

the frequency of occurrence of an individual word token (e.g. *walk, talk, go*), quantified from a corpus of speakers' usage in conversation or interview. Neighborhood density is defined as the number of words in a language, also based on corpus data from speakers, that differ from a given word by only one phoneme, i.e. the number of words that can be generated by a one-phoneme substitution, addition, or deletion (e.g., for *cat*: neighbors include *sat, rat, cap, can, cut, kit, at, cast*, and so on). Words with a relatively high number of neighbors are referred to as more "dense" (e.g. *cat*) and those with fewer neighbors are referred to as more "sparse" (e.g. *sponge*).

#### **D. Data Analysis Plan**

The dependent variables for this analysis were the correct use of 1) third person singular (3S) and 2) regular past tense (ED). Independent variables included: 1) sonority change of the morphological boundary between the suffix and base word, 2) average phonotactic probability of all individual segments in the base word, 3) average phonotactic probability of all biphones in the word word 4) the final segment phonotactic probability of the base word 5) the final biphone phonotactic probability of the base word, 6) word frequency of the base word, 7) neighborhood density of the base word. The effects of these independent variables on the dependent variables were assessed using a logistic regression model to determine whether any of the base word characteristics significantly predicted correct use of the 3S and ED finiteness markers in children with SLI compared to their peers with typical speech and language skills.

## E. Reliability

Inter-rater reliability was measured in order to provide a measure of the strength of this data coding and analysis plan. Reliability was calculated for the 3S and ED morphemes. Transcripts from 20% of the sample (i.e., four TD transcripts and four SLI transcripts) were randomly selected and scored by a second judge who was not involved in the original data collection or coding process. For the eight transcripts, the second judge was asked to independently replicate the accuracy coding for the 3S and ED morphemes as well as the Sonority coding. The judge extracted the relevant word tokens, coded the tokens' accuracy for each finiteness marker (as correct or omitted), utterance finality, and sonority change across morphological boundaries. Reliability of 90% or greater was deemed as acceptable. Between two independent raters, agreement was greater than 96% for all variables. Table 5 summarizes the number of discrepancies between two the raters, as well as the percent reliability.

**Table 5.** Inter-Rater Reliability

	<b>Aggregate</b>	<b>Word Token</b>	<b>Correct Finiteness</b>	<b>Finality</b>	<b>Sonority Change</b>
<b>Morpheme</b>	3S	7 (97.1%)	5 (97.9%)	7 (97.0%)	6 (97.5%)
	ED	1 (99.6%)	0 (100%)	1 (99.6%)	2 (99.2%)
<b>Group</b>	TD	3 (98.8%)	2 (99.2%)	3 (98.7%)	2 (99.2%)
	SLI	5 (98.9%)	3 (98.8%)	5 (97.9%)	6 (97.5%)
	Total	8 (96.7%)	5 (97.9%)	8 (96.6%)	8 (96.6%)

## CHAPTER 3

### RESULTS

#### A. Logistic Regression

The data were analyzed using logistic regression, a statistical model chosen because the data contain multiple, continuous independent variables, and two binary dependent variables. In this case, seven word-level, continuous variables, previously described under Data Analysis Plan in the Methods section, are used to predict two binary outcome variables: third person singular (3S) finiteness marking (0 = third person singular omitted; 1 = third person singular correctly marked) and regular past tense (ED) finiteness marking (0 = regular past tense omitted; 1 = regular past tense correctly marked). A 7-predictor logistic regression model was fitted to the data to inform the likelihood that increases in correct third person singular and regular past tense use are predicted by phonological and lexical characteristics of the words to which they are affixed. Between the TD and SLI groups, the data included a set of 913 word tokens (454 word tokens for the TD group, 459 word tokens for the SLI group; 773 instances of 3S obligatory contexts; 140 instances of ED obligatory contexts). For the SLI group, these factors were able to correctly predict 63.1% of third person singular productions and 68.4% of regular past tense productions. For the TD group, these factors were able to correctly predict 64.4% of third person singular productions and 81.8% of regular past tense productions. We will present the results for the phonological predictors followed by the lexical predictors. The logistic regression summary statistics for the 3S morpheme

are reported in Tables 6 (SLI group) and 7 (TD group), and Tables 8 (SLI group) and 9 (TD group) for the ED morpheme.

**Table 6.** Logistic Regression Results: 3S Morpheme for the SLI Group

Type	Variable	Coefficient $\beta$	S.E. $\beta$	Wald	Exp ( $\beta$ )	$p$
Phono-logical	Sonority Change	.035	0.49	0.517	1.036	0.472
	Segment Mean PP	-21.834	13.454	2.634	<.001	0.105
	Final Segment PP	1.199	9.552	0.016	3.315	0.900
	Biphone Mean PP	306.014	111.775	7.495	<0.001	0.006
	Final Biphone PP	-142.636	60.714	5.519	<.001	0.019
Lexical	Word Frequency	-0.075	0.204	0.134	0.928	0.715
	Phon. Neighbors	0.075	0.025	8.878	1.078	0.003

**Note:** Significant predictors are shaded in gray.

**Table 7.** Logistic Regression Results: 3S Morpheme for the TD Group

Type	Variable	Coefficient $\beta$	S.E. $\beta$	Wald	Exp ( $\beta$ )	$p$
Phono-logical	Sonority Change	0.059	0.048	1.539	1.061	0.215
	Segment Mean PP	-9.291	13.549	.470	<.001	0.493
	Final Segment PP	9.415	8.130	1.341	12276.361	0.074
	Biphone Mean PP	194.760	109.199	3.181	3.829E+84	0.074
	Final Biphone PP	-88.2211	56.366	2.450	<0.001	0.118
Lexical	Word Frequency	0.172	0.176	0.952	1.187	0.329
	Phon. Neighbors	0.030	0.021	2.076	1.030	0.150

**Note:** Significant predictors are shaded in gray.

**Table 8.** Logistic Regression Results: ED Morpheme for the SLI Group

Type	Variable	Coefficient $\beta$	S.E. $\beta$	Wald	Exp ( $\beta$ )	$p$
Phono-logical	Sonority Change	-0.165	0.129	1.627	0.848	0.202
	Segment Mean PP	-2.812	32.809	.007	.060	0.932
	Final Segment PP	-6.723	19.242	0.122	<.001	0.727
	Biphone Mean PP	156.736	169.561	.854	<0.001	0.355
	Final Biphone PP	-26.596	104.692	.065	0.000	0.799
Lexical	Word Frequency	1.345	0.494	7.4	3.838	0.007
	Phon. Neighbors	-0.042	0.049	.746	0.958	0.388

**Note:** Significant predictors are shaded in gray.

**Table 9.** Logistic Regression Results: ED Morpheme for the TD Group

Type	Variable	Coefficient $\beta$	S.E. $\beta$	Wald	Exp ( $\beta$ )	$p$
Phono-logical	Sonority Change	0.119	0.179	0.442	1.126	0.506
	Segment Mean PP	-15.528	40.652	0.146	<.001	0.702
	Final Segment PP	-11.576	19.489	0.353	0.000	0.553
	Biphone Mean PP	129.538	261.354	.246	<0.001	0.620
	Final Biphone PP	47.362	158.242	.090	<0.001	0.765
Lexical	Word Frequency	0.120	0.599	0.040	1.128	0.819
	Phon. Neighbors	-0.015	0.064	0.057	0.985	0.811

**Note:** Significant predictors are shaded in gray.

## B. Phonological Predictors

**1. 3S Morpheme.** In the SLI group, three phonological variables significantly predicted 3S marking: high mean biphone probability, low final biphone probability, and increases in number of phonological neighbors. This suggests that children in the SLI group were responding to certain phonological characteristics of the base word when processing the optional finiteness marking of verbs. In other words, the SLI group was more likely to mark finiteness on base verbs whose individual phonemes were on average phonotactically more probable, whose final biphone pair of segments was less probable, and who had many lexical neighbors.

Several other phonological variables were tested, but not significant predictors of 3S marking by children with SLI: sonority change, mean phonotactic probability of all segments in the base word, and phonotactic probability of the final segment. See Table 6 for a summary of the logistic regression statistics for the 3S morpheme in the SLI group.

None of the phonological predictors were significant for 3S marking in the TD group. Children in the TD group, unlike the SLI group, appeared to ignore phonological characteristics when producing the 3S morpheme. See Table 7 for a summary of the logistic regression statistics for the 3S morpheme in the TD group.

**2. ED Morpheme.** No phonological variables significantly predicted ED marking in the participants of either the SLI or TD groups. See Table 8 for a summary of the logistic regression statistics for the ED morpheme in the SLI group, and Table 9 for a summary of the logistic regression statistics for the ED morpheme in the TD group.

### **C. Lexical Predictors**

**1. 3S Morpheme.** The SLI group's marking of 3S was significantly predicted by the lexical neighborhood density of the base word. Children were more likely to correct produce the 3S morpheme as the number of neighbors increased for the base word. Children with SLI showed no effects of word frequency for marking of the 3S morpheme. See Table 6 for a summary of the logistic regression statistics for the 3S morpheme in the SLI group.

The TD group showed no sensitivity to lexical variables for the 3S morpheme. See Table 7 for a summary of the logistic regression statistics for the 3S morpheme in the TD group.

**2. ED Morpheme.** Children in the SLI group demonstrated an influence of word frequency on their marking of the ED morpheme for the regular past tense. Specifically, increases in word frequency predicted a greater likelihood of correct ED marking. The SLI group was not sensitive to neighborhood density for the ED morpheme. See Table 8 for a summary of the logistic regression statistics for the ED morpheme in the SLI group.

No lexical variables significantly predicted ED marking for the TD group. See Table 9 for a summary of the logistic regression statistics for the ED morpheme in the TD group.

#### **D. Hosmer and Lemeshow Test**

The Hosmer and Lemeshow test indicates, for logistic regression models, how well the model in question matches the observed data. If such a goodness-of-fit test returns a significant result ( $p < 0.05$ ), it means that the model does not fit the data, and conversely a non-significant result ( $p > 0.05$ ) suggests a good fit. As shown in Table 10, a Hosmer and Lemeshow test performed on the data of the current study resulted in non-significant  $p$  values for both morphemes in both groups, corroborating the fit of the model to the data.

**Table 10.** Hosmer and Lemeshow Test

<b>Group</b>	<b>X<sup>2</sup></b>	<b><i>p</i></b>
SLI – 3S	11.972	0.101
SLI – ED	6.415	0.492
TD – 3S	8.709	0.367
TD – ED	4.695	0.697

## **E. Summary of Results**

Taken together, the significance of these phonological and lexical predictors in the regression model shows a sensitivity to base word characteristics, for children with SLI, when marking finiteness via the third person singular *-s* and regular past tense *-ed* morphemes. At the same time, the data are indicative of a lack of sensitivity to those same phonological and lexical predictors of finiteness marking for TD children. Children with SLI were more likely to accurately mark the 3S morpheme when the base word had high mean biphone probability, low final biphone probability, and more phonological neighbors. This group was also more likely to accurately mark the ED morpheme when the base word occurred more frequently in the language. Thus, word level characteristics differentially affected 3S and ED use within the SLI group.

## CHAPTER 4

### DISCUSSION

#### A. Overall Findings

The goal of the current study was to examine a broad array of variables, some phonological and some lexical, that may influence the likelihood of children optionally marking verb finiteness in spontaneous speech, to compare those influences across the third person singular *-s* (3S) and regular past tense *-ed* (ED) morphemes, and to compare the performance between typically-developing children and children with SLI. This investigation revealed patterns in the influential role that these variables may play in the morphological learning of children in the Optional Infinitive and Extended Optional Infinitive stages, when verbs are variably marked for finiteness or else produced in the infinitive form. This study was a first step in addressing a gap in the literature, that is, the study of a variety of word-level effects' predictive power on the accuracy of children's optional use of multiple finiteness markers, within an unstructured language context.

The overall pattern revealed by logistic regression demonstrates two key findings: 1) a differing model of performance between the typically-developing group and the specific language impairment group and 2) different patterns of sensitivity to word level characteristics for 3S versus ED morphemes within the SLI group. The SLI group's accuracy of finiteness marking of 3S morphemes was significantly predicted by: increases in mean biphone probability, decreases in final biphone probability, and increases in neighborhood density. The SLI participants' accuracy for the ED morpheme was predicted only by increases in a base words' word frequency. In contrast, the TD

participants in the study followed a strategy of finiteness marking that was not predicted by any of the variables analyzed. The results presented here agree with the Extended Optional Infinitive model of morphological development in SLI (Rice et al., 1998) and with the Input Informativeness model (Hadley, Rispoli, Fitzgerald, & Bahnsen, 2011). We will first discuss the theoretical implications of this work, focusing on these two theoretical frameworks. We will then offer preliminary clinical implications of the work.

## **B. Theoretical Implications**

**1. Group Differences.** The children in the current study had finiteness marking that was consistent with the Optional and Extended Optional Infinitive period (Rice, Wexler, & Hershberger, 1998). Rice et al. (1998) conclude that children with SLI acquire knowledge of finiteness marking in a similar pattern to their TD peers, with a significant difference being a protracted time frame in SLI relative to TD. In the current study, as in Rice et al. (1998), children in the SLI group demonstrated lower rates of finiteness marking compared to language-matched TD children. Where the current study differs in its examination of statistical predictors in the base word. From the results found here, we might propose an update of the EOI model that incorporates word-level variables. Not only do children with SLI continue to mark finiteness at relatively low rates at ages for which TD peers have begun to outgrow optional marking, but they also demonstrate reliance on statistical regularities in the base words later in development than TD children.

It is known that very young TD children do incorporate effects of phonological complexity in the finiteness marking decision process (Song et al., 2009). From the

comparative performances seen here, however, it appears that TD children by the age of 3 have adopted a strategy other than using phonological or lexical properties to facilitate verb finiteness marking, as they do so at a different overall rate of accuracy from the SLI group and do not show influences from the current study's independent variables. The SLI group, meanwhile, shows influences from both phonological and lexical variables. This may be taken as evidence that children with SLI utilize a less mature knowledge of the grammatical properties of verbs used in their speech, or at least that they less reliably succeed in producing morphemes to realize finiteness marking when verbs require it grammatically.

In contrast to children with SLI, typically developing children did not appear to base their finiteness marking on any of the variables considered here. One possible interpretation of this finding is that, unlike children with SLI, children with typical language skills have developed a more robust knowledge of finiteness, despite the fact that they continued to treat finiteness as optional, and that they no longer need additional phonological or lexical cues to facilitate using finiteness. By contrast, the children within the SLI group utilize multiple phonological and lexical variables in order to facilitate their finiteness marker use.

Recall that all participants in the current study were within the age range of the (Extended) Optional Infinitive stage, which measures the developmental period during which a child goes from not marking finiteness in verbs to variably marking this property some of the time (Rice et al., 1998). The EOI phase ends when the child marks finiteness in all obligatory contexts, and during this phase, variables that predict a child's accuracy

of finiteness marking may be informative of the strategies used by the child to realize finiteness marking in a given context (Rice & Wexler, 1996). The SLI group in the current study demonstrated sensitivity to mean biphone phonotactic probability, final biphone phonotactic probability, neighborhood density, and word frequency (and see Tables 6 and 8 for a more complete account). It may be that this sensitivity is due to this group's slower rate of language learning, and resulting reliance on an earlier strategy to facilitate finiteness marking. If this is the case, then these variables may serve to assist the SLI group's finiteness marking accuracy by representing less complex linguistic forms, as seen in past findings of SLI sensitivity and TD insensitivity to phonological variables in structured probes (Song et al., 2009; Leonard et al., 2007; Marshall & van der Lely, 2007).

The patterns of finiteness marking observed here show that children with SLI are more likely to mark the regular third person *-s* on verbs that come from more dense phonological neighborhoods, while TD children mark that morpheme independently of neighborhood density. This is in contrast to Hoover et al. (2012), who found that TD children in a structured language probe of 3S marking were more likely to mark the third person singular for dense rather than sparse verbs, while children with SLI were not sensitive to neighborhood density. One explanation for such a discrepancy in performance could be the spontaneous versus elicited design paradigms employed in each study. Because the current study analyzed less structured speech patterns, the children may have had less exposure to each word token, compared to Hoover et al.'s (2012)

design in which the participants were presented with a structured template that included the target infinitive verb.

Because the use of morphology to convey information about verb finiteness is obligatory under the corresponding linguistic circumstances, as children develop and pass through the EOI stage we might expect them to adopt a strategy of finiteness marking that is influenced by fewer factors apart from that linguistic context. A fully accurate, adult model of language production would produce verbs marked for finiteness in all obligatory contexts, regardless of phonological or lexical factors. Therefore, the observation that the TD group did not demonstrate significant effects for any of the variables marks this as the group closer to a mature pattern of finiteness marking, as also observed in Rice et al.'s (1998) longitudinal study of TD and SLI finiteness marking accuracy over several years within spontaneous and elicited language tasks.

**2. Morpheme Type Differences.** Among the SLI group, it is notable that different variables produced significant effects for the ED versus 3S morphemes.

*a. Developmental Trajectories.* From the similar developmental patterns of 3S and ED (Brown, 1973), it was predicted that phonological and lexical variables would similarly predict marking of these two morphemes. Brown (1973) observed that the third person singular *-s* and the regular past tense *-ed* are acquired at similar ages (i.e., during Brown's Stage IV corresponding roughly to the ages of 40 to 46 months in typical development) and therefore should have grown similarly. Likewise, Rice and colleagues (Rice et al., 1995; Rice & Wexler, 1995; Rice et al., 1998) note that while there are some differences in the growth trajectories of finiteness markers, the morphemes generally

cluster together to show a singular developmental pattern within the broader category of “finiteness.” Despite this, the data here suggest that children with SLI do not treat these two tense markers exactly equally, with more significant effects seen to influence 3S marking than ED.

This differing pattern of performance based on morpheme type might be explained by the differences in their frequency of use exhibited by different morphological tenses within the language input (Ambridge, Kidd, Rowland, & Theakson, 2015). Because the language samples under analysis in the current study were collected with an emphasis by the adult speaker on production of 3S, the immediate language input for children in the study was morphologically loaded. The frequent occurrences of third person singular inflection in the adult speech may have influenced the participants’ speech production patterns, as evidenced by the higher rate of 3S production compared to ED (see Tables 1 and 2), and consequently different effects of word level variables.

*b. Input Informativeness.* The fact that children apparently inflected these two morpheme types independently of each other, rather than treating them as two realizations of a single form of morphological learning, might also be explained by examining the data through the Input Informativeness model (Hadley et al., 2011). This model includes the hypothesis that children’s morphological learning is driven by their analysis of evidence for correct grammar from linguistic input. Hadley and colleagues (2011) use the term “input informativeness” to refer to the amount of linguistic evidence present in this input that is unambiguous, i.e. samples of grammatical productions that clearly demonstrate one correct form for the child to imitate. In other words, children

observe the language spoken around them. During speech production, they consider multiple, alternative morphological constructions (e.g., *Luke flies to Dagobah* as well as *\*Luke fly to Dagobah*). Exposure to unambiguous occurrences, especially frequently, adjusts this internal probabilistic algorithm to select the morphological form (e.g., marking *-s* in the context of the third person singular) that matches the input. Children learn novel morphological forms most effectively in conjunction with linguistic input that is informative (Hadley et al., 2011).

The results of the current study can be therefore interpreted through the Input Informativeness model as an explanation for the observation that ED and 3S were affected differently by the word-level variables. Due to inequalities in the input informativeness of these two morphemes, children who exhibit variable finiteness marking may select correct inflected forms for obligatory contexts at different rates of accuracy and with greater likelihoods based on different word level variables.

**3. Effects of Predictor Variables.** We now present some preliminary theoretical implications of the observed effects or lack of effects on finiteness marking from each of the word-level variables. See Tables 6 – 9 for a report of the effects of logistic regression results by language group and by morpheme type.

*a. Segment/Biphone Probability.* Measures of phonotactic probability varied in their influence on finiteness marking across the three research questions posed at the start of the current study. High biphone average probability and low final biphone probability were significant predictors of children with SLI more frequently marking verbs for third person singular. That high phonotactic probability (in the form of biphone average

probability) facilitated morphophonological processing of the 3S morpheme, alongside greater neighborhood density, is congruent with the work of Hoover, Storkel, and Hogan (2010). Hoover and colleagues used structured elicitation of nonwords in a word-learning study of children aged three to five years, while manipulating phonotactic probability and neighborhood density, and found that the two variables when present together facilitate children's ability to form connections between lexical items. Specifically, more common sound combinations with denser phonological neighborhoods were effective for promoting this type of lexical storage for preschool-age children. Notably, these facilitating effects are not found in mature adult word learners (Storkel, Armbruster, & Hogan, 2006). It may be that this convergent information is helpful at an age when speakers have not yet mastered the language domain in question, and if so this would help explain why TD children who are closer to leaving the Optional Infinitive stage do not show sensitivity to effects of either phonotactic probability or neighborhood density in the current study.

While average biphone probability was significant when high, it was low final biphone probability that showed a significant influence on finiteness marking in the current study. Children with SLI were more likely to mark 3S verbs for finiteness when the final biphone pair had low phonotactic probability. This pattern of final biphone probability shows an instance of greater phonological complexity facilitating finiteness marking, as opposed to average biphone probability, for which children demonstrated more accurate 3S marking for less phonologically complex forms. This suggests that the relative uniqueness of the base word-final phonological structures caused by the low

phonotactic probability resulted in more salient morphophonological cues, and therefore greater accuracy.

Neither mean segment probability nor final segment probability showed significant predictive effects for either language group, i.e., adjacent pairs of phonemes in the base word were treated as more meaningful than the individual phonemes. This may be related to the task of morphological affixation, in which allomorphs of the finiteness marker (e.g., *sits* as /s/, *spends* as /z/, and *buzzes* as /əz/) must be realized according to the natural classification of the adjacent phoneme in word-final position of the base word. The intrinsic nature of comparing biphone pairs to the process of affixation may explain the significance of biphone probability measures given the non-significance of segment measures.

The typically-developing group showed no influence from phonotactic probability variables for either morpheme. A likely explanation for this is that this group has acquired a sufficiently robust knowledge of finiteness marking that these children have discarded phonotactic probability of the base word as a strategy for phonological processing tasks. McKean, Letts, and Howard (2013) observed TD children and children with SLI in a nonword repetition task in which phonotactic probability of target words was controlled. They found that the SLI groups showed a sensitivity to effects of phonotactic probability that closed over time, though not as quickly as the effect closed for the TD participants.

In sum, two of the measures of phonological complexity—namely, mean biphone probability and phonological neighborhood density—did contribute positively to

finiteness marking, as hypothesized, but only for the SLI group. In this group, those two variables being lower in complexity—with higher phonotactic probability and with denser neighborhoods—seemed to increase participants' accuracy for marking the 3S property.

*b. Sonority Change.* Sonority was not shown to predict either morpheme for either group, countering the expectation that sonority might function similarly to other measures of phonological complexity by predicting more accurate finiteness marking for words that contain a word-final fall in sonority. As this structure would satisfy the Sonority Sequencing Principle (Clements, 1990), it would be phonotactically simpler. Since no such effect was found, it may be that sonority perception does not affect the type of phonological judgment that children make when inflecting verbs in the Extended Optional Infinitive period. One possible reason for this is that inflectional morphemes are relatively fixed in phonological structure. Though they may contain multiple allomorphs, they are a closed set of phonological forms. Previous studies investigating the role of sonority in clinical contexts (e.g., Morisette et al., 2006) have not focused on verb suffixation, and so the current study may indicate that sonority is used by children to judge phonological accuracy only on the basis of discrete lexical items, and not across morphological boundaries formed by affixation.

*c. Word Frequency.* Contrary to Rispens and de Bree (2014), it was not the TD group was sensitive to effects of word frequency, but rather the SLI group. The TD children showed no effect for this variable, while the SLI group was more accurate for words with high frequency. Differences in experimental design may explain these

discrepancies in group sensitivity. In the current study, children's spontaneous speech patterns were analyzed, meaning that a child with impaired lexical representations in the SLI group may have treated lower-frequency words as novel, and resultingly have demonstrated reliable marking of ED for the most frequent words.

*d. Neighborhood Density.* Similar to the effect of word frequency, neighborhood density showed an influence that ran partially-counter to the hypotheses based on Hoover et al. (2012). Like Hoover et al. (2012), words from denser phonological neighborhoods were more frequently marked for 3S, but in the current study the effects were significant for SLI, not the TD group, the exact opposite pattern found by Hoover et al. (2012). However, it may be that the presence of a predictive influence from a statistical regularity in word-level effects is more relevant than the specific direction of the effect and when that effect is significant for typical development versus SLI, as these effects are highly task-, age-, and language status-dependent (Werker & Curtin, 2005).

### **C. Clinical Implications**

In addition to carrying theoretical implications, the current study can inform clinical treatment for verb finiteness in children with SLI. The results described here indicate that children with SLI can respond to variations in the statistical regularity of target words for the purposes of finiteness marking. Verb finiteness conveys obligatory grammatical information in English, and is particularly difficult for children with SLI (Goffman & Leonard, 2000), who are seen to lag behind typically-developing children in their acquisition of consistent finiteness marker use (Rice & Wexler, 1996).

For clinicians targeting finiteness marking in this population, manipulating the phonological and lexical characteristics of target verbs can scaffold a client's accurate production of the 3S and ED morphemes. Words with higher mean biphone probability, lower final biphone probability, denser phonological neighborhoods, and higher word frequency all show an effect of predicting more accurate finiteness marking in children with SLI. Therefore, by targeting words that feature these properties, a clinician may be able to stimulate a client to produce finiteness markers at a higher rate of accuracy.

#### **D. Limitations**

The current study incorporated a number of features into its design that had not been described simultaneously in prior studies of the topic of finiteness marking in SLI: analysis of spontaneous speech, recruitment of participants within the Optional Infinitive and Extended Optional Infinitive stages, comparison between the 3S and ED morphemes, examination of multiple word level variables and comparison between TD and SLI groups. At the same time, its design was limited by certain considerations. One of these was the use of transcripts collected in a previous investigation (Hoover et al., 2012). While these language samples contained examples of both of the finiteness markers under investigation, the original study focused on 3S, and therefore the children's speech may have included an imbalance in the frequency of 3S use compared to the typical frequency of occurrence for this morpheme in natural language. The study's validity may have been improved by analyzing speech in which the use of finiteness markers was generally elicited, without targeting any specific morphemes (e.g., Hadley & Walsh, 2014).

Another potentially limiting aspect of the current study is the distribution of TD participants. Children in the TD group were matched by MLU to the participants of the SLI group (Hoover et al., 2012), making them similar in overall linguistic development, according to that one measure. Although the ages of the SLI (average 4;10) and TD (average 3;3) groups place them both within the expected ages of the Optional and Extended Optional Infinitive stages, it may be that the TD group had already abandoned the use of word-level statistical properties as a strategy for finiteness marking (Leonard et al., 2007). However, it was observed that despite similar MLUs between language groups, the TD group was on average more accurate in their use of finiteness markers than the SLI group, for each morpheme individually as well as overall (see Table 3). If word-level characteristics truly represent an early learning mechanism (Song et al., 2009), then a more similar pattern of sensitivity to word-level effects between groups might have been observed if the TD group had been age-matched rather than language-matched, in other words by recruiting younger TD children.

### **E. Future Studies**

The results described in this study motivate potential avenues of future investigation. Based on the findings here, we might extend this line of inquiry by examining a similar array of word-level effects, finiteness-marking morphemes, and language groups via different experimental designs.

One potentially revealing extension of the current work would be a longitudinal study that tracked the development of this area of linguistic performance over multiple years of a child's life. Beginning in participants' second year and continuing through the

conclusion of the Optional Infinitive or Extended Optional Infinitive phases, a study that measured finiteness marking as it developed could provide additional information about the word-level strategies used by TD children and children with SLI to mark finiteness at different stages of development. Consistent with the findings here, we would predict that typically developing children would show a very early sensitivity to phonological and lexical variables. Over time, they would discard this strategy as their finiteness marking became less optional and more resembled a mature, obligatory paradigm. Children with SLI would lag behind their TD peers, in their rate of optional infinitive marking and their sensitivity to word-level characteristics may persist relative to TD peers.

Alternatively, the results described here could be expanded upon by replicating the current study's design—analyzing the spontaneous finiteness marking for ED and 3S among TD children and children with SLI—and pairing this spontaneous language task with elicited data from a language probe task. For example, Song et al. (2009) studied finiteness marking among TD children by analyzing both spontaneous speech and imitated sentences. The inclusion of language probe data from the same set of participants would complement the spontaneous data and indicate whether children's performance, and by extension the strategy used to inform that performance, differ based on the context in which the utterance is produced. This longitudinal view of word-level statistical regularities informing finiteness marking could then be compared to Rice et al.'s (1998) model of the EOI phase that shows children with SLI acquiring knowledge of finiteness marking over a longer time frame than TD children.

## **F. Conclusion**

The current study has presented findings from the spontaneous language of typically-developing children and children with specific language impairment, who show variable use of inflectional morphemes to mark finiteness in verbs. Transcripts of participants' speech were analyzed, and it was found that certain word characteristics predicted more accurate finiteness marking for children with SLI: high biphone average phonotactic probability, low final biphone probability, high neighborhood density, and high word frequency. No variables predicted the TD group's use of finiteness markers.

Based on the Extended Optional Infinitive model of morphological development (Rice et al., 1998) and the Input Informativeness model of language acquisition (Hadley et al., 2011), these results seem to point to children with SLI as utilizing an earlier strategy to facilitate their use of finiteness markers and one that may not treat all inflectional markers as equal with respect to the use of word-level characteristics as a mechanism for facilitating accuracy. TD peers may demonstrate use of finiteness marking independent of word-level characteristics due to having developed a more robust knowledge of morphology. The results endorse these word-level characteristics as potentially informative to target selection in clinical intervention for SLI.

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