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Phonotactic probability and past tense use by children with specific language impairment and their typically developing peers

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Abstract

A group of preschool-aged children with specific language impairment (SLI), a group of typically developing children matched for age (TD-A), and a group of younger typically developing children matched for mean length of utterance (TD-MLU) were presented with novel verbs in context that required them to inflect with past tense *–ed*. The novel verbs differed in their phonotactic probabilities. The children with SLI were less likely than the other two groups to produce the novel verbs with *–ed*. Furthermore, they were less likely to use *–ed* with novel verbs of low phonotactic probability than those of high probability; this difference was not seen in the other two groups of children. It appears that the phonotactic composition of verbs is one factor that can contribute to the variability of past tense use by children with SLI.

Keywords

specific language impairment; phonotactic probability; past tense

Introduction

There is an abundance of evidence indicating that preschool-aged English-speaking children with specific language impairment (SLI) are highly inconsistent in their use of past tense forms. Although young typically developing children proceed through a period during which they show inconsistency with such forms, for children with SLI, the period of inconsistency is longer. Furthermore, during this period of inconsistency, these children's levels of past tense use seem uncommonly low. For example, children with SLI use past tense forms with lower percentages of use in obligatory contexts than do younger typically developing children matched according to mean length of utterance (MLU), as well as same-age typically developing peers (e.g. Rice & Wexler, 1996; Oetting & Horohov, 1997; Rice, Wexler, & Hershberg, 1998; Leonard et al., in press). Whereas, for example, typically developing three-year-olds might use past tense *–ed* in an average of 53% of obligatory contexts, five-year-old children with SLI might use this inflection in only 23% of obligatory contexts, on average (Rice, Wexler, & Cleave, 1995).

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Rice, Wexler, and their colleagues have proposed that the inconsistency seen in the use of past tense forms (and other morphemes related to tense and agreement) by children with SLI can be attributed to the children's failure to acquire the principle that tense is obligatory in main clauses. According to this account, tense and agreement features are present in the grammars of children with SLI. Furthermore, these children do not use these forms haphazardly; only rarely do they produce these forms in inappropriate contexts.

Other investigators have proposed that the past tense difficulties of children with SLI are not independent of frequency of occurrence factors. For example, Oetting and Horohov (1997), Marchman, Wulfeck, and Ellis Weismer (1999), Norbury, Bishop, and Briscoe (2001), and van der Lely and Ullman (2001) have all reported that children with SLI were more likely to use past tense with frequently occurring verbs than with infrequently occurring verbs. However, other findings have not been uniform across the studies. Oetting and Horohov and van der Lely and Ullman (2001) reported greater frequency effects of past tense use on the SLI group than on the typically developing groups. In fact, in the Oetting and Horohov study, the children with SLI showed only numerically but not statistically lower percentages of use than younger MLU controls for the verbs with higher frequency of occurrence. Marchman et al. reported stronger frequency effects for the SLI group only when the phonological composition of the verbs was also considered, and Norbury et al. found that word frequency effects influenced the past tense use of children with SLI and typically developing children to the same degree.

Recently, Marshall and van der Lely (2006) extended the notion of frequency by examining past tense use in two types of phonetic contexts, one in which the past tense inflection in combination with the final segment of the stem formed a consonant cluster that never appears in a monomorphemic word (as in [gd]) and one in which the past tense inflection in combination with the final segment of the stem formed a consonant cluster that does appear in monomorphemic words (as in [ld]). Not surprisingly, the latter type of context is more frequent than the former. Marshall and van der Lely found that 9- to 12-year-old children with SLI were less likely to use past tense *–ed* when the inflected form resulted in a cluster that does not appear monomorphemically than when it resulted in a cluster that is seen in monomorphemic words. Younger typically developing children aged 5- to 7-years of age used past tense *–ed* to the same degree in both phonetic contexts.

Both van der Lely and Ullman (2001) and Marshall and van der Lely (2006) interpreted their findings as suggesting that children with SLI may rely more heavily on the storage and retrieval of regular past tense forms (e.g. storing and retrieving forms like *jumped* and *walked*) than on generating past tense forms by inflecting stems (e.g. applying *–ed* to *jump* and *walk* when the context requires it).

In the present study, we continue to examine factors related to frequency of occurrence and phonological composition in the use of past tense by children with SLI. However, our focus is somewhat different from that of previous studies. First, we employ novel (that is, made-up) verbs that refer to novel actions. Our use of verbs of this type provides us with a closer look at how reliant children with SLI are on stored past tense forms. Because they have never heard these novel verbs before, their use of past tense *–ed* with these verbs cannot reflect the simple retrieval of previously stored inflected forms.

The limited data available on the use of past tense inflections with novel verbs do not seem consistent with the position that the past tense *–ed* use of children with SLI are based primarily on retrieving stored inflected forms. Norbury et al. (2001) found that 7- to 10-year-old children with SLI were as likely to mark past tense on novel verbs as on actual English verbs, and, furthermore, did not differ from younger typically developing children (matched for receptive vocabulary) in this regard.

By definition, novel verbs have zero frequency of occurrence in English. However, we can nevertheless gauge whether children's use of past tense with such verbs is influenced by input factors. In the present study, the novel verbs differ in terms of their phonotactic probabilities, that is, in terms of the frequency with which the adjacent phonemes of the novel word appear together in actual words of the language. Of course, even novel verbs with high phonotactic probabilities require the children to apply a rule if such verbs are to be inflected properly. That is, even though a novel verb such as [rɪθ] may have phoneme combinations that are more frequently encountered than a novel verb such as [jiθ], even the former has never before been heard with a past tense inflection. Yet it is still true that novel verbs with high and low phonotactic probabilities differ in the degree to which children might be able to rely on phonological familiarity in applying an inflection to a stem.

In this study, phonotactic probability is determined across the entire (novel) word, following the conventions established in previous research (e.g. Jusczyk, Luce, & Charles-Luce, 1994; Vitevich & Luce, 1999; Storkel, 2001, 2003; Storkel & Maekawa, 2005; Munson, Kurtz, & Windsor, 2005; Storkel, Armbrüster, Hogan, 2006). Thus, whereas in the Marshall and van der Lely (2006) study the word-final clusters formed with the addition of the inflection differed in their phonotactic frequency, in the present study, the novel verbs differ in their overall phonotactic probability. In fact, we ensured that some of the novel words with high and low overall phonotactic probability involved the same clusters (e.g. [gd]) to ensure that these clusters were not primarily responsible for the differences seen. It should also be noted that, in tasks in which children must inflect a stem that is presented by an experimenter (as in the method used in the present study), it is not clear whether the phonotactic probability of the stem is the key operative factor or whether the principal operative factor is the phonotactic probability of the stem + inflection. In the former case, children may be less certain of the verb stem itself, owing to its less typical phonotactic properties. In the latter case, the problem may rest in the children's anticipation of or execution in inflecting the stem that creates an overall form that is less typical. For this reason, in the present study we ensure that novel verbs have the same status as both high and low probability examples in both bare stem and inflected form.

We do not presume that phonotactic factors are the sole contributor to the variable use of past tense forms by children with SLI. In fact, this factor may function in combination with other factors in leading to the unusually slow progression out of the period of optional use by children with SLI. For example, these children, like young typically developing children, might initially fail to grasp the notion that tense is obligatory in main clauses. However, once this principle takes hold, children with SLI may at first have greater success in using past tense *–ed* with verb forms that have familiar phonotactic properties. Phonotactic probability may well capture such a tendency. In this study, we test the hypothesis that phonotactic probability will exert a greater effect on the past tense *–ed* use of children with SLI than on the past tense *–ed* use of typically developing children.

Method

Participants

Thirty children participated in the study. Ten of the children had been diagnosed as language impaired and had been recommended for language intervention. These children, 4 girls and 6 boys, ranged in age from 4;6 (years; months) to 6;6 and had a mean age of 5;4. Each child scored below the 5th percentile on the Structured Photographic Expressive Language Test – II (SPELT-II, Werner & Kresheck, 1983a). All 10 children passed a hearing screening, an oral mechanism examination, showed no signs suggestive of autism, and had no history of neurological impairment. Each of these children scored above 95 on the Columbia Mental Maturity Scale (CMMS, range = 97–122, *M* = 105.40, *SD* = 8.30). Based on a spontaneous speech sample of 100 utterances, the children's MLUs in words ranged from 3.44 to 5.08 (*M* = 4.23, *SD* = 0.52). MLU was not a selection criterion, but was used to equate children approximately on sentence length (see below). Hereafter, these children will be referred to as the SLI group.

Another 10 children were typically developing and, on average, were almost 2 years younger than the children in the SLI group. Ages ranged from 2;8 to 4;1, with a mean age of 3;4. Six children were girls, 4 were boys. All children were reported to be developing normally, and passed a hearing screening. The 7 children in this group who were above age 3;0 were administered the Structured Photographic Expressive Language Test – Primary (SPELT-P, Werner & Kresheck, 1983b) and all scored above the 17th percentile. The 3 younger children were administered the Reynell Developmental Language Scales (Reynell & Gruber, 1990) and earned standard scores above 100. Three of these children were sufficiently old to be administered the CMMS; these children scored above 100; the remaining children in this group received the Leiter International Performance Scale – Revised (Roid & Miller, 1997) and scored above 100. These children's MLUs, in words, based on a 100-utterance spontaneous speech sample, were similar to those of the children in the SLI group. MLUs ranged from 3.59 to 5.08 (*M* = 4.20, *SD* = 0.41). Hereafter these children will be referred to as the TD-MLU group.

The remaining 10 children, 2 girls and 8 boys, were similar to the children in the SLI group in chronological age. Hereafter, these children are referred to as the TD-A group. The children in this group ranged in age from 4;5 to 6;8, with a mean age of 5;4. Each of these children were reported to be developing normally and passed a hearing screening. All of these children scored above the 17th percentile on the SPELT-II and above 95 on the CMMS. Their MLUs in words based on a 100-utterance spontaneous speech sample ranged from 4.50 to 6.13 (*M* = 5.27, *SD* = 0.57).

Materials

A total of 12 novel verb stems were created by selecting 12 consonant-vowel-consonant nonwords employed by Jusczyk et al. (1994). Six of these had been classified by Jusczyk et al. as high phonotactic probability nonwords, on the basis of their summed positional phoneme frequency and summed biphone frequency. The remaining six nonwords had been classified as low phonotactic probability nonwords based on both summed positional phoneme frequency and summed biphone frequency. These nonwords were presented to the children in bare stem form, and a context was created that required the children to produce these forms with the past tense *–ed* inflection. As noted earlier, because it is not clear whether the phonotactic probability of the stem (presented by the experimenter) or the phonotactic probability of the stem + inflection (to be produced by the child) were the operative factors, we also ensured that the phonotactic probability of the stem + *-ed* inflection did not change the status of the novel verbs in terms of their high versus low phonotactic probabilities. Table I provides the values for the summed positional phoneme frequencies and summed biphone frequencies for both the stems and the stems with inflections, based on Vitevich and Luce (2004). As can be seen in table I, although there was no overlap in the summed positional phoneme frequencies or summed biphone frequencies for the high and low phonotactic probability nonwords, the high and low probability sets overlapped in their stem-final phonemes. Specifically, both sets employed stem-final /b/, /l/, /g/, and /θ/, and differed only in the use of stem-final /n/ for the high probability set and /ŋ/ for the low probability set. Although /n/ is more frequent in word-final position than /ŋ/, the latter is not infrequent, and, in fact, is more frequent in this position than one of the stem-final phonemes used in the high (as well as low) probability set, /θ/. It can also be noted in table I that in both the high and low phonotactic probability sets, stem + *-ed* combinations could result in consonant clusters that either appear in monomorphemic words (e.g. /ld/, /nd/) or do not (e.g. /bd/, /gd/).

Although phonotactic probability was the measure of central importance in the present study, a related measure, neighborhood density, might have affected performance. This measure refers to the number of words in the language that are similar to the target word based on substituting, deleting, or adding one phoneme (Luce & Pisoni, 1998). Although phonotactic probability and neighborhood density are often correlated, the two measures are separable. In a recent study that employed nonwords that orthogonally varied in phonotactic probability and neighborhood density, Storkel, Armbrüster, and Hogan (2006) found that the two measures may influence different components of word learning. Whereas phonotactic probability may ‘trigger’ new learning, neighborhood density may affect the integration of the new lexical representation with those that already exist. Given the nature of our task, in which children must inflect a novel verb stem, it seemed likely that each of the components discussed by Storkel et al. could be involved. For this reason, the low phonotactic probability nonword stems that were selected also had relatively low neighborhood densities (0 to 9 words), and the high phonotactic probability nonword stems had relatively high neighborhood densities (7 to 19 words). One exception was allowed; the low phonotactic probability nonword stem [⊲a⋃l] had 9 neighbors. However, several of these (e.g. *jowl, shale, yowl*) seemed unlikely to be known by children. All other nonword stems in the low phonotactic probability set had 6 or fewer neighbors. We do not believe that this deliberate linking of phonotactic probability and neighborhood density posed a problem. To our knowledge, the only situation in which high neighborhood density can be disadvantageous is one involving speed of real-word recognition (e.g. Luce & Pisoni, 1998). Given that our task involves the experimenter pairing a novel verb with a novel action (see below) and the child's task is one of brief recall and production, we reasoned that high neighborhood novel verbs would be advantageous, as both production and recall performance tends to be higher with high neighborhood words compared to low neighborhood words (e.g. Roodenrys & Hinton 2002).

Procedure

Each child was seen individually by two experimenters. One experimenter introduced the children to three stuffed toy characters, Pooh, Tigger, and Eeyore. These characters had soft, movable parts, enabling them to perform a variety of actions. The Tigger character performed the first 8 actions (including 2 practice items), and Eeyore performed the remaining actions. The children were told that Pooh's friends, Tigger and Eeyore, wanted to show them some funny things that they have learned to do, and these funny things had funny names. Pooh would also watch these funny actions, but he often forgot to pay attention. Therefore, the children would need to help Pooh. The children were then told to watch closely and listen carefully, so that if Pooh forgot to watch, the children could tell him what happened.

The task then proceeded with the second experimenter, acting as Tigger or Eeyore, announcing the action to be performed, saying the novel verb three times in bare stem form, and then performing the action. Pooh (played by the first experimenter) then confessed that he did not see what happened and asked the child. The question required use of the novel verb inflected with *–ed*. An example is shown in (1).

(1)

Eeyore:	Now I think I want to [rɪθ]. Sometimes it's nice to [rɪθ]. Watch me [rɪθ]! (Eeyore then hangs by his ears and rocks back and forth)
Pooh:	Uh-oh…I didn't see what happened. What did he just do?
Exper 1:	He….
Child:	[rɪθt]

Two practice items preceded the 12 novel verbs of interest. The first item employed the familiar verb *hop*; the second item used the novel (practice) verb [pek]. If children did not produce the inflection *–ed* with the familiar verb or novel verb in the practice items, the experimenter asked the child to repeat the utterance *He hopped*/[pekt]. In the second practice item, the experimenter reminded the child to pay close attention because Tigger's action had a funny name.

Following the practice items, 15 items were presented. Twelve of these were the novel actions of interest. All of the actions were intransitive, in which the toy character moved or used a body part in an unusual way (such as Eeyore hanging by his ears). The intransitive nature of these actions allowed the experimenter to produce the names of these actions in sentence-final position (as in ‘Watch me [rɪθ]!’) and the child, in turn, could produce a single-word response (as in [rɪθt]). Three familiar actions were also included (*walk, wave, hop*) as the 3rd, 7th, and 11th item. The items with high and low phonotactic probability appeared on the list in alternating order, such that each type appeared throughout the list.

Results

Responses were treated as scorable if they were phonologically accurate renditions of the novel verb. The mean number of scorable responses to novel verb items was 8.60 (*SD* = 2.63), 10.10 (*SD* = 1.66), and 10.70 (*SD* = 1.95) for the SLI, TD-MLU, and TD-A groups, respectively. The children with SLI were less likely to provide a scorable response. For both the SLI and TD-MLU groups, more unscorable responses occurred on low phonotactic probability items (59% and 61% for the SLI and TD-MLU groups, respectively). However, given the similar proportions of unscorable responses on low probability items for the two groups, the data do not seem to be skewed in this regard. The most frequent unscorable response for the children with SLI was the production of a novel verb that was used in the previous item (9 responses in total). The next most frequent unscorable response for this group was some variation of ‘I don’t remember’ (8 responses in total), followed by productions of an actual word that bore no phonological similarity to the novel verb (7 responses in total). Most of the latter responses appeared to be attempts to produce familiar verbs whose referent actions shared physical characteristics with the action used for the novel verb. For example, for the novel action of Eeyore spinning his tail around in a circle, one child produced the verb *spin*. Four responses were treated as unscorable because even after review of the audiorecordings, the presence or absence of the inflection could not be determined. On 3 occasions, the children produced a response that was not a recognizable real word, but did not bear a phonological similarity to the target novel verb. Finally, 2 unscorable responses were productions of a real verb that phonologically resembled the target novel verb (e.g. *jump* for [d↗¯n]), though its meaning may not have matched the type of action that was modeled for the novel verb. For the TD-MLU and TD-A groups, most unscorable responses were variations of ‘I don’t remember’ (7 and 5 responses, respectively), though the TD-MLU children also showed instances of producing a novel verb that was used in the preceding item (4 responses in total). For all groups of children, all errors on scorable responses were productions of the novel verb in bare stem form (without the –*ed* inflection).

Scorable responses were examined by means of a mixed model analysis of variance (ANOVA) with participant group (SLI, TD-MLU, TD-A) as a between-subjects variable and phonotactic probability (high, low) as a within-subjects variable. For each child, the number of correct past tense responses was divided by the number of scorable responses and this value was multiplied by 100 to yield a percentage. Arc-sine transformations were then performed on the percentages. The ANOVA employed the arc-sine transformed scores; however, means and standard deviations are presented here using the percentage data to facilitate interpretation of the data. All 30 children in the study produced past tense –*ed* with novel verbs to some degree.

The ANOVA revealed a significant main effect for participant group, F (2, 27) = 23.29, $p < .001$. Post-hoc LSD testing at the .05 level revealed that the SLI group showed significantly lower past tense *–ed* use than the TD-MLU group who, in turn, showed significantly lower use of past tense *–ed* than the TD-A group. In spite of the lower performance levels by the children with SLI, all children in this group produced one or more appropriate instances of the novel verb inflected with *–ed*. A significant main effect was also seen for phonotactic probability, F (1, 27) = 4.61, $p = .041$. As can be seen from table II, past tense *–ed* use was higher for novel verbs with high phonotactic probability than for novel verbs with low phonotactic probability. The participant group by phonotactic probability interaction did not prove significant, F (1, 27) = 1.20, $p = .316$.

From an inspection of table II, it appears that the SLI group's use of past tense *–ed* was influenced more by phonotactic probability than was the past tense *–ed* use of the other two groups of children, the non-significant interaction notwithstanding. Because we had hypothesized larger effects for phonotactic probability for the SLI group than for the remaining groups, comparisons were performed between the high and low probability novel verbs for the SLI and TD-MLU groups, and between the SLI and TD-MLU groups for high and low probability novel verbs (see Hsu, 1999 for the use of such statistical comparisons following ANOVA). According to the Newman-Keuls test (corrected for multiple comparisons), for the children with SLI, past tense *–ed* was significantly greater for high probability novel verbs than for low probability novel verbs ($p = .030$, large effect size d of 0.982), and this was the only group for which this was true. In addition, the SLI group differed significantly from the TD-MLU group (favoring the latter) only for low probability novel verbs ($p = .019$, large effect size d of 1.544).

Recall that both the high and low phonotactic probability novel verbs employed stem-final /b/, /l/, /g/, and /θ/, but /n/ appeared only in the high probability set and /ŋ/ only in the low probability set. The uneven distribution of the latter two stem-final consonants did not appear to distort the data. The SLI group had greater accuracy with *–ed* on high probability items than on low probability items and the same proved true for /n/ (64%) versus /ŋ/ (44%) items. In contrast, the TD-MLU children showed no phonotactic probability effects and the same proved true for /n/ (81%) versus /ŋ/ (78%) items.

Discussion

The children with SLI were significantly less likely to use past tense *–ed* with novel verbs than either the younger TD-MLU children or the TD-A children. These children were also less likely to use this inflection with novel verbs of low phonotactic probability than with novel verbs of high phonotactic probability. Items of low phonotactic probability distinguished these children from the TD-MLU group.

Before discussing the implications of these findings, several caveats are in order. First, we deliberately selected novel verbs whose high or low neighborhood densities did not differ from their high or low phonotactic probabilities. In a task such as ours, we reasoned that high values on these two measures would function in the same, facilitative manner. However, it is possible that the orthogonal treatment of these two properties might reveal differences in the way these properties affect performance on this type of task. This seems like a worthwhile topic for future research.

We should also note that our findings might have reflected how well children can inflect 'fast-mapped' verbs rather than how well they can inflect newly learned verbs that are more fully incorporated into their lexicons. In our task, the children heard each novel verb three times in succession in bare stem form and then were immediately given the opportunity to produce it in inflected form. We do not know if performance levels would be different if, for example, the children had received more exposures of the novel verb and then demonstrated comprehension of the verb (e.g. by making a toy character perform the action requested by the experimenter) before being asked to produce it in a context requiring the past tense *–ed* inflection. It is possible that with increased familiarity with the novel verb, overall performance levels might be higher and the effects of phonotactic probability might be diminished.

Our finding that all of the children with SLI produced novel verbs with past tense *–ed* indicates that their limited and variable use of this inflection is not the result of having memorized inflected verbs as unanalyzed forms. Although this may be the case in select instances, it is not plausible to assume that such memorization is the typical case for these children, given their ability to inflect novel verbs. This evidence, then, joins evidence obtained in other types of studies (e.g. those showing over-regularizations such as *throwed*) in illustrating that children with SLI possess some degree of knowledge of past tense use in spite of their limited skill in this area (e.g. Eyer & Leonard, 1995; Oetting & Horohov, 1997; Marchman et al., 1999).

How should the observed effects of phonotactic probability be interpreted? A strong interpretation of the data would be that children with SLI differ only from TD-A children and not TD-MLU children in their ability to use past tense *–ed* with verbs of high phonotactic probability. Considering an earlier finding by Oetting and Horohov (1997) that children with SLI did not differ from TD-MLU children in using past tense with words of high frequency of occurrence, this interpretation does not appear extreme. However, the absence of a difference between the children with SLI and the TD-MLU children may easily have reflected insufficient power; it can be seen from table II that the mean percentage for the TD-MLU children was numerically higher than that of the children with SLI for novel verbs of high phonotactic probability. We suspect that children with SLI are more generally limited than TD-MLU in their use of past tense *–ed*.

However, it is nevertheless the case that children with SLI are more adversely affected by low phonotactic probability than both TD-MLU and TD-A children when applying *–ed* to novel verbs. There are at least two possible reasons for this disproportionate difficulty. The first is that, because children with SLI are more limited in their past tense ability in general, they are more dependent on a new verb's typicality. New verbs that deviate from familiar lexical entries may fall close to the children's threshold of past tense application, and bare stem productions could be a frequent result.

Recall that we used two units in measuring phonotactic probability – the bare stem and the stem + inflection. Novel verbs that had low phonotactic probability in bare stem form had low probability in their inflected form. Conversely, novels verbs with high phonotactic probability in bare stem form could also be classified as having high phonotactic probability when inflected. Given that novel verbs had the same high or low classification regardless of the unit used, we cannot be certain which of these two units was more influential in children's impressions of typicality. However, the probability status of the stem seems to be the more likely candidate. The consonant clusters formed through inflection of *–ed* were very similar for the high and low phonotactic probability words. For example, the consonant clusters /bd/ and /gd/, which do not occur in word-final position in monomorphemic words, were required for inflecting both high and low phonotactic probability items with *–ed*. If children were reticent to add inflections because the resulting cluster would be less typical (given that it does not appear monomorphemically in final position), the difference between the children's use of past tense *–ed* in high versus low probability items should have been smaller or nonexistent.

A second possible reason for the strong phonotactic probability effects on the performance of the children with SLI is that the less familiar phonotactic forms placed a greater burden on the children's phonological working memory. In this case, the problem would not be the novel verb's low phonotactic typicality, but rather the incomplete retention of the novel verb. There is abundant evidence that children with SLI perform poorly on tasks of nonword repetition, and this difficulty is often attributed to limitations in working memory (Gathercole & Baddeley, 1990; Dollaghan & Campbell, 1998; Ellis Weismer et al., 2000; Conti-Ramsden, 2003; Bishop, Adams, & Norbury, 2006). If the children with SLI had difficulty retaining the novel verb stem in working memory, they would have had a less stable form on which to attach *–ed*. One result of this difficulty would be to simply produce the bare stem, if it is still retained; the other would be to abandon the response altogether. Consistent with this interpretation is our observation made earlier that the children with SLI were more likely than the other groups to respond with 'I don't know' or 'I can't remember'.

Of the two possibilities, the first seems more likely. The fact that children with SLI are usually more limited in their overall use of past tense *–ed* than TD-MLU children (see Leonard, 1998) makes it more plausible that less phonotactically typical verbs could greatly suppress their tendency to apply this inflection. The phonological working memory explanation seems less plausible given that previous studies comparing SLI and younger TD groups on tasks of this type have produced mixed results (see Graf Estes, Evans, & Else-Quest, 2007). If children with SLI are not appreciably poorer than younger TD children in phonological working memory, it is not clear how this factor could have influenced the SLI group more than the TD-MLU group in the present study.

The findings of the present study have implications for future studies of past tense *–ed* use by children with SLI. For example, researchers examining the effects of factors such as verb semantics or argument structure on past tense use might need to control for the phonotactic probability of the verbs selected. If not, accidental confounds between phonotactic probability and the factor of primary interest may distort the findings. The findings also have clinical implications. For example, before a clinician can be confident that a given assessment protocol resulted in an accurate picture of a child's use of past tense, the phonotactic probabilities of the verbs used in the protocol would need to be examined. The inclusion of a disproportionate number of verbs with high phonotactic probability, for example, might overestimate the child's actual ability.

A host of factors may conspire to render past tense *–ed* use difficult for children with SLI. Judging from the findings of the present study, one of these factors seems to be phonotactic probability.

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Table I

Sum of positional phoneme frequencies and biphone frequencies for the high phonotactic probability and low phonot
st

	Positional Phoneme Frequency	Biphone Frequency		Positonal Phoneme Frequency	Biphone Frequency
High					
[pæb]	.1898	.0112	[pæbd]	.2301	.0114
[de⁄⃗¯n]	.1491	.0071	[d⁄⃗¯nd]	.1894	.0202
[ga⋂n]	.1564	.0053	[ga⋂nd]		.1967
.0184					
[t⊲æl]	.162	.0107	[t⊲æld]	.2023	.0147
[kæg]	.190	.015	[kægd]	.2303	.0151
[r⋂θ]	.1537	.0182	[r⋂θt]	.2431	.0182
M	*.1668*	*.0113*		*.2153*	*.0163*
SD	*.0183*	*.0048*		*.0219*	*.0032*
Low					
[j b]	.0504	.0002	[j bd]	.0907	.0004
[⊲a⋃l]	.0931	.0005	[⊲a⋃ld]	.1334	.0045
[t⊲ ŋ]	.0371	.0011	[t⊲ ŋd]		.0774

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Table II

Mean percentages (and standard deviations) of past tense –*ed* use by the three participant groups for high and low phonotactic probability novel verbs.

Group	High Probability	Low Probability
SLI	52.20 (26.71)	27.50 (23.61)
TD-MLU	67.30 (32.62)	68.90 (29.52)
TD-A	98.30 (5.38)	92.60 (9.61)