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Decreased Sensitivity to Long-Distance Dependencies in Children with a History of Specific Language Impairment: Electrophysiological Evidence

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Abstract

Purpose—One possible source of tense and agreement limitations in children with SLI is a weakness in appreciating structural dependencies that occur in many sentences in the input. We tested this possibility in the present study.

Method—Children with a history of SLI (H-SLI; $N = 12$; M age 9;7) and typically developing same-age peers (TD; $N = 12$; M age 9;7) listened to and made grammaticality judgments about grammatical and ungrammatical sentences involving either a local agreement error (e.g., *Every night they talks on the phone*) or a long-distance finiteness error (e.g., *He makes the quiet boy talks a little louder*). Electrophysiological (ERP) and behavioral (accuracy) measures were obtained.

Results—Local agreement errors elicited the expected anterior negativity and P600 components in both groups of children. However, relative to the TD group, the P600 effect for the long-distance finiteness errors was delayed, reduced in amplitude, and shorter in duration for the H-SLI group. The children's grammaticality judgments were consistent with the ERP findings.

Conclusions—Children with H-SLI seem to be relatively insensitive to the finiteness constraints that matrix verbs place on subject-verb clauses that appear later in the sentence.

Keywords

specific language impairment; ERP; morphosyntax; P600; anterior negativity

Among speakers of English, the use of tense and subject-verb agreement can be rather fragile. For example, speakers can be led to produce agreement errors such as *The set of earrings are on the night stand* when the element closest to the verb calls for a different verb form than the subject with which the verb should agree. Likewise, on occasion speakers will have difficulty maintaining the correct tense when the sentence is relatively complex, as in *Jill usually entered her workplace with anxiety, as she knew that with the weak economy her job is most in jeopardy*. Of course, such errors are the exception, occurring only in select, often predictable contexts.

For young English-speaking children, however, error-free use of tense and subject-verb agreement (hereafter, tense/agreement) is much more daunting. During the preschool years, many children show inconsistent use, producing in one moment *Mommy drive to work every day* and in the next, *Mommy drives to work every day*. Yet such inconsistent use masks considerable grammatical knowledge on the children's part. For example, when an overt tense/agreement form is produced, it is usually correct. Productions such as *I likes ice cream* are exceedingly rare. For most children, this period of inconsistent use of tense/agreement morphology is short-lived; by the time children approach six years of age, productions such as *Mommy drive to work every day* are quite uncommon (Rice, Wexler, & Hershberger, 1998).

However, for one group of children – those with a diagnosis of specific language impairment (SLI) – the period of inconsistent use is significantly extended. These are children whose extraordinary weaknesses with spoken language occur in spite of normal hearing, age-appropriate scores on nonverbal tests of intelligence, and the absence of frank neurological damage or disease (Leonard, 1998). For these children, some degree of tense/agreement inconsistency can be seen through the early school years (Marchman, Wulfeck, & Ellis Weismer, 1999; Norbury, Bishop, & Briscoe, 2001; Rice et al. 1998) and, in especially severe cases, into adolescence and beyond (van der Lely, 1997).

Substantial evidence indicates that when children fail to mark tense/agreement, the resulting “omissions” are actually instances in which the children select a nonfinite verb form, which, in English, is a bare stem (Rice & Wexler, 1996). Thus, when children say *Every day Mommy drive to work*, the children are not failing to articulate an intended third person singular –s inflection; instead they seem to be selecting the same nonfinite verb form that might appear in a sentence such as *We saw Mommy drive to work*.

The reasons for children's alternation between correct tense/agreement forms and nonfinite forms are not yet clear. One prominent view is that a maturationally-based linguistic principle does not emerge in the grammars of young children until the preschool years in typically developing children, and much later in children with SLI. Until this emergence, the children treat tense/agreement as optional (Rice & Wexler, 1996; Rice, Wexler, & Cleave, 1995; Wexler, 1994). Recently, Leonard and Deevy (2011) have proposed an alternative explanation. These investigators proposed that children initially fail to grasp the structural dependencies in sentences such as *Let's watch the girl run*, *We watch the boy play basketball*, and *Does the girl like ice cream?* in which the nonfinite subject-verb sequence (*girl run*, *boy play*, *girl like*) is permissible because of the presence of a finite form that appears earlier in the sentence. According to Leonard and Deevy, without appreciating these structural ties, children inappropriately extract sequences such as *The girl run*, *The boy play basketball*, and *The girl like ice cream* and not only use them as stand-alone utterances but also as a basis for generating new, novel sentences (e.g., *The cat run*, *The man play cards*, *The boy like cookies*). As a result, nonfinite subject-verb sentences compete with sentences with tense/agreement that also appear in the children's input and serve as a basis for new utterances. Children with SLI are assumed to be especially slow to learn the structural dependencies within these kinds of sentences and, as a result, they continue to alternate between nonfinite forms and correct forms for a protracted period.

Although there is some debate about the sources of children's alternating use of nonfinite and tense/agreement forms, evidence is clear that this alternation can be seen in comprehension as well as production tasks. This was first shown in children's performance on grammaticality judgment tasks, especially in children with SLI, for whom the variable period is significantly protracted. For example, six-year-old children with SLI often judge as grammatical sentences such as *He eat toast* yet will reject as ungrammatical those such as *I drinks milk* (Redmond & Rice, 2001; Rice, Wexler, & Redmond, 1999). This pattern of responding is in keeping with their production profile; children with SLI rarely produce overt inflection errors (such as *I drinks*), yet they do indeed produce nonfinite bare stems in contexts requiring a tense/agreement form (as in *He eat*). Non-adult-like grammaticality judgments of this type can be seen in children with SLI at least until the age of 15 years (Rice, Hoffman, & Wexler, 2009).

In fact, weaknesses of this type are evident even when children with SLI appear to no longer produce bare stem forms in tense/agreement contexts. Leonard, Miller, and Finneran (2009) presented evidence of this type in a study comparing a group of adolescents with SLI and a group of same-age typically developing peers. The participants listened to sentences and pressed a computer key as soon as they heard a target word in the sentence. Some of the sentences contained a grammatical error immediately before the target word. Typically such errors, when detected, have the effect of slowing response time, as if they caused a momentary distraction. The SLI group showed the expected slowing when tense/agreement commission errors appeared just before the target word (e.g., *A good dog should learns tricks when it is a puppy*). However, when the error involved the absence of a tense/agreement morpheme in a context that required one (e.g., *Brian likes it when he draw cartoons and funny faces*) the participants with SLI showed no evidence of slowing. In contrast, the control group showed slowing in response to both types of error. Leonard et al. noted that the pattern of responses exhibited by the SLI group was reminiscent of these individuals' early sentence production patterns, in which commission errors seemed to be ruled out, but bare stem (likely nonfinite) verb forms were permissible in contexts requiring tense/agreement.

Rice et al. (2009) studied a group of older children who, at an earlier age, had shown a protracted period of inconsistent tense/agreement use. Even at 15 years of age, these children were more likely than same-age peers to accept as grammatical questions with missing tense/agreement forms. This weakness was seen even though some of these children scored at age level on standardized tests of language, and were no longer omitting tense/agreement forms in their spontaneous speech.

In the present investigation, we apply ERP methods to extend the examination of children's tense/agreement sensitivity. First, we seek to confirm that subtle weaknesses in tense/agreement persist in children who have a history of protracted tense/agreement inconsistency at an earlier age, even when standardized language testing suggests that the children possess close-to-age-level language abilities. The study of such children is important for several reasons. Children with SLI who later score in the typical range of spoken language ability are nevertheless found to score significantly below their peers on academic measures such as reading ability (Catts, Fey, Tomblin, & Zhang, 2002). It is likely

that subtle language weaknesses that escaped scrutiny during formal testing constituted an added burden in the children's attempt to acquire academic skills. Indeed, this phenomenon may constitute an example of the “illusory recovery” discussed by Scarborough and Dobrich (1990), in which children assumed to have resolved their language difficulties are often found to (re)qualify as language impaired on the basis of a different set of tests administered at a later age. It is also possible that children with subtle deficits can earn age-appropriate scores through compensatory mechanisms. As noted by Karmiloff-Smith (2009), children with disorders may resemble peers in their overt behavior, yet do so in a manner that reflects the workings of atypical brain networks. This last possibility points to the need for ERP studies.

A second goal of the present investigation is to assess the feasibility of the competing sources of input account of Leonard and Deevy (2011) by employing as sentence stimuli two different types of commission errors. One type of error involves a subject-verb agreement violation (e.g., *Every night they talks on the phone*). Both maturation principle accounts (e.g., Rice & Wexler, 1996), and competing sources of input accounts (Leonard & Deevy, 2011) predict that children with SLI will show sensitivity to such errors, as these errors were not a characteristic of the children's earlier speech. The other type of commission error involves the appearance of a tense/agreement inflection in a context that requires a nonfinite verb form, as in *He makes the quiet boy talks a little louder*. According to a maturation principle account, children with a history of SLI should be sensitive to such errors. On the other hand, according to the competing sources of input account, these children should have residual difficulty with the structural dependencies that require a nonfinite verb when a finite verb appears earlier in the sentence. Not appreciating these structural constraints, these children should respond primarily to the second clause, as in (using the above example) *the quiet boy talks a little louder*. Independent of the preceding clause, this clause is locally grammatical, showing proper subject-verb agreement (*boy talks*). For this reason, the competing sources of input account predicts that children with a history of SLI should be relatively insensitive to this type of error. We compare the responses of children with a history of SLI to those of a group of same-age typically developing children. We begin with a discussion of the relevant ERP components for the grammatical manipulations of interest based on previous research.

Anterior Negativity

One ERP component often associated with morphosyntactic processes is a negative-going wave at lateral/mid-lateral electrode sites with a relatively early peak latency in adult participants between 100 and 500 ms following the point of violation. This component, referred to generically as anterior negativity (or left anterior negativity if it is lateralized to the left hemisphere), is often observed in the context of morphosyntactic violations, such as subject-verb agreement errors (e.g., *The elected officials hopes to succeed*) (Coulson, King, & Kutas, 1998; Osterhout & Mobley, 1995). However, anterior negativity has also been associated with fully grammatical sentences with long-distance syntactic dependencies (e.g., *The patient met the doctor to whom the nurse with the white dress showed the chart during the meeting*) (Gouvea, Phillips, Kazanina, & Poeppel, 2010; Phillips, Kazanina, & Abada, 2005). Although anterior negativity has been interpreted as reflecting the initial detection of

a morphosyntactic violation (Friederici, 2002), not all such violations elicit this component. Furthermore, in studies of long-distance dependencies, anterior negativity might reflect the process of holding incomplete syntactic dependencies in memory (e.g., holding a *wh*-word in memory until its interpreted position in the sentence is heard) (Phillips et al., 2005).

Early ERP studies of children with SLI focused on components elicited by the mere presence of function words, with anterior negativity emerging as an important component in this work. For example, Neville, Coffey, Holcomb, and Tallal (1993) found that function words elicited a left anterior negativity in a group of typically developing children, whereas, for a group of children with SLI, the anterior negativity was symmetrical over both hemispheres.

Fonteneau and van der Lely (2008) found that grammatical errors of gap-filling (e.g., *Who did Joe see someone?*) elicited an early left anterior negativity in typically developing children and adolescents but not in a group with Grammatical SLI – a subgroup identified on the basis of marked grammatical deficits. The latter group instead showed evidence of a later negativity that resembled the N400 typically associated with semantic violations. In a study of German-speaking school-age children with SLI, Sabisch, Hahne, Glass, von Suchodoletz, and Friederici (2009) observed a left anterior negativity in response to category violations such as when a participle appeared immediately after a preposition (e.g., *Der Stock wurde ins geworfen* “The stick was in-the thrown”) instead of a noun (e.g., *Der Stock wurde ins Wasser geworfen* “The stick was in-the water thrown”).

Subject-verb violations of the type investigated in the present study were examined in a study of adolescents with SLI by Weber-Fox, Leonard, Hampton Wray, and Tomblin (2010). Two types of subject-verb violations were employed. The first constituted a commission error, in which the third person singular *-s* inflection was inappropriately added to the verb (e.g., Every day the farmers plows their corn and soybean fields). The second type of error was the use of a bare stem in a context requiring a verb inflected with third person singular *-s* (e.g., Every day the dog growl when someone passes his yard). Weber-Fox et al. found that both the adolescents with SLI and their typically developing same-age peers showed greater mean amplitude of the anterior negativity for sentences with subject-verb violations than for comparable fully grammatical sentences. The two participant groups did not differ in this regard. There were too few items of each violation type to determine if these group differences applied across all items or only to one type of violation. This question is especially relevant given that errors with inappropriate bare stems are more compatible with earlier production patterns of children with SLI than are errors with overt agreement violations.

P600

A well documented ERP component associated with morphosyntactic violations is a positive- going wave at central-parietal electrode sites with a peak latency in adult participants approximately 600 ms after the point of violation. This component – the P600 – is elicited by subject-verb agreement violations (e.g., Osterhout & Mobley, 1995) and long-distance syntactic dependencies (e.g., Gouvea et al., 2010). This same component is

associated with responses to garden-path sentences, as in *The broker persuaded to sell the stock was sent to jail* (e.g., Osterhout & Holcomb, 1992), in which the subject-verb combination renders a preferred interpretation (of an agent-action relationship in this instance) that proves to be incompatible with the remaining portion of the sentence. Traditionally, the P600 has been taken to reflect syntactic reanalysis. However, because this component can also be seen in response to complex sentences that are fully grammatical, some investigators have suggested that the P600 might be better characterized as reflecting syntactic integration. In the case of wh-word dependencies, for example, the P600 might reflect completion of the dependency link between the earlier-appearing wh-word and its later interpreted position (Kaan, Harris, Gibson, & Holcomb, 2000).

The range of morphosyntactic phenomena that elicit a P600 has complicated interpretation of this component. A further complication is the fact that the P600 can vary somewhat across morphosyntactic stimuli in latency, amplitude, and duration. Gouvea et al. (2010) have proposed that the latency of the P600 might be dictated by retrieval processes, whereas amplitude and duration might be controlled by structure building processes. Within the range of normal typical language functioning, the P600 seems to vary with language aptitude. In studies of both children (Hampton Wray & Weber-Fox, 2013) and adults (Pakulak & Neville, 2010), phrase structure errors such as *The boy swings the bat at his that ball* elicit a more robust P600 component in participants with higher than average language test scores than in participants with lower than average language test scores.

P600 results for children with SLI have varied according to the type of morphosyntactic violation employed. In the study by Fonteneau and van der Lely (2008) discussed above, no differences were found between adolescents with Grammatical SLI and controls in the P600 when presented with errors such as *Who did Joe see someone?* Similarly, in the Sabisch et al. (2009) investigation, the category violations (as in *The stick was in-the thrown*) elicited a P600 that was comparable in the SLI and age control groups. In their study on subject-verb violations, Weber-Fox et al. (2010) found that the adolescents with SLI showed a less robust P600 component than the control group. Recall that the two groups were similar in showing significant anterior negativity for these same errors. Again, the fact that both commission errors (e.g., *Every day the farmers plows their corn and soybean fields*) and bare-stem errors (e.g., *Every day the dog growl when someone passes his yard*) were employed did not allow the investigators to determine whether one type of subject-verb error was more influential than the other.

In the present study, only commission errors are employed. Based on the assumptions of both the maturation principle account and the competing sources of input account, children with a history of SLI are expected to provide evidence of both anterior negativity and a P600 component comparable to those of age controls for errors that reflect local subject-verb agreement errors, as in *Every night they talks on the phone*.

For violations of the type seen in *He makes the quiet boy talks a little louder*, the same two components are expected to be seen in the history of SLI group according to the maturation principle account. However, according to the competing sources of input account, reduced amplitude for these components should be found. That is, given these children's presumed

residual weaknesses with such structures, the subordinate clause (as in *the quiet boy talks a little louder*) should be processed with little regard for the matrix clause. Given the local agreement within the subordinate clause (*boy talks*) when the clause is taken as an unconstrained unit, the children with a history of SLI should treat the sentence as unremarkable.

For typically developing children, we expect that sentences such as *He makes the quiet boy talks a little louder* will elicit a clear P600. However, we are less certain about the appearance of anterior negativity. Although this component has been associated with both morphosyntactic violations and syntactic dependencies, the type of error reflected here constitutes a long-distance error of finiteness. The morphosyntactic violation is not one of tense or subject-verb agreement. Furthermore, it is not clear that the appearance of a matrix clause (as in *He makes*) that constrains the verb in the subordinate clause to be nonfinite is the same as the dependency relation seen when a *wh*-word signals the need for a later-appearing interpreted position. This is an important empirical question, for which we have no clear basis for a prediction.

Method

Participants

Twenty-four children, ages 7;3 (years; months) to 11;5, served as participants. Twelve of the children (M age = 9;7, SD = 17 months, nine males, three females) had been diagnosed as exhibiting SLI as preschoolers. The children were first seen between the ages of 4;1 and 6;6 as participants in the studies of Leonard, Davis, and Deevy (2007) and Leonard et al. (2007) or Leonard and Deevy (2011). At the time of their entry in these studies, these children passed a hearing screening, a screening measure of oral structure and function and scored within the normal range in nonverbal intelligence on the *Columbia Mental Maturity Scale* (Burgemeister, Blum, & Lorge, 1972). All met the criterion of a significant language deficit by scoring below -1.5 SD on the Structured Photographic Expressive Language Test – II (Werner & Kresheck, 1983), a test with very good diagnostic accuracy as measured by sensitivity and specificity. Because the studies for which the children were recruited focused on factors that contribute to weak tense/agreement morphology, all children met the additional criterion of scoring in the clinically significant range (-2 SD) on the Finite Verb Morphology Composite (Leonard, Miller, & Gerber, 1999), a measure that assesses the children's level of consistency in the use of the tense/agreement morphemes, third person singular *-s*, past tense *-ed*, copula *is*, *are*, *am*, *was*, *were*, and auxiliary *is*, *are*, *am*, *was*, *were*. Thus, as preschoolers, all of these children with SLI had displayed inconsistent use of tense/agreement morphology that was uncharacteristic of typically developing children of the same age. Hereafter, these children with a history of SLI will be referred to as the H-SLI group.

The remaining 12 children were functioning in the typical range of development in all areas according to parental and teacher report. Hereafter these children are referred to as the TD group. These children resembled the H-SLI group in age (M age = 9;7, SD = 16 months). Three were male, nine were female.

At the outset of the present study, all children passed a hearing screening and a screening test that clearly placed the children in the “non-autistic” range of functioning on the *Childhood Autism Rating Scale - 2* (Schopler, Van Bourondien, Wellman, & Love, 2010). No child was taking medications that could affect brain function at the time of study participation. Eleven of the 12 children in the H-SLI group and all 12 children in the TD group were regarded as right handed based on an augmented version of the Edinburgh Handedness Questionnaire (Cohen, 2008; Oldfield, 1971). One of the children in the H-SLI group had received a diagnosis of ADHD, though was not on medication. This child was included given that a diagnosis of SLI preceded that of ADHD and that, although these two types of deficits are often seen together, the particular language weaknesses associated with SLI (such as tense/agreement deficits, as seen in our participants with SLI) are not characteristic of the kinds of language weaknesses seen in children with ADHD who do not have an accompanying diagnosis of SLI (Redmond, Thompson, & Goldstein, 2011).

Consistent with their earlier diagnosis of SLI, the children with H-SLI continued to exhibit age-appropriate nonverbal intelligence, with average scores on the *Test of Nonverbal Intelligence - 4* (Brown, Sherbenou, & Johnsen, 2010) of 105.67 ($SD = 7.94$). The nonverbal intelligence scores of this group did not differ from those of the age controls ($M = 108.83$; $SD = 8.23$), $t(22) = 0.96$, $p = .348$. Furthermore, the two groups showed no differences in the education level of their mothers ($p = .596$) or fathers ($p = .109$) – measures that are often used as estimates of socioeconomic status (Hollingshead, 1975).

When tested at the time of the present study, the children with H-SLI, as a group, scored within the normal range of functioning on composite measures of language ability. In particular, their Core Language Index on the *Clinical Evaluation of Language Fundamentals - 4* (CELF-4; Semel, Wiig, & Secord, 2003) averaged 98.09 ($SD = 13.29$). All children used third person singular –s correctly on the three items of the CELF-4 that included this morpheme, though their responses often simplified the syntactic structure of the sentences used for these items. In fact, these children's scores on the CELF-4 were significantly lower than those of their same-age typically developing peers ($M = 113.58$, $SD = 7.16$), $t(22) = 3.77$, $p = .001$, $d = 1.45$). Furthermore, in two areas of language known to be especially vulnerable in individuals with SLI – sentence repetition and nonword repetition – the children with H-SLI lagged even farther behind the age controls. Each of these measures displays very good sensitivity and specificity in distinguishing children with SLI from their typically developing peers (Conti-Ramsden, Botting, & Farragher, 2001; Graf Estes, Evans, & Else-Quest, 2007). Furthermore, previous studies have shown that even those children with a history of SLI with presumably “resolved” language problems score significantly lower than their peers on these measures (Hesketh & Conti-Ramsden, 2013). On the Recalling Sentences subtest of the CELF-4 (a sentence repetition measure), scaled score means for the two groups were, respectively, 7.33 ($SD = 2.64$) and 11.50 ($SD = 2.28$), $t(22) = 4.14$, $p < .001$, $d = 1.69$). Six of the children with H-SLI earned a scaled score of –1 SD or lower on this subtest, whereas no child in the TD group scored so low. For nonword repetition, mean percentages correct on the Nonword Repetition Test (Dollaghan & Campbell, 1998) were 81.34 ($SD = 7.18$) and 90.54 ($SD = 3.31$), $t(22) = 4.03$, $p < .001$, $d = 1.65$, respectively. Differences were even greater for the more challenging items consisting

of four-syllable nonwords. Nine children in the H-SLI group scored -1 SD or lower on these items based on the typical child data reported by Archibald and Gathercole (2006). No child in the TD group scored at such a low level. Finally, based on responses to questionnaire items, parents of all but one child in the H-SLI group noted some continuing concern related to the language-related skills of their children. The parent of the remaining child in this group noted that the language-related skills of her child had resolved the previous year.

Stimuli

Each child heard 120 experimental sentences and 16 filler sentences. To arrive at the 120 experimental sentences, grammatical and ungrammatical versions of 120 different sentences were constructed, resulting in a master list of 240 experimental sentences. Sixty sentences, referred to here as “grammatical local agreement sentences” had the structure seen in *Every night they talk on the phone*, with the pronouns *I*, *we*, or *they* as the subject followed by a verb showing proper agreement with the subject. Sixty additional sentences were constructed by adding an inappropriate third person singular *-s* to the verb in each of the first 60 sentences, as in *Every night they talks on the phone*. These sentences are referred to here as sentences with “local agreement errors,” because the agreement violation occurs between the subject and adjacent verb. Another 60 sentences are referred to as “grammatical long-distance finiteness sentences” and had the structure seen in *He makes the quiet boy talk a little louder* or *Does the shy mouse hide under the bed?* In these sentences, the verb in the matrix clause (*He makes*) requires the verb in the subordinate clause to be nonfinite (*talk*); likewise, a fronted auxiliary (*Does*) requires the later-appearing lexical verb to take a nonfinite form (*hide*). The remaining 60 experimental sentences were created by adding an inappropriate third person singular *-s* inflection to the nonfinite verb in each of the grammatical long-distance finiteness sentences, as in *He makes the quiet boy talks a little louder* and *Does the shy mouse hides under the bed?* We refer to these sentences as sentences with “long-distance finiteness errors.” To ensure that the vocabulary used in the sentences was age-appropriate, the words initially employed in the sentences were selected from the MacArthur-Bates Communicative Inventory (Fenson et al., 1993), with some substitution of words to avoid redundancy.

Two different sentence lists were created from the master list, with 30 of the sentences of each of the four types of experimental sentences placed in each list. No list had both the grammatical and ungrammatical version of the same sentence. The same 16 filler sentences were added to each of the lists, resulting in 136 sentences per list. The filler sentences began with a phrase similar to that of the long-distance finiteness sentences (e.g., *He/she makes...*, *He/she watches...*, *Let's have...*, *Let's watch...*), but the complement of the verb was a noun phrase rather than a subject-verb clause (e.g., *She makes a sandwich for lunch* versus *He makes the quiet boy talk louder*; *Let's watch a cartoon on TV* versus *Let's watch the busy squirrel bury an acorn*).

Half of the children in each participant group received one list, with the remaining children in each group receiving the other list. Thus, each child heard 30 sentences from each of the four experimental sentence types and 16 filler sentences. The composition of each list

ensured that the child did not hear the grammatical and ungrammatical version of the same sentence. The 136 sentences were randomized for each participant.

All sentences were spoken at a natural rate by an adult female speaker and recorded on a Marantz Solid State Recorder (model PMD661) at a sampling rate of 44,100 Hz. The onsets of the grammatical and ungrammatical verbs were determined by visually inspecting the auditory waveforms using Praat software (Boersma & Weenik, 2004), while also listening to the sentence segments using a gating procedure to confirm onset times. All sentences were root mean square normalized to 70 dB.

Each recorded sentence was paired with a colorful picture that was semantically related to the sentence. The auditory sentences and visual displays were presented using Presentation software (9.70). The pictures were displayed with a visual angle of 4.4 degrees horizontally and vertically to minimize eye movement, and served as a fixation point while the audio recording of the sentence was played. The picture was always presented prior to the onset of the matching sentence, with the timing between the onset of the picture and the onset of the sentence randomly varied between 800 and 1200 ms. The sentence stimuli were presented via a sound bar at the bottom of the computer monitor at an intensity of 60-65 dB SPL. Each picture was accompanied by one sentence.

The sentences were arranged so that, 500 ms following the offset of each sentence, a screen showing the question “Was this a good sentence?” appeared and marked the onset of the 3000-ms response window. The interval between trials was randomly varied between 750 and 1500 ms. The sentences (120 experimental and 16 filler sentences) were presented in a random order over six blocks, with 23 sentences in the first five blocks, and 21 sentences in the sixth block. Each child completed all six blocks.

In summary, the grammatical error in both the local subject-verb agreement error sentences and the long-distance finiteness error sentences was caused by the inappropriate appearance of the third person singular inflection –s. The two types of errors also shared the characteristic that they appeared in sentences that are never heard in the ambient language. Thus, the intrusion of –s and lack of familiarity are controlled across the two error types. The difference lies in the fact that detection of the error in the first type of sentence relies only on recognition of the agreement clash between adjacent elements (e.g., *they talks*) whereas error detection in the second type of sentence relies on children detecting agreement between the subject and verb in the second clause that should not be present. Error detection in this second case relies on children knowing that the later-appearing verb is constrained to be nonfinite, given the earlier-appearing matrix verb. It is this second kind of detection ability that we suspect is vulnerable in children with H-SLI.

Procedures

The research protocol was approved by the authors’ institutional review board, and consent was obtained for all participants. At the beginning of the session, participants were fitted with an EEG cap and seated in a dimly lit sound attenuation booth, approximately four feet from a computer monitor. Each child first completed two practice blocks, which contained grammatical and ungrammatical sentences unlike those used in the experimental sentence

stimuli (e.g., The lucky girl will ride on a pony; The little dog will burying a bone). Children were instructed to listen to each sentence and, when prompted by the question on the screen, to press one of the buttons on a response box (RB-530, Cedrus Corporation) to indicate a good sentence or the other button if the sentence contained a mistake. If, after two practice blocks, the participant was still uncertain about how to respond to the question, one or two additional practice blocks were provided. After successful completion of the practice blocks, the six experimental blocks were presented. Each block lasted approximately three minutes. After each block, the children played several rounds of a board game of their choice. Together with game breaks, the testing session lasted approximately one hour.

Scoring and Analyses for Accuracy

For each sentence type – local agreement and long-distance finiteness – we examined the children's accuracy in judging the grammaticality of the sentences by employing the measure A' . This measure is used in two-alternative forced-choice procedures such as ours to adjust for children's bias toward accepting sentences (e.g., Rice et al., 1999). The formula for A' makes use of the proportion of hits (correctly accepting grammatical sentences) and false alarms (incorrectly accepting ungrammatical sentences). An A' value of 1.00 reflects complete (adult grammar) accuracy; a value of .50 reflects either acceptance of all sentences as grammatical or chance level performance on both grammatical and ungrammatical sentences. Using A' as the dependent measure, we examined the accuracy data with an analysis of variance (ANOVA) with participant group (H-SLI, TD) as a between-subjects variable and sentence type (local agreement, long-distance finiteness) as a within-subjects variable.

ERP Recordings and Analyses

Electroencephalographic (EEG) data were recorded from the scalp at a sampling rate of 512 Hz using 32 active Ag-AgCl electrodes secured in an elastic cap (Electro-Cap International Inc., USA). Electrodes were positioned over homologous locations across the two hemispheres according to the criteria of the International 10-10 system (American Electroencephalographic Society, 1994). The specific locations were as follows: mid-line sites: FZ, CZ, PZ, and OZ; mid-lateral sites: FP1/FP2, AF3/AF4, F3/F4, FC1/FC2, C3/C4, CP1/CP2, P3/P4, PO3/PO4, and O1/O2; and lateral sites: F7/F8, FC5/FC6, T7/T8, CP5/CP6, and P7/P8; and left and right mastoids. EEG recordings were made with the Active-Two System (BioSemi Instrumentation, Netherlands), in which the Common Mode Sense (CMS) active electrode and the Driven Right Leg (DRL) passive electrode replace the traditional “ground” electrode (Metting VanRijn, Peper, & Grimbergen, 1990). During recording, data were displayed in relationship to the CMS electrode and then referenced offline to the average of the left and right mastoids (Luck, 2005). The Active-Two System allows EEG recording at high impedances by amplifying the signal directly at the electrode (BioSemi, 2013; Metting VanRijn, Kuiper, Dankers, & Grimbergen, 1996). In order to monitor for eye movement, additional electrodes were placed over the right and left outer canthi (horizontal eye movement) and below the left eye (vertical eye movement). Horizontal eye sensors were referenced to each other, while the sensor below the left eye was referenced to FP1 in order to create electro-oculograms. Prior to data analysis, EEG recordings were filtered between 0.1 and 30Hz. Individual EEG records were visually

inspected to exclude trials containing excessive muscular and other non-ocular artifacts. Ocular artifacts were corrected by applying a spatial filter (EMSE Data Editor, Source Signal Imaging Inc., USA) (Pflieger, 2001). ERPs were epoched starting at 200 ms pre-stimulus and ending at 2000 ms post-stimulus onset. The 200 ms prior to the recording onset served as a baseline.

Mean amplitude measurements of anterior negativity and P600 were time-locked to the onset of the finite verb in the local agreement sentences and to the onset of the nonfinite verb in the long-distance finiteness sentences. Anterior negativity was measured between 575 and 775 ms. The P600 component was measured over three consecutive time windows. These windows included “Early” (700-950 ms), “Mid” (950-1200 ms), and “Late” (1200-1450 ms) intervals and allowed for more detailed quantifications of the timing of the P600 component elicited in the TD and H-SLI groups for each condition. This greater detail seemed important given that the local agreement and long-distance finiteness sentences presumably involve different morphosyntactic processes, which, in turn, can affect latency.

Two approaches to analysis were adopted for the ERP measures, each involving repeated-measures ANOVAs. The first was a standard approach, employing as factors group (TD and H-SLI), grammaticality (grammatical and ungrammatical), hemisphere (left and right), anterior-posterior distribution (F, FC, C, CP, P), and laterality (lateral and mid-lateral). Analysis of midline sites was performed separately from mid-lateral and lateral sites and lacked the factors of hemisphere and laterality. Results for midline electrode sites paralleled those for the lateral/mid-lateral electrode sites in all but one case. Therefore, for the sake of succinctness in reporting the results, we report the statistical outcomes for the ERP measures from lateral and mid-lateral sites, except in one case where the results from midline electrode sites provide additional information. In cases where the omnibus analysis produced a significant interaction, it was further evaluated with step-down ANOVAs, with factors specific to any given interaction. For all repeated measures with greater than one degree of freedom in the numerator, the Huynh-Feldt (H-F) adjusted p -values were used to determine significance (Hays, 1994). Effect sizes, indexed by the partial eta squared statistic (η_p^2), are reported for all significant repeated-measures ANOVA effects. Because the goal of this study was to identify the influence of group membership and sentence type on behavioral and neural response, we report significant results only for the factors of group and grammaticality and for their interaction with each other or other factors.

Although the statistical approach just described follows standard practice, it has the disadvantage of requiring multiple comparisons, even when analysis (as in our case) is confined to main effects and interactions involving group and grammaticality. For this reason, we also employed a second approach, referred to here as the “reduced factors” approach. The factor of grammaticality was eliminated by employing instead a difference measure, computed by subtracting, within each time interval, the mean amplitude for grammatical sentences from the mean amplitude for the corresponding ungrammatical sentences. This difference value served as the dependent measure. For each of the two ERP components under investigation, anterior negativity and the P600, we employed the six electrodes historically associated with these components. This allowed us to eliminate as factors hemisphere, anterior-posterior distribution, and laterality, leaving electrode as the

lone within-subjects factor. For anterior negativity, we employed electrodes at the lateral/mid-lateral anterior sites F7/8, F3/4, and FC5/6; for the P600, the central-parietal electrode sites CP1/2, P3/4, Cz, and Pz were selected. For these reduced factors analyses, only the main effect for group and the group $\times$ electrode interaction were of interest.

Results

Accuracy

Using A' as the dependent measure, we found a significant main effect for group, $F(1, 22) = 13.38, p = .002, \eta_p^2 = .378$ as well as for sentence type, $F(1, 22) = 16.64, p < .001, \eta_p^2 = .431$. However, these findings are shaped by a significant participant group $\times$ sentence type interaction, $F(1, 22) = 13.33, p = .002, \eta_p^2 = .377$. Least-significant-difference testing indicated that the children with H-SLI were significantly more accurate on local agreement inflections ($M = .944, SD = .064$) than on long-distance finiteness sentences ($M = .789, SD = .167$), $p < .001, d = 1.226$. These children's accuracy on local agreement sentences did not differ from the TD children's accuracy on local agreement sentences ($M = .975, SD = .012$), $p = .287$. However, the children with H-SLI were significantly less accurate than the TD group on long-distance finiteness sentences ($M = .983, SD = .017$), $p < .001, d = 1.634$. The TD children showed similar accuracy levels for the two sentence types, $p = .765$. Although all children in the TD group made errors, they approached ceiling levels on both types of sentences. The interaction (with 95% confidence intervals) is illustrated in Figure 1.

ERP Analyses

The number of trials included in the ERP analyses was highly similar for the two groups of children for both the grammatical (SLI $M = 27.58, SD = 1.31$; TD $M = 27.67, SD = 1.72$) and ungrammatical (SLI $M = 26.25, SD = 2.30$; TD $M = 26.67, SD = 2.35$) local agreement sentences and the grammatical (SLI $M = 27.67, SD = 2.15$; TD $M = 27.00, SD = 2.13$) and ungrammatical (SLI $M = 27.25, SD = 3.05$; TD $M = 28.08, SD = 1.83$) long-distance finiteness sentences. Given these similarities, we had no reason to suspect distortions in the data that would be attributable to the number of trials included in the analyses. For each sentence type (local agreement, long-distance finiteness) and ERP component (anterior negativity, P600), we first report the results using the standard statistical approach, followed by the results based on the reduced factors approach. Recall that the latter employed only group and electrode as factors, with the difference measure (mean amplitude for the ungrammatical sentences minus the mean amplitude for the corresponding grammatical sentences) as the dependent measure.

ERPs Elicited by Local Agreement Errors

The grand averages elicited by the grammatical and ungrammatical local agreement sentences are plotted for the TD (Figure 2) and H-SLI (Figure 3) groups. Anterior negativity and P600 components are indicated on the grand averages for both groups.

Anterior Negativity (575-775 ms)—An increase in the anterior negativity was elicited by local agreement errors relative to the corresponding grammatical sentences (grammaticality, $F(1, 22) = 4.779, p = .04, \eta_p^2 = .178$, grammaticality $\times$ anterior-posterior

distribution, $F(4, 88) = 7.802, p = .001, \eta_p^2 = .262$). The amplitudes of the anterior negativity did not differ for the TD and H-SLI group, $F(1, 22) = .291, p = .595$, grammaticality $\times$ group, $F(1, 22) = 2.037, p = .168$. The reduced factors analysis revealed no group, $F(1, 22) = 2.679, p = .116$, or electrode $\times$ group interaction, $F(5, 110) = .326, p = .779$.

P600—As can be observed in Figures 2 and 3, local agreement errors elicited a P600 in both the TD and H-SLI groups relative to the grammatical sentences. As described in the Method, the P600, a broad ERP component, was measured in three successive temporal windows to gain more detailed quantifications for the early, mid, and longer latency aspects of the broad, relatively long duration component. The grammaticality and group effects for each of the three temporal windows are summarized below.

Early (700-950 ms): There was no effect of grammaticality on the P600 amplitude in this early window for the local agreement sentences over lateral/mid-lateral electrode sites, $F(1, 22) = .630, p = .436$. However, for midline electrode sites, the P600 elicited by the local agreement errors was larger compared to the grammatical sentences over posterior electrode sites, grammaticality $\times$ anterior-posterior distribution, $F(3, 66) = 4.957, p = .006, \eta_p^2 = .184$. There were no differences between the TD and H-SLI groups for either the lateral/mid-lateral or midline electrode sites, main effect of group, $F(1, 22) = .827, p = .373$, or interactions of grammaticality with group, $F(1, 22) = .057, p = .813$. The reduced factors analysis revealed no group, $F(1, 22) = 1.426, p = .245$, or electrode $\times$ group interaction, $F(5, 110) = .282, H-F p = .884$.

Mid (950-1200 ms): Local agreement errors elicited increased P600 amplitudes over centro-parietal sites, grammaticality $\times$ anterior-posterior distribution, $F(4, 88) = 12.022, p < .001, \eta_p^2 = .353$. There were no differences between the TD and H-SLI groups either in main effect of group, $F(1, 22) = .04, p = .843$, or interactions of grammaticality with group, $F(1, 22) = .697, p = .413$. There were also no group, $F(1, 22) = .250, p = .622$, or electrode $\times$ group interaction, $F(5, 110) = .240, H-F p = .903$, based on the reduced factors analysis.

Late (1200-1450 ms): Local agreement errors also elicited increased P600 amplitudes over mid-lateral centro-parietal sites, grammaticality $\times$ laterality, $F(1, 22) = 6.846, p = .016, \eta_p^2 = .237$, grammaticality $\times$ anterior-posterior distribution, $F(4, 88) = 7.996, p = .001, \eta_p^2 = .267$, in the later temporal window. As with the early and mid latency temporal intervals, there were no group differences in the amplitudes of the P600 in this later temporal window, group $F(1, 22) = .212, p = .650$, grammaticality $\times$ group $F(1, 22) = 2.589, p = .122$. The reduced factors analysis revealed no group, $F(1, 22) = 2.711, p = .114$, or electrode $\times$ group interaction, $F(5, 110) = .268, H-F p = .898$.

In summary, local agreement errors elicited an increase in amplitude of the anterior negativity and the P600 relative to the corresponding grammatical sentences, with no significant amplitude differences of ERP components between the TD and H-SLI groups.

ERPs Elicited by Long-Distance Finiteness Errors

Grand average ERPs elicited by the grammatical and ungrammatical long-distance finiteness sentences are plotted for the TD (Figure 4) and H-SLI (Figure 5) groups. Unlike the results for the local agreement errors, there were no anterior negativities elicited by the long-distance finiteness errors for either group (Figures 4 and 5). Below we summarize the grammaticality effects as well as the similarities and differences between the TD and H-SLI groups for the measures within the temporal window in which anterior negativity was observed for the local agreement errors, as well as for the P600 ERP component.

Analysis of the temporal window for the anterior negativity (575-775 ms)—No anterior negativity was elicited by the long-distance finiteness sentences (Figures 4 and 5), and there were no differences in ERP mean amplitudes between the grammatical and ungrammatical versions of these sentences, $F(1, 22) = .294, p = .598$. Also, there were no differences between the groups in the amplitude of the anterior negativity, group, $F(1, 22) = 1.337, p = .260$, grammaticality $\times$ group, $F(1, 22) = 1.487, p = .236$. In addition, there was no effect of group, $F(1, 22) = .982, p = .333$, or electrode $\times$ group interaction, $F(5, 110) = 1.017, H-F p = .398$, based on the reduced factors analysis.

P600—The mean amplitudes of the P600 elicited by the long-distance finiteness sentences are reported below for the same consecutive temporal windows as those utilized in the analyses of the P600 elicited by the local agreement sentences. Again we focus on the grammaticality and group comparisons in the standard analysis, and group in the reduced factors analysis.

Early (700-950 ms): An interaction of grammaticality $\times$ anterior-posterior distribution $\times$ laterality $\times$ group was observed, $F(4, 88) = 2.833, p = .04, \eta_p^2 = .114$. Follow-up analyses revealed that the long-distance finiteness errors elicited increased P600 amplitudes for only the TD group in the early temporal window over the mid-lateral centro-parietal sites. Specifically, the TD group exhibited increased P600 amplitudes over mid-lateral electrode sites, grammaticality $\times$ laterality, $F(1, 11) = 5.446, p = .04, \eta_p^2 = .331$. In contrast, the step-down ANOVA for the H-SLI group revealed no effect of condition, $F(1, 11) = .238, p = .635$, or interactions involving condition, condition $\times$ hemisphere, $F(1, 11) = 3.213, p = .101$, condition $\times$ ant-post distribution, $F(4, 44) = .440, p = .591$, condition $\times$ hemisphere $\times$ ant-post distribution, $F(4, 44) = .161, p = .878$, condition $\times$ laterality, $F(1, 11) = 1.271, p = 2.84$, condition $\times$ hemisphere $\times$ laterality, $F(1, 11) = 1.069, p = .323$, condition $\times$ anterior-posterior distribution $\times$ laterality, $F(4, 44) = 1.674, p = .197$, condition $\times$ hemisphere $\times$ anterior-posterior $\times$ laterality, $F(4, 44) = .128, p = .972$. Figure 6, first interval, illustrates the mean amplitudes of the P600 for the TD (upper) and H-SLI (lower) groups over mid-lateral central-parietal sites for the early temporal window. The reduced factors analysis also revealed a difference between the TD and H-SLI groups, $F(1, 22) = 4.845, p = .039, \eta_p^2 = .180$, with larger P600 difference amplitudes in the early temporal window for the TD group ($M = 4.589 \mu V$) compared to the H-SLI group ($M = .026 \mu V$).

Mid (950-1200 ms): The ungrammatical long-distance finiteness sentences elicited a larger P600 mean amplitude, with the maximum of this effect being over mid-lateral central-

parietal electrode sites, grammaticality, $F(1, 22) = 44.835, p < .001, \eta_p^2 = .671$, grammaticality $\times$ anterior-posterior distribution, $F(4, 88) = 3.388, p = .048, \eta_p^2 = .133$, grammaticality $\times$ laterality, $F(1, 22) = 34.541, p < .001, \eta_p^2 = .611$, grammaticality $\times$ anterior-posterior distribution $\times$ laterality $F(4, 88) = 3.041, p = .031, \eta_p^2 = .121$. The amplitude of the P600 was larger for the TD group compared to the H-SLI group, grammaticality $\times$ group, $F(1, 22) = 6.881, p = .016, \eta_p^2 = .238$. Follow-up step down ANOVAs revealed that the increased P600 amplitude elicited by the long-distance finiteness errors was significant in both groups, with the largest effect over mid-lateral electrode sites for both groups, TD group, $F(1, 11) = 41.862, p < .001, \eta_p^2 = .792$, grammaticality $\times$ laterality, $F(1, 11) = 29.497, p < .001, \eta_p^2 = .728$; H-SLI group, $F(1, 11) = 8.615, p = .014, \eta_p^2 = .439$, grammaticality $\times$ laterality, $F(1, 11) = 9.425, p = .011, \eta_p^2 = .461$. To gain additional information concerning the participant group differences in the P600 in the mid temporal window, the mean amplitude for each child was examined. All 12 TD children showed a positivity, whereas this was true for only eight of the children with H-SLI. Three of the four children showing no positivity were among those with the lowest language scores during diagnostic testing. This difference in amplitude of the P600 for the two groups is evident in the ERP grand average waveforms (Figures 4 and 5) and is illustrated as the group means for the P600 mid temporal window in Figure 6, middle interval. The reduced factors analysis also revealed a difference between the TD and H-SLI groups, $F(1, 22) = 6.394, p = .019, \eta_p^2 = .225$, with larger difference amplitudes of the P600 in the mid temporal window for the TD group ($M = 9.466 \mu V$) compared to the H-SLI group ($M = 4.568 \mu V$).

Late (1200-1450 ms): Similar to the results for the P600 early temporal window, the long-distance finiteness errors elicited increased P600 amplitudes for the TD group only, grammaticality $\times$ group, $F(1, 22) = 8.558, p = .008, \eta_p^2 = .280$. Follow-up step down ANOVAs for each group revealed a significant effect of condition for the TD group that was largest over mid-lateral central parietal sites, grammaticality, $F(1, 11) = 13.968, p = .003, \eta_p^2 = .559$, grammaticality $\times$ anterior-posterior distribution, $F(4, 44) = 5.473, p = .009, \eta_p^2 = .332$, grammaticality $\times$ laterality, $F(1, 11) = 14.138, p = .003, \eta_p^2 = .562$, grammaticality $\times$ anterior-posterior distribution $\times$ laterality, $F(4, 44) = 3.651, p = .032, \eta_p^2 = .249$. In contrast, the step-down ANOVA for the H-SLI group revealed no effects of grammaticality, $F(1, 11) < 1.642, p > .226, F(4, 44) < 1.813, p > .161$. Figure 6, third interval, illustrates the mean amplitudes of the P600 during this late temporal window for the TD and H-SLI groups. The reduced factors analysis also revealed a difference between the TD and H-SLI groups, $F(1, 22) = 12.853, p = .002, \eta_p^2 = .369$, with larger difference amplitudes of the P600 in the late temporal window for the TD group ($M = 9.159 \mu V$) compared to the H-SLI group ($M = .897 \mu V$).

In summary, the long-distance finiteness errors elicited increased P600 amplitudes in the early, mid, and late temporal windows in the TD group. The H-SLI displayed increased P600 amplitudes only in the mid temporal window which was reduced in amplitude compared to the TD group. This group difference was confirmed in the reduced factor analysis. Thus, the P600 effect for the long-distance finiteness errors was delayed, reduced in amplitude, and shorter in duration for the H-SLI group.

Discussion

The H-SLI and TD participant groups did not differ in their accuracy in judging the local agreement sentences. With *A'* scores well above .90, both groups clearly demonstrated sensitivity to subject-verb agreement violations. This finding is consistent with earlier studies showing that children with SLI reject sentences with overt subject-verb agreement errors (e.g., Rice et al., 1999). The similar accuracy levels exhibited by the two participant groups for sentences of this type are consistent with both the maturation principle and competing sources of input accounts, given that subject-verb sequences containing overt agreement errors are not part of the input grammar.

The accuracy data were quite different for long-distance finiteness errors. Although the TD group was just as accurate on these sentences as on the local agreement sentences, this was decidedly not the case for the children with H-SLI. Based on their behavioral judgments, the children with H-SLI appeared to have difficulty recognizing the ungrammatical nature of long-distance finiteness errors.

For both participant groups, local agreement errors elicited an increase in amplitude of both the anterior negativity and the P600 component relative to the comparable grammatical sentences. These increases in amplitude were similar in degree in the TD and H-SLI groups. This finding was expected given that errors of this type (e.g., *they talks*) are not characteristic of the errors made by children with SLI at a younger age, and thus they were not likely to represent a residual vulnerability in the H-SLI group.

To our knowledge, this is the first examination of ERP data for sentences that constitute long-distance finiteness errors. Such sentences differ from most ungrammatical sentences because the tense/agreement violation is not locally ungrammatical – that is, the appearance of third person singular *-s* in the second clause is not problematic because it fails to agree with the subject (indeed it does agree with the subject in person and number). The problem rests with the fact that the earlier-appearing finite form requires the verb in the second clause to be nonfinite.

Neither the TD group nor the H-SLI group showed evidence of an anterior negativity component in the context of long-distance finiteness errors. We were uncertain whether such errors would elicit an anterior negativity component in the TD group. For these sentences, errors are not local and the long-distance dependency relation is quite different from those employed in previous studies reporting anterior negativity in typically developing children and adults.

In contrast, long-distance finiteness errors elicited a very robust P600 in the TD group. These errors were associated with increased P600 amplitudes in the early, mid, and late temporal windows for these children. Although we found increased amplitudes in the mid temporal window for the H-SLI group, even in this window, these increases were not as large as in the TD group. Indeed, several of the children with H-SLI showed no evidence of a P600 even in the mid temporal window. Relative to the TD children, then, the P600 effect for the children with H-SLI for long-distance finiteness errors was delayed, reduced in amplitude, and shorter in duration.

For both groups of children, the ERP profile for the long-distance finiteness errors differed from that of local subject-verb agreement errors in that only the latter provided evidence of an anterior negativity component. This suggests that the cognitive processes involved in the case of long-distance finiteness errors might have been more akin to those involved in garden-path sentences, especially given that syntactic garden paths often elicit a P600 but not anterior negativity (e.g., Gouvea et al., 2010). Of course, in garden-path sentences, reanalysis leads to an alternative and permissible interpretation of the sentence. In the case of long-distance finiteness errors, reanalysis does not resolve the listener's problem with the sentence. However, the fact that the verb in the second clause agrees with the subject in person and number might well prompt a reanalysis of the sentence in a way that does not occur when a local violation (as in *they talks*) is heard.

In their study of older children and adolescents with Grammatical SLI, Fonteneau and van der Lely (2008) found that ungrammatical sentences such as *Who did Joe see someone?* elicited a significant P600 component, comparable to that seen in a group of same-age peers. Sentences of this type share one characteristic with our long-distance finiteness errors. In both cases, the source of the problem is not the juxtaposition of two elements that clash. For example, the sequence *see someone* presents difficulties only to the extent that the presence of *someone* is recognized as incompatible with the earlier-appearing wh-word, *who*. And herein lies the difference: the presence of a wh-word clearly signals a dependency relation. Such a clear signal is not apparent in our long-distance finiteness errors. Instead, an earlier-appearing finite verb places a constraint on the verb in the clause that follows, one that requires this verb to be nonfinite. It is this structural constraint that we assume is poorly grasped in SLI and represents a residual weakness in those children with a history of SLI. Without a refined sensitivity to this dependency, the children with H-SLI could easily have treated an otherwise grammatical sequence (e.g., *the quiet boy talks*) as appropriate.

Although the children with H-SLI in our study also showed evidence of a P600 component when listening to sentences with long-distance finiteness errors, this component was less robust in latency, amplitude, and duration than we found in the TD children. It is noteworthy that this group difference occurred, given the absence of a group difference for the P600 component in the Fonteneau and van der Lely (2008) study. At the group level, our participants with H-SLI could probably be characterized as exhibiting a “milder” impairment. If severity were a factor, we should have found smaller (or no differences) between the TD and H-SLI groups rather than the larger group differences that we found, compared to those reported by Fonteneau and van der Lely.

Although both the grammaticality judgment findings and the P600 findings revealed a significant weakness in processing long-distance finiteness errors by the children with H-SLI, both types of measures indicated some degree of sensitivity on their part. The *A'* values for the H-SLI group, though well below those of the TD group, were nevertheless above the .50 value associated with chance. Likewise, in the mid temporal window, there was evidence of a P600 in the H-SLI group, even though it was less robust than in the TD group.

What might account for the fact that the P600 for the H-SLI group was not only smaller in amplitude but also short-lived, no longer evident in the late temporal window? One

speculation – in line with the competing sources of input account – is that these children detected an oddity but their relatively weak command of long-distance dependency relationships allowed the local agreement to over-ride the initial detection of an infelicity, thus “resolving” the problem.

Apart from the competing sources of input account that predicts these particular group differences, we are not aware of an alternative account that provides a rationale for expecting them. The following proposal seems to us to be the most plausible. As noted earlier, we could document that when the children in the H-SLI group were preschoolers, they exhibited an inconsistency in the use of tense/agreement morphemes that was uncharacteristic for their age. One possible source of this inconsistency, we argue, was their difficulty in grasping the structural ties that occur in sentences in which finite information early in the sentence dictates the use of a nonfinite form in a later appearing subject-verb sequence, as in *We watch the girl play tennis*. Without an appreciation of these structural dependencies, the children saw no constraint against extracting the nonfinite clause (*the girl play tennis*) and using it as one of the bases for generating new utterances.

We believe that sensitivity to the ungrammatical nature of our long-distance finiteness errors requires knowledge of these same structural dependencies. This similarity may seem less obvious given that, at an earlier stage, the children are assumed to have extracted nonfinite clauses for use and, later, in the current study, the children were relatively insensitive to clauses that were inappropriately finite. The connection is that, in each instance, the children appeared to treat later-appearing subject-verb sequences as unconstrained. Given this lack of constraint, nonfinite subject-verb sequences are not dependent on a larger structure, and finite subject-verb sequences are not out of place alongside a preceding matrix clause.

Why were the children with H-SLI less sensitive than the TD children to the structural dependencies of the long-distance finiteness sentences? There are at least two possibilities. First, the children might have no longer retained information in the matrix clause by the time the subject-verb proposition in the second clause was processed. Without retention of the earlier-appearing information, the subject-verb proposition would be unconstrained. Alternatively, the children might have successfully retained the relevant information but simply had incomplete knowledge of how matrix clauses constrain the finiteness of the verb in the later-appearing clause. For example, whereas the matrix clause *He makes* requires a nonfinite verb in the second clause, the matrix clause *He thinks* requires a finite verb (e.g., *He thinks the quiet boy talks a little loud*). Future studies involving careful manipulations of syntactic structure, length, and memory demands might well provide evidence that favors one or the other of these alternative explanations for the children's relative insensitivity to structural dependencies.

Although we view the findings as highly compatible with the competing sources of input approach, these findings were, of course, shaped by our decisions regarding the selection of both participants and stimuli. For example, we were more concerned about selecting children who had exhibited a protracted period of inconsistent tense/agreement use as youngsters than we were about their standardized language test scores at the time of the study. Although we refer to the participants as children with a history of SLI because some

of them scored within -1 SD of the mean on our composite measure of language ability at the outset of the study, it is frequently the case that children with such histories continue to exhibit subtle deficits (as indeed, we found in the present study) and, as noted by Karmiloff-Smith (2009), even age-appropriate scores on tests of language may have been earned in part through the use of compensatory mechanisms. Nevertheless, it is possible that our findings would have been different if only children with fully resolved language difficulties had been recruited, or, conversely, if we had recruited only children exhibiting a much more severe language deficit at the time of the study. Similarly, our inclusion of one child who was diagnosed as exhibiting ADHD as well as SLI might have influenced our findings to a small degree. Such a dual diagnosis is quite common, though the language symptoms of SLI (which were, in fact, evident in this child) can be distinguished from those tied specifically to ADHD (Redmond et al. 2011).

Our choice of sentence stimuli might also have shaped the results. We selected a representative collection of sentences with an early-appearing finite verb and a later appearing nonfinite subject-verb sequence, in keeping with our hypothesis. Stimuli included questions (e.g., Does the nice doctor look/looks into the child's ear?), declarative sentences (e.g., *She makes the nice girl pick/picks a new toy*), and requests (e.g., Let's watch the friendly dolphin leap/leaps into the air). Although we believe that this variety enhanced the validity of the findings, it is possible that certain construction types were more influential than others. This seems especially plausible given that children with SLI only gradually increase the proportion of tense/agreement morphemes in their speech, and this could be due to the children discovering the long-distance dependency relations in the input one construction at a time.

Finally, we point out that our two statistical approaches to data analysis differed by more than the number of comparisons involved. The reduced factors approach held the advantage of involving only group and electrode as factors. However, the dependent measure for these analyses – the difference in mean amplitude between the grammatical and corresponding ungrammatical sentences – eliminated the possibility of determining whether there were amplitude differences between the grammatical and ungrammatical sentences. For example, according to the standard statistical approach, both groups of children showed a significant increase in anterior negativity for local agreement errors, and neither group showed such an increase for long-distance finiteness errors. However, the reduced factors analyses could only indicate that the two groups did not differ in anterior negativity for either construction type. This difference in the type of information the two approaches offer should be considered in future studies. When group differences are the central concern, the reduced factors approach seems advantageous. However, if sensitivity to the grammatical – ungrammatical distinction is of importance, separate amplitude values for grammatical and ungrammatical sentences may be called for. Similarly, the standard statistical approach might be more appropriate when employing novel sentence constructions or previously untested clinical populations because, in such cases, the resulting ERP components will have unknown scalp distributions. When considering which approach to adopt, it is necessary to bear in mind the risk of spurious findings when a large number of factors and interactions are considered without any adjustment of p -values.

Although much remains to be done before the competing sources of input proposal can be accepted as accurate, the present study was successful in demonstrating that the larger sentence structure must be considered in any attempt to uncover the source of tense/agreement weaknesses in children. We employed two types of sentences that, superficially, seemed to have the same type of error – the inappropriate attachment of a third person singular –s inflection. Yet the same inappropriately placed inflection elicited rather different ERP profiles for the two sentence types, due to the particular syntactic structures within which the offending inflection was housed. It was this difference in the syntactic context of the inappropriate inflection, rather than the mere appearance of the inappropriate inflection, that was responsible for the significant differences observed between the children with H-SLI and their typically developing peers.

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Appendix

List 1 (of 2) of the stimulus sentences used in the study.

Local Agreement Sentences (grammatical)

Every morning I wake up very early.

On Sundays I write a letter to my friend.

At night I take a shower before bedtime.

At the pool I dive into the water.

Every day I drink a glass of milk.

Every afternoon I read a comic book.

When it's sunny I wear a pair of sunglasses.

At the theater I wait in line for popcorn.

After dinner I work on my math homework.

When it's cold I put on my warm hat.

On Saturdays they visit an old friend.

Every afternoon they take a short nap.

After school they walk all the way home.

Every summer they take a vacation.

Every morning they eat a healthy breakfast.

Every evening they pick a game to play.

When it's hot they turn on the air conditioner.

Every night they talk on the phone.

Sometimes they sing a happy song.

On weekends they bake an apple pie.

Sometimes we walk around the block.

At dinner we turn off the TV.

Every weekend we rent a rowboat.

Sometimes we shop at the mall.

When it snows we light a fire in the fireplace.

Every morning we help our mom wash dishes.

When it's hot we swim in the lake.

Every winter we go ice fishing.

Sometimes we find a lucky penny.

After breakfast we make our beds.

Local Agreement Sentences (ungrammatical)

At breakfast I eats a bowl of cereal.

Every evening I visits a friend next door.

After school I helps a friend with homework.

Sometimes I sits on my bed and read.

In cold weather I wears a heavy coat.

Every morning I feeds all my pets.

When it rains I wears a pair of boots.

When it's hot I wears a short sleeve shirt.

When it's warm I rides a bike to school.

Sometimes I brings a friend to my house.

Every morning they buys a newspaper.

At lunch they sits at a big round table.

Every day they lets us play games with them.

After work they sweeps up the office.

Every day they rides a bus to school.

Every afternoon they talks about the weather.

When it rains they carries an umbrella.

When it's cold they builds a warm fire.

When it's cold they sleeps under a heavy blanket.

When it snows they builds a snowman.

Every day we runs around the playground.

Every morning we cooks a dozen eggs.

At night we turns off the lights at ten o'clock.

Before school we checks our homework.

Every summer we plants a vegetable garden.

Every day we talks on the telephone.

Every evening we comes inside to play.

When it's sunny we sits in the shade.

At night we looks at the moon.

Sometimes we laughs at a funny story.

Long-Distance Finiteness Sentences (grammatical)

She makes the hungry girl eat a hamburger.

He makes the thirsty boy drink a glass of water.

She makes the curious girl open a birthday present.

He makes the busy boy eat a healthy lunch.

She makes the pretty girl wait in line.

She makes the happy girl come over to visit her.

He watches the little boy kick a red ball.

She watches the graceful girl dive into the pool.

She watches the helpful man carry a large package.

She watches the fast pony leap over a fence.

He watches the silly monkey wear a straw hat.

He watches the big dog sleep on a rug.

Does the nice lady smile at the clown?

Does the gentle nurse hold a child's hand?

Does the smart student work on her homework?

Does the slow turtle crawl under a rock?

Does the huge whale dive under the water?

Does the little duck swim on the pond?

Let's watch the yellow bird fly across the sky.

Let's watch the busy squirrel bury an acorn.

Let's watch the furry bunny eat a fresh carrot.

Let's watch the clever student read a difficult book.

Let's watch the little baby hold a shiny toy.

Let's watch the young girl hug a stuffed animal.

Let's have the quiet girl paint a pretty picture.

Let's have the young pilot land on the runway.

Let's have the nice babysitter bake a chocolate cake.

Let's have the friendly waiter bring a glass of water.

Let's have the proud fisherman show us his fish.

Let's have the young chef cook a delicious meal.

Long-Distance Finiteness Sentences (ungrammatical)

He makes the dirty boy takes a warm bath.

She makes the nice girl picks a new toy.

He makes the playful boy dives into the pool.

She makes the nervous girl reads a scary story.

He makes the quiet boy talks a little louder.

He makes the noisy boy goes outside to play.

She watches the happy girl climbs up the ladder.

She watches the sleepy girl falls asleep.

He watches the thirsty farmer drinks a glass of water.

She watches the dirty kitten licks its paw.

She watches the green frog leaps into the water.

She watches the wise owl sits on a branch.

Does the brave fireman drives a red truck?

Does the nice doctor looks into the child's ear?

Does the handsome prince rides a black horse?

Does the wild deer jumps over the fence?

Does the shy mouse hides under the bed?

Does the curious cat hides inside the sack?

Let's watch the black cow stands in the field.

Let's watch the noisy bird builds a sturdy nest.

Let's watch the friendly dolphin leaps into the air.

Let's watch the young cowboy finds a lost cow.

Let's watch the helpful teacher writes on the board.

Let's watch the graceful dancer stands on one foot.

Let's have the kind maid brings us extra towels.

Let's have the talented boy sings a popular song.

Let's have the silly clown makes a balloon animal.

Let's have the clever girl builds a sand castle.

Let's have the interesting lady talks about her life.

Let's have the tired boy sleeps on the sofa.

Filler Sentences

He makes an ice cream sundae.

She makes a sandwich for lunch.

He makes a funny face.

She makes a list of things to do.

Let's have a piece of chocolate cake for dessert.

Let's have a glass of iced tea with dinner.

Let's have a good time at the party.

Let's have a snack before bedtime.

Let's watch a baseball game this afternoon.

Let's watch a new movie at the theater.

Let's watch a cartoon on TV.

Let's watch a parade on New Year's Day.

He watches a funny movie on TV.

She watches a music video on MTV.

He watches a news program before bedtime.

She watches a funny video on the internet.

References

Archibald L, Gathercole S. Nonword repetition: A comparison of tests. *Journal of Speech, Language, and Hearing Research*. 2006; 49:970–983.

- Boersma, P.; Weenik, D. Praat [Computer software]. University of Amsterdam; Amsterdam: 2004.
- Brown, L.; Sherbenou, R.; Johnsen, S. Test of Nonverbal Intelligence – 4. Psychological Corporation; San Antonio, TX: 2010.
- Burgemeister, B.; Blum, L.; Lorge, I. Columbia Mental Maturity Scale. Harcourt Brace Jovanovich; New York: 1972.
- Catts H, Fey M, Tomblin JB, Zhang X. A longitudinal investigation of reading outcomes in children with language impairments. *Journal of Speech, Language, and Hearing Research*. 2002; 45:1142–1157.
- Cohen, M. [05/27/2013] Handedness Questionnaire. 2008. from <http://www.brainmapping.org/shared/Edinburgh.php#>
- Conti-Ramsden G, Botting N, Faragher B. Psycholinguistic markers for specific language impairment. *Journal of Child Psychology and Psychiatry*. 2001; 42:741–748. [PubMed: 11583246]
- Coulson S, King J, Kutas M. Expect the unexpected: Even-related brain potentials to morphosyntactic violations. *Language and Cognitive Processes*. 1998; 13:21–58.
- Dollaghan C, Campbell T. Nonword repetition and child language development. *Journal of Speech, Language, and Hearing Research*. 1998; 41:1136–1146.
- Fenson, L.; Dale, P.; Reznick, J.; Thal, D.; Bates, E.; Hartung, J., et al. The MacArthur-Bates Communicative Development Inventories: User's guide and technical manual. Brookes; Baltimore, MD: 1993.
- Fonteneau E, van der Lely H. Electrical brain responses in language-impaired children reveal grammar-specific deficits. *PLOS ONE*. 2008; 3:e1832. [PubMed: 18347740]
- Friederici A. Towards a neural basis of auditory sentence processing. *Trends in Cognitive Science*. 2002; 6:78–84.
- Graf Estes K, Evans J, Else-Quest N. Differences in the nonword repetition performance of children with and without specific language impairment. *Journal of Speech, Language, and Hearing Research*. 2007; 50:177–195.
- Gouvea A, Phillips C, Kazanina N, Poeppel D. The linguistic processes underlying the P600. *Language and Cognitive Processes*. 2010; 25:149–188.
- Hampton Wray A, Weber-Fox C. Specific aspects of cognitive and language proficiency account for variability in neural indices of semantic and syntactic processing in children. *Developmental Cognitive Neuroscience*. 2013; 5:149–171. [PubMed: 23557881]
- Hays, WL. Statistics. Fifth edition.. Harcourt Brace College Publishers; Fort Worth, TX: 1994.
- Hesketh A, Conti-Ramsden G. Memory and language in middle childhood in individuals with a history of specific language impairment. *PLOS ONE*. 2013; 8:e56314. [PubMed: 23409172]
- Hollingshead, A. Four factor index of social status. Yale University, Department of Sociology; New Haven, CT: 1975. Unpublished manuscript
- Kaan E, Harris A, Gibson E, Holcomb P. The P600 as an index of syntactic integration difficulty. *Language and Cognitive Processes*. 2000; 15:159–201.
- Karmiloff-Smith A. Nativism versus neuroconstructivism: Rethinking the study of developmental disorders. *Developmental Psychology*. 2009; 45:56–63. [PubMed: 19209990]
- Leonard, L. Children with specific language impairment. MIT Press; Cambridge, MA: 1998.
- Leonard L, Davis J, Deevy P. Phonotactic probability and past tense use by children with specific language impairment and their typically developing peers. *Clinical Linguistics and Phonetics*. 2007; 21:747–758. [PubMed: 17882693]
- Leonard L, Deevy P. Input distribution influences degree of auxiliary use by children with SLI. *Cognitive Linguistics*. 2011; 22:247–273. [PubMed: 23750074]
- Leonard L, Deevy P, Kurtz R, Krantz Chorev L, Owen A, Polite E, Elam D, Finneran D. Lexical aspect and the use of verb morphology by children with specific language impairment. *Journal of Speech, Language, and Hearing Research*. 2007; 50:759–777.
- Leonard L, Miller C, Finneran D. Grammatical morpheme effects on sentence processing by school-aged adolescents with specific language impairment. *Language and Cognitive Processes*. 2009; 24:450–478. [PubMed: 19690626]

- Leonard L, Miller C, Gerber E. Grammatical morphology and the lexicon in children with specific language impairment. *Journal of Speech, Language, and Hearing Research*. 1999; 42:1076–1085.
- Marchman V, Wulfeck B, Ellis Weismer S. Morphological productivity in children with normal language and SLI: A study of the English past tense. *Journal of Speech, Language, and Hearing Research*. 1999; 42:206–219.
- Metting VanRijn, AC.; Kuiper, AP.; Dankers, TE.; Grimbergen, CA. Low-cost active electrode improves the resolution in biopotential recordings.. Paper presented at the 18th Annual International Conference of the IEEE Engineering in Medicine and Biology Society; Amsterdam, The Netherlands. 1996.
- Metting VanRijn AC, Peper A, Grimbergen CA. High-quality recordings of bioelectric events. Part 1: Interference reduction, theory and practice. *Medical and Biological Engineering and Computing*. 1990; 28:389–397. [PubMed: 2277538]
- Neville H, Coffey S, Holcomb P, Tallal P. The neurobiology of sensory and language processing in language-impaired children. *Journal of Cognitive Neuroscience*. 1993; 5:235–253. [PubMed: 23972156]
- Norbury CF, Bishop DVM, Briscoe J. Production of English finite verb morphology: A comparison of SLI and mild-moderate hearing impairment. *Journal of Speech, Language, and Hearing Research*. 2001; 44:165–178.
- Oldfield R. The assessment and analysis of handedness: The Edinburgh Inventory. *Neuropsychologia*. 1971; 9:97–113. [PubMed: 5146491]
- Osterhout L, Holcomb P. Event-related potentials and syntactic anomaly. *Journal of Memory and Language*. 1992; 31:785–804.
- Osterhout L, Mobley L. Event-related brain potentials elicited by failure to agree. *Journal of Memory and Language*. 1995; 34:739–773.
- Pakulak E, Neville H. Proficiency differences in syntactic processing of monolingual native speakers indexed by event-related potentials. *Journal of Cognitive Neuroscience*. 2010; 22:2728–2744. [PubMed: 19925188]
- Pflieger, ME. Theory of a spatial filter for removing ocular artifacts with preservation of EEG.. Paper presented at the EMSE Workshop; Princeton University; 2001.
- Phillips C, Kazanina N, Abada S. ERP effects of the processing of syntactic long-distance dependencies. *Cognitive Brain Research*. 2005; 22:407–428. [PubMed: 15722211]
- Redmond S, Rice M. Detection of irregular verb violations by children with and without SLI. *Journal of Speech, Language, and Hearing Research*. 2001; 44:655–669.
- Redmond S, Thompson H, Goldstein S. Psycholinguistic profiling differentiates specific language impairment from typical development and from attention-deficit/hyperactivity disorder. *Journal of Speech, Language, and Hearing Research*. 2011; 54:99–117.
- Rice M, Hoffman L, Wexler K. Judgments of omitted BE and DO in questions as extended finiteness clinical markers of specific language impairment (SLI) to 15 years: A study of growth and asymptote. *Journal of Speech, Language, and Hearing Research*. 2009; 52:1417–1433.
- Rice M, Wexler K. Toward tense as a clinical marker of specific language impairment in English-speaking children. *Journal of Speech and Hearing Research*. 1996; 39:1239–1257. [PubMed: 8959609]
- Rice M, Wexler K, Cleave P. Specific language impairment as a period of extended optional infinitive. *Journal of Speech, Language, and Hearing Research*. 1995; 38:850–863.
- Rice M, Wexler K, Hershberger S. Tense over time: The longitudinal course of tense acquisition in children with specific language impairment. *Journal of Speech, Language, and Hearing Research*. 1998; 41:1412–1431.
- Rice M, Wexler K, Redmond S. Grammaticality judgments of an extended optional infinitive grammar: Evidence from English-speaking children with specific language impairment. *Journal of Speech, Language, and Hearing Research*. 1999; 42:943–961.
- Sabisch B, Hahne C, Glass E, von Suchodoletz W, Friederici A. Children with specific language impairment: The role of prosodic processes in explaining difficulties in processing syntactic information. *Brain Research*. 2009; 1261:37–44. [PubMed: 19401165]

- Scarborough H, Dobrich W. Development of children with early language delay. *Journal of Speech and Hearing Research*. 1990; 33:70–83. [PubMed: 2314086]
- Schopler, E.; Van Bourgondien, M.; Wellman, G.; Love, S. *Childhood Autism Rating Scale - 2*. Western Psychological Services; Los Angeles, CA: 2010.
- Semel, E.; Wiig, E.; Secord, W. *Clinical Evaluation of Language Fundamentals – 4*. Psychological Corporation; San Antonio, TX: 2003.
- van der Lely H. Language and cognitive development in a grammatical SLI boy: Modularity and innateness. *Journal of Neurolinguistics*. 1997; 10:75–107.
- Weber-Fox C, Leonard L, Hampton Wray A, Tomblin JB. Electrophysiological correlates of rapid auditory and linguistic processing in adolescents with specific language impairment. *Brain and Language*. 2010; 115:162–181. [PubMed: 20889197]
- Werner, E.; Kresheck, J. *Structured Photographic Expressive Language Test – II*. Janelle; Dekalb, IL: 1983.
- Wexler, K. Optional infinitives, Head movement and the economy of derivation.. In: Lightfoot, D.; Hornstein, N., editors. *Verb movement*. Cambridge University Press; Cambridge, England: 1994. p. 305-350.

Figure 1. Mean accuracy (A' values) on the sentence acceptability judgment task. Error bars are 95% confidence intervals.

Figure 2.

Grand-averaged waveforms for TD group – local agreement sentences. Examples of grammatical and ungrammatical sentences are *Every night they talk on the phone* and *Every night they talks on the phone*, respectively.

Figure 3. Grand-averaged waveforms for H-SLI group – local agreement sentences. Examples of grammatical and ungrammatical sentences are *Every night they talk on the phone* and *Every night they talks on the phone*, respectively.

Figure 4.

Grand-averaged waveforms for TD group - long-distance finiteness sentences. Examples of grammatical and ungrammatical sentences are *He makes the quiet boy talk a little louder* and *He makes the quiet boy talks a little louder*, respectively.

Figure 5.

Grand-averaged waveforms for H-SLI group - long-distance finiteness sentences. Examples of grammatical and ungrammatical sentences are *He makes the quiet boy talk a little louder* and *He makes the quiet boy talks a little louder*, respectively.

Figure 6. Mean P600 amplitudes for TD (upper) and H-SLI (lower) groups for mid-lateral centro-parietal sites for the early, mid, and late temporal windows for the long-distance finiteness sentences. Error bars reflect standard errors.