Research Note

Sensitivity to Morphosyntactic Information in Preschool Children With and Without Developmental Language Disorder: A Follow-Up Study

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Purpose: This study tested children's sensitivity to tense/agreement information in fronted auxiliaries during online comprehension of questions (e.g., *Are the nice little dogs running?*). Data from children with developmental language disorder (DLD) were compared to previously published data from typically developing (TD) children matched according to sentence comprehension test scores.

Method: Fifteen 5-year-old children with DLD and fifteen 3-year-old TD children participated in a looking-while-listening task. Children viewed pairs of pictures, 1 with a single agent and 1 with multiple agents, accompanied by a sentence with a fronted auxiliary (*is* + single agent or *are* + two agents) or a control sentence. Proportion looking to the target was measured.

Results: Children with DLD did not show anticipatory looking based on the number information contained in the auxiliary (*is* or *are*) as the younger TD children had. Both groups

showed significant increases in looking to the target upon hearing the subject noun (e.g., *dogs*).

Conclusions: Despite the groups' similar sentence comprehension abilities and ability to accurately respond to the information provided by the subject noun, children with DLD did not show sensitivity to number information on the fronted auxiliary. This insensitivity is considered in light of these children's weaker command of tense/agreement forms in their speech. Specifically, we consider the possibility that failure to grasp the relation between the subject-verb sequence (e.g., *dogs running*) and preceding information (e.g., *are*) in questions in the input contributes to the protracted inconsistency in producing auxiliary forms in obligatory contexts by children with DLD.

Supplemental Material: <https://doi.org/10.23641/asha.7283459>

Among the groups of children experiencing significant difficulties with language learning is a group referred to as children with developmental language disorder (DLD), also frequently labeled children with specific language impairment. These are children whose significant limitations with language cannot be attributed to factors such as hearing impairment, neurological damage or disease, intellectual disability, or autism spectrum disorder. Children with DLD constitute a heterogeneous group. Nevertheless, there are common linguistic profiles that emerge in the literature on these children. For children with DLD acquiring English, a common profile is a mild to

moderate deficit in areas of language such as vocabulary and phonology and a more severe deficit in the area of morphosyntax. During the preschool years, the latter deficit is often reflected in these children's inconsistency in producing morphemes that express tense and agreement (T/A). For example, a 5-year-old with DLD might say *Molly sings every day* in one instance and *Molly sing every day* in another. The same child might also alternate between saying *Tanya's running* and *Tanya running*. When the T/A morpheme is produced, it is usually correct; the problem is that often this morpheme is omitted in contexts in which it is obligatory.

Attempts to explain this inconsistency have ranged from accounts that rely on linguistic principles to those that depend on notions of processing speed or capacity (see Leonard, 2014, for a review). In recent years, accounts that place greater emphasis on the importance of child-directed input have emerged in the literature. One such account has been offered by Leonard and his colleagues and has been referred to as the "competing sources of input" account

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Editor-in-Chief: Sean Redmond

Editor: Megan Dunn Davison

Received January 30, 2018

Revision received April 18, 2018

Accepted July 1, 2018

https://doi.org/10.1044/2018_JSLHR-L-18-0038

Disclosure: The authors have declared that no competing interests existed at the time of publication.

(Leonard, 2014). This account assumes that some portion of children's inconsistency with T/A morphemes can be attributed to the children's difficulty in interpreting sentences in which a subject–nonfinite verb sequence appears toward the end of an input sentence, as in *Let's watch The Frog Hop, Make the car go faster, I saw the girl running, Is the boy playing the guitar?* and *Did the horse win the race?*, among others. Although not appropriate as independent sentences, these sequences can occur as part of larger structures in which a lexical verb (e.g., *watch, make, saw*) or auxiliary verb (e.g., *is, did*) that appears earlier in the sentence calls for a nonfinite verb to follow. According to the competing sources of input approach, children have difficulty in grasping this dependency relationship.

Initially, even young typically developing (TD) children are assumed to have difficulty in understanding this relationship. However, for children with DLD, this difficulty may be protracted, extending through the late preschool years and sometimes beyond. The following developmental progression is hypothesized. For all children, input utterances such as *Look, the cat's eating* and *Wow, that dog runs really fast* are assumed to be the basis for children's corresponding utterances (*The cat's eating, That dog runs fast*) that contain T/A morphemes. However, at the same time, children hear input sentences such as *I see the cat eating, Is the cat eating?, Watch that dog run really fast, and Does the dog run really fast?* Early in typical language development, young children will not grasp the structural ties in the latter sentences, and so there will be no constraints on extracting the subject–nonfinite verb sequences and using them as stand-alone utterances (e.g., *The cat eating, That dog run really fast*). Therefore, for a brief period, there will be two sources of generating new sentences that express the same proposition (*The cat's eating, The cat eating*). These alternative sources for generating otherwise similar utterances give the account its name—competing sources of input.

Young TD children quickly learn that these subject–nonfinite verb sequences are structurally connected to the T/A-marked lexical or auxiliary verb appearing earlier in the input utterance. As a result, the subject–nonfinite verb sequence no longer serves as the basis for generating new stand-alone utterances. In contrast, children with DLD continue to have difficulty with input sentences of this type. Consequently, the subject–nonfinite verb sequences continue to serve as one source for generating new utterances (e.g., *The girl eating, The cat running, The boy run fast, The dog bark*).

Several types of evidence have been gathered to support the basic assumptions of the competing sources of input proposal. Leonard and Deevy (2011) and Leonard, Fey, Deevy, and Bredin-Oja (2015) adapted a novel verb teaching procedure first used by Theakston, Lieven, and Tomasello (2003). In these studies, preschool-age children with DLD with inconsistent use of T/A morphemes were compared to either age-matched TD children at mastery levels in their T/A production or younger TD children approaching mastery levels. The children were presented with one set of novel verbs exclusively in sentences with T/A marking (e.g., *The bird was channing, All day long the dog*

rells, Do you think the cat pags?) and another set exclusively in sentences containing subject–nonfinite verb sequences (e.g., *We saw the bird neffing, Let's watch the cat mabb, Does the dog tome?*). Following the presentation period, the children were tested on their use of all novel verbs in contexts in which a T/A morpheme was required (e.g., contexts requiring *The cow is neffing, Every day the mouse mabbs*). The results indicated that the children with DLD were more likely than their TD counterparts to use the novel verb in the way it was originally heard. This result was not due only to the children's generally weaker production of T/A morphology because, for novel verbs heard exclusively in contexts with T/A morphemes, the children with DLD actually showed a higher level of appropriate T/A production than in their everyday language.

Although these studies show that children with DLD are more likely than TD children to be influenced by how a novel verb appears in the input, it does not reveal the reasons why these children might be more prone to produce a verb inappropriately if it was heard in a subject–nonfinite verb sequence. In two different experiments, Leonard and colleagues asked whether some of the input structures containing subject–nonfinite verb sequences might cause comprehension problems for these children (Leonard & Deevy, 2011; Souto, Leonard, Deevy, Fey, & Bredin-Oja, 2016). Children with DLD and younger TD children matched on sentence comprehension test scores were presented with sentences such as *The dad sees the girl sleeping*. Comprehension of these sentences was assessed through a multiple-choice picture-pointing format. In both studies, the children with DLD were less accurate than the younger TD children. Inspection of the children's language production revealed that, although the DLD and TD groups were matched on sentence comprehension test scores, the TD children showed much greater use of T/A morphemes than the children with DLD.

As noted earlier, according to the competing sources of input proposal, a variety of input structures containing subject–nonfinite verb sequences could contribute to alternation between correct T/A morpheme production and the omission of these morphemes. Structures seen in sentences such as *The dad sees the girl sleeping* could certainly be one of them. In fact, some of the utterances documented in the DLD literature, such as *Her sleeping*, might have their origins in input sentences such as *The dad sees her sleeping*. However, if the competing sources of input proposal is correct, other input structures must also play a role, perhaps a more dominant role.

Questions with fronted auxiliary or copula verbs appear to be a likely source, for several reasons. First, questions are frequent in the input, constituting approximately 32% of speech directed to young children (Cameron-Faulkner, Lieven, & Tomasello, 2003). Second, children with DLD are just as likely or more likely to say *She sleeping* as to say *Her sleeping*. Of the potentially problematic input structures, those with fronted auxiliaries or copula forms are the ones containing pronouns with nominative case such as *she* and *he* (e.g., *Is she sleeping?*). Third, Rispoli, Papastratakos, Stern, and Hadley (2015) found that parents'

use of uncontractible copula *is* in declaratives was predictive of their children's future copula *is* production, but the parents' use of copula *is*-fronted questions was not facilitative. Finally, Fey, Leonard, Bredin-Oja, and Deevy (2017) conducted an intervention study in which children with DLD were assigned randomly to one of two conditions. One condition included a comprehension activity in which the children needed to attend to the tense of the fronted auxiliary in order to select the correct visual scenario, as in *Is the girl climbing a ladder?* versus *Was the girl climbing the ladder?* The other condition used an otherwise identical activity but the children could ignore the tense of the fronted auxiliary because the contrasts were of the type *Is the girl climbing a ladder?* versus *Is the boy climbing a ladder?* Children assigned to the first condition showed greater gains in their use of auxiliary *is*. Although these findings are in line with expectations based on the competing sources of input proposal, the treatment procedures used in the two conditions employed by Fey et al. (2017) differed in other respects as well, and therefore, the results cannot be uniquely attributed to the comprehension activities.

In this study, we approached the issue of children's understanding of the dependency relations in auxiliary-fronted questions in a different way. We made the assumptions that children with DLD detect the presence of fronted auxiliaries in questions, and they understand the pragmatic force of questions—that these utterances seek information or confirmation from the listener. However, according to the competing sources of input proposal, these children do not appreciate that the fronted auxiliary is structurally tied to the rest of the utterance. Off-line responses to questions such as *Is the little boy running?* do not serve as a sensitive means of testing this proposal, because once children hear the entire question, they can respond to the basic proposition. Instead, we employed a looking-while-listening (LWL) paradigm in which the children saw pictures on a screen corresponding to questions such as *Is the nice little boy running?* and *Are the nice little dogs running?* The number information in the fronted auxiliary (*Is* vs. *Are*) provided a cue to the target picture (e.g., one boy running vs. two dogs running) that was not available in control sentences (e.g., *See the nice little boy running?* *See the nice little dogs running?*). In LWL, eye gaze patterns reveal incremental processing of information in a sentence. In this case, if children know that the fronted auxiliary must be structurally connected to the unfolding sentence, they might use its number cue to anticipate the sentence subject and look immediately to the corresponding picture before hearing the subject noun named (e.g., ...*boy*, ...*dogs*).

Using these questions in a previous LWL study, Deevy, Leonard, and Marchman (2017) found that 3-year-old TD children who were nearing mastery in their use of auxiliary *is* and *are* (averaging over 90% in obligatory contexts) showed clear evidence of anticipatory looking. That is, the children showed greater looking toward the target picture on the basis of the number information in the auxiliary, before the noun was heard. Lukyanenko and Fisher (2016) have also provided evidence of anticipatory looking by young

TD children, using questions with copula forms such as *Where is/are the good cookie/cookies?* However, these investigators did not report the children's own level of T/A use.

Anticipatory looking is not the only way that children can show sensitivity to the number information in fronted auxiliary or copula forms. Lukyanenko and Fisher (2016) noted that “integration” can occur along with or instead of “prediction” (their term for anticipatory looking). In integration, children use the earlier-appearing number information in the auxiliary or copula form to constrain word identification but only *after* candidate nouns have been activated based on perceptual (phonetic) evidence. Within the LWL paradigm, integration is reflected by greater looking at the appropriate picture after the noun is heard for questions such as *Are the nice little dogs running?* than for control sentences that lack number cues, such as *See the nice little dogs running?*

Either fronted auxiliary or fronted copula forms could be employed to test children's sensitivity to earlier-appearing number information. We chose fronted auxiliary *is/are* in questions in this study, because children's failure to make use of the fronted auxiliary could lead to the extraction and production of the subject–nonfinite verb sequences (e.g., *Man driving a truck*) that are so frequently cited in the DLD literature and observed in novel verb studies with these children (e.g., Leonard & Deevy, 2011). The TD children participating in Deevy et al. (2017) served as our comparison group. These 3-year-olds served as a suitable basis of comparison with our 4- and 5-year-old children with DLD because their scores on a standardized test of sentence comprehension were very similar. Importantly (and as is expected in such comparisons), the children with DLD were significantly more limited in their auxiliary production than the younger TD children. Accordingly, if one source of T/A inconsistency is a failure to appreciate the structural ties between fronted auxiliaries and the remainder of the question, the children with DLD should differ from the younger TD children by showing no evidence of the use of this information either to anticipate (predict) or integrate the subject noun, despite resembling these children in their scores on a more general sentence comprehension test.

Evidence of prediction would be reflected in significantly greater looking to the target in the “T/A cue” condition than in the “no T/A cue” condition before hearing the subject noun (as was found in our TD group). Evidence of integration would be reflected in this same pattern of looking (i.e., the preference for the T/A cue condition) when it occurs after the onset of the subject noun.

In the case of children with DLD, it is important to ensure that an at-noun response could be safely interpreted. These children often show slow response times on a variety of linguistic and nonlinguistic tasks (e.g., Leonard et al., 2007). Therefore, it is possible that a response to *is* or *are* at the point of the noun could reflect anticipation with slow execution of the looking response. We try to guard against this possible ambiguity in this study by increasing the distance between auxiliary *is/are* and the target noun, inserting two

rather than one adjective between them (e.g., *nice little*). If the children with DLD are capable of prediction, the added distance should provide sufficient time for a detectable response to *is* and *are* prior to noun onset. With this added distance, it should be easier to interpret these children's looking responses toward the target at the point of the noun. Greater looking in response to questions such as *Are the nice little dogs running?* than in response to control questions such as *See the nice little dogs running?* would suggest integration. However, if the children look at the target picture to the same degree regardless of condition, it would appear they were responding solely to the noun. Such a pattern might suggest that the fronted auxiliary (*is*, *are*) was serving primarily as a pragmatic signal of a question rather than also representing a constituent that has a close structural relationship with the remainder of the question.

Accordingly, we test the following predictions:

1. Based on the competing sources of input account, children with DLD who are inconsistent in their production of auxiliary *is* and *are* will show no anticipatory looking at the appropriate picture in response to questions of the type *Is the nice little boy running?* and *Are the nice little dogs running?* They will differ in this regard from younger TD children matched on sentence comprehension test scores who show greater production of auxiliary *is* and *are*.
2. The children with DLD will also differ from the younger TD children by showing no looking difference in the noun region (i.e., once the noun has been heard) between questions such as *Are the nice little dogs running?* and control sentences such as *See the nice little dogs running?* Unlike the TD children, then, the DLD group will provide no evidence of integration.
3. In contrast, the children with DLD will demonstrate overall responsiveness to the task by showing greater looking at the appropriate picture in the noun region than in the pre-noun region. These children will resemble the younger TD children in this regard. Thus, the children with DLD will be responsive to the questions as a whole but lack sensitivity to the structural relations between the fronted auxiliary and the remainder of the utterance.

Method

Participants

A total of 34 preschool-age children participated in this study, including 19 children with DLD and 15 TD children whose data were previously reported (Deevy et al., 2017). During data analysis, it became apparent that four children with DLD who participated did not meet our criterion for minimum number of useable trials (see Measures/Data Analysis below); thus, we describe and report data for 15 children with DLD. These children were recruited through speech-language pathologists in local schools and

private clinics. We obtained informed consent to participate from each child's parent in accord with the policies of the human subjects review board of the authors' institution.

Children with DLD ranged in age from 4;0 (years; months) to 5;11 ($M = 4;11$, $SD = 7.75$ months); eight were males, and 11 were females. Thirteen children were White, one was African American/White, and one was Asian/White. All children were monolingual and came from homes in which only mainstream American English was spoken. All met exclusionary criteria established for specific language impairment (here referred to as DLD): They passed a hearing screening, an oral motor screening, and screening for autism spectrum disorder, the Childhood Autism Rating Scale, Second Edition (Schopler, Reichler, & Renner, 2010). All received a standard score above 85 on either the Primary Test of Nonverbal Intelligence (Ehrler & McGhee, 2008) or the Kaufman Assessment Battery for Children, Second Edition (Kaufman & Kaufman, 2004; $M = 106.73$, $SD = 10.07$). Our inclusionary criterion for this group was a standard score below 87 on the Structured Photographic Expressive Language Test–Preschool 2 (SPELT-P 2; Dawson, Eyer, & Fonkalsrud, 2005), determined by Greenslade, Plante, and Vance (2009) to be the cutoff point yielding high sensitivity and specificity for this age group. Thirteen of the children scored below this cutoff, and two scored slightly above it ($M = 77.73$, $SD = 7.94$, range 61–89). In order to confirm the diagnosis of the latter two children, their language samples were analyzed using Developmental Sentence Scoring (Lee, 1974). Both were retained because their Developmental Sentence Scoring score fell below the 10th percentile. Note that, for the SPELT-P 2, the standard score ranges of the DLD and TD groups (see below) were nonoverlapping, even when the standard error of measurement was taken into account.

Children in the TD group were, on average, approximately 1.5 years younger ($M = 3;6$, $SD = 3.3$ months); 11 were males, and four were females. Fourteen were White, and one was Hispanic and American Indian/Alaska Native; all came from monolingual, mainstream English-speaking homes. All children passed a hearing screening and received a standard score above 85 on the Primary Test of Nonverbal Intelligence ($M = 119.23$, $SD = 12.58$) and above 87 on the SPELT-P 2 ($M = 118.17$, $SD = 8.17$, range 98–131).

In anticipation of a study comparing their performance with an older DLD group, children in the TD group completed a measure of their general sentence comprehension abilities: the Sentence Structure subtest of the Clinical Evaluation of Language Fundamentals Preschool–Second Edition (Wiig, Secord, & Semel, 2004). All children with DLD also received this test; 14 matched a TD child within 2 points in raw score and one matched within 4 points. Thus, the two groups' sentence comprehension abilities were comparable (DLD: $M = 15.80$, $SD = 3.65$, range 7–22; TD: $M = 14.33$, $SD = 2.58$, range 9–20; $t(28) = 1.21$, $p = .28$, $d = 0.47$). As expected, scaled scores (thus anchored to chronological age) on the same subtest differed significantly (DLD: $M = 10.13$, $SD = 2.47$, range 6–15; TD: $M = 12.33$,

$SD = 1.68$, range 9–16; $t(28) = -2.85$, $p = .008$, $d = 1.04$). Groups did not differ in socioeconomic status, as measured by years of maternal education (DLD: $M = 15.67$, $SD = 2.77$; TD: $M = 16.67$, $SD = 2.09$; $t(28) = -1.12$, $p = .27$, $d = 0.41$).

Auxiliary *Is* and *Are* Production Measures

To document children's use of auxiliary *is* and *are*, we examined production accuracy through an elicitation task and a spontaneous language sample. We used an auxiliary production probe task with 10 *is* items and 10 *are* items (Leonard et al., 2003). While watching a sentence enacted with toys, the children were prompted to complete a declarative sentence beginning with either a singular or plural noun phrase. Items were counted as scorable if the child provided a sentence continuation that included the target verb (or an acceptable semantic substitute) in progressive form (see Example 1). In this context, children were not expected to repeat the subject noun phrase in their response and rarely did so. Hence, nearly all productions of auxiliary were uncontracted.

1. Experimenter: "Tell me about the babies. The babies..."
Child: "... are crying." Or "... crying."

For each child, a percentage of correct use of auxiliary *is* and *are* was computed by dividing the number of correct productions by the number of scorable items and multiplying by 100. Incorrect responses were primarily omissions but also included substitutions of the alternative form (e.g., *is* for *are*).

The spontaneous speech sample was collected for each child during conversational play and consisted of at least 125 utterances. Samples were audio-recorded and transcribed using the Systematic Analysis of Language Transcripts (Miller & Iglesias, 2010). Percentages of use of auxiliary *is* and *are* in obligatory contexts were calculated. For auxiliary *are*, all contexts were counted, including those for first-person singular (*we*) and second person (*you*). Two trained examiners transcribed each sample, comparing their coding of grammatical morphology. Discrepancies were resolved through consensus.

As reported in Deevy et al. (2017), the TD children showed high accuracy with these morphemes, averaging 93.93% correct use of *is* ($SD = 10.59$) and 98.00% correct use of *are* ($SD = 4.14$) on the elicitation task. Similarly high averages were seen in their spontaneous speech ($M = 94.03$, $SD = 10.05$ and $M = 88.10$, $SD = 22.86$ for *is* and *are*, respectively). As expected, children with DLD demonstrated lower levels in both *is* and *are* on the elicitation task, averaging 69.98% ($SD = 35.24$) and 62.42% correct ($SD = 36.33$), respectively; accuracy was lower in the spontaneous speech sample ($M = 35.41$, $SD = 32.15$ and $M = 35.18$, $SD = 38.23$ for *is* and *are*, respectively). A mixed-model analysis of variance was conducted on children's auxiliary production accuracy, with participant group as a between-subjects variable and measure (elicitation task, spontaneous speech) and number (singular auxiliary *is*, plural auxiliary *are*) as

within-subject variables. We found a significant effect of group, $F(2, 27) = 91.31$, $p < .0001$, partial $\eta^2 = .77$, favoring the TD children. A significant effect of measure, $F(1, 27) = 8.30$, $p < .01$, partial $\eta^2 = .24$, was found reflecting better performance on the probes; this was likely due to the relatively low formulation demands of this task, which required children simply to supply the verb phrase. There were no other significant effects or interactions.

The accuracy of auxiliary production varied widely for children with DLD whereas TD children showed much less variability. Although children with DLD were inconsistent in their production of these morphemes, each did show at least one use of both *is* and *are*, either in spontaneous speech or in the probes (range for *is*: 17%–100%, range for *are*: 13%–100%). Thus, a failure to use the cue provided by these morphemes in the LWL task could not reflect a lack of knowledge of *is* and *are*. Although children with DLD occasionally reached a high level of accuracy, this was typically confined to an individual form or measure. Thus, no child was at 100% on both *is* and *are*; in addition, any child who scored 100% on a morpheme on the probes was at or below 50% in spontaneous speech for the same morpheme.

Procedure—LWL

During the LWL procedure, children sat in front of a 54-in. flat screen high-definition television and viewed pairs of drawings. Each pair was accompanied by a sentence that described one of the drawings. A digital camera situated directly below the center of the screen recorded the child's face. Four familiarization trials were followed by 32 experimental trials presented in pseudorandom order using PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993). No more than three consecutive targets appeared on the same side, and no more than three consecutive targets were in the same condition. The pictures remained on-screen during the trial. Each trial comprised a 1,500-ms silent preview, followed by presentation of the sentence (3,800 ms) and another 2,500 ms of silence.

After every eight experimental trials, a reinforcement trial occurred, featuring an image of a cartoon character and an encouraging statement. After Trial 16, children were given a short break, during which they had the opportunity to stand up, stretch, and talk. The entire procedure lasted about 6 min. To ensure a sufficient number of usable experimental trials, children repeated the task on a subsequent day, viewing a different pseudorandom order. This resulted in a total of 64 trials per child with 16 trials in each condition. List order was counterbalanced across children.

Stimuli

Sixteen color illustrations depicted eight different agent–action combinations (see Supplemental Materials S1 and S2 for example illustrations). For each combination, two versions were created, one featuring a single agent and one featuring a pair of agents (e.g., *dog running*, *dogs running*). On each trial, the target and distractor featured

the same action but different agents, always differing in number (e.g., *one boy running, two dogs running*). In order to control for salience, these pairs were yoked, and the plural and singular versions were matched in overall size. Each of the eight agent–action combinations appeared equally often in its singular and plural version and equally often as target and distractor, with location of the target picture (left or right) counterbalanced.

The auditory stimuli consisted of 32 sentences recorded by a female native speaker of English. Eight subject–verb combinations appeared in a cross of two conditions (T/A cue or no T/A cue; singular or plural subject number; sentence stimuli are provided in online supplemental materials, Supplemental Material S3). The stimulus sentences were constructed to align the timing of critical onsets, that is, the onsets of words that identified the target picture. In both the T/A cue and no T/A cue conditions, the target picture could be identified at the noun. In the T/A cue condition, the inverted number-marked auxiliary provided an earlier cue. If children did not detect the early cue, the subsequent noun might represent the first point at which they could identify the target. In order to capture the children’s response to both the auxiliary and noun and to compare across conditions, it was necessary to match the timing of these word onsets across condition (see below).

Two further characteristics of the target sentences should be noted. First, an exclamation (*Look!, Hey!, Oh!, Hmm...*) preceded each target sentence, engaging the child’s attention and providing a buffer between the beginning of the auditory stimulus and the onset of the critical word (*is/are/see*). Second, the noun was always modified by two superfluous adjectives (*nice little*), creating a time lag between the T/A cue (*is, are*) and the noun (e.g., *boy*). This ensured sufficient time to measure an eye gaze response driven by the early cue alone, independent of the following noun. It also allowed more flexibility in the event that children in the DLD and TD groups differed in the time course of their response.

The auditory portion of the trial lasted 3,800 ms, including the initial attention-getter. The two regions of interest in our analysis were (a) the pre-noun region, beginning at the onset of *is/are/see*, and (b) the noun region, beginning at the onset of the noun. The stimulus sentences were edited in Praat (Boersma & Weenink, 2014) to ensure alignment of onsets of these two regions across conditions, as shown here:

Hey!	Is/Are/See the nice little	boy(s) running?	
0	834	2,404	3,800 ms

Coding

Each child’s face was video-recorded as she viewed the experimental pictures. This recording was combined with a time stamp and information about the timing of trial events (picture on/off, sound on/off) for later coding. Using custom software, videos were first prescreened to eliminate trials on which there was auditory interference (e.g., adult or child talking) or on which the child was

looking somewhere other than the screen during or after the presentation of auditory stimuli. Next, the child’s eye gaze was coded frame-by-frame, with 33-ms resolution (30.3 frames per second). Children’s gaze in each frame was judged as *left* (looking at the picture on the left), *right* (looking at the picture on the right), *off* (moving from one picture to the other), or *away* (not looking at either picture and not shifting between pictures). Coders were blind to sentence condition (working without access to sound) and to target picture location. Training of coders included familiarization with the lab’s coding protocol and application of these rules to increasingly more challenging practice videos drawn from previous studies. Working with the first author, six such videos were coded and compared line by line until the trainee reached at least 90% frame and shift agreement on at least 85% comparable trials (see below). Afterward, the assistant coded independently, and the first author reviewed the full file of approximately every fifth participant. Disagreements were noted and discussed, helping to maintain adherence to lab coding rules. In addition, for each file, coders maintained a log of trials for which coding decisions were not straightforward; these were reviewed and coded with the first author.

Once files were coded, we identified and eliminated trials for which the child’s looking pattern may not have reflected comprehension of the auditory stimulus. Criteria for exclusion were inattention (looking “away”) at the onset of *is/are* or *see* or periods of inattention lasting longer than 500 ms during sentence presentation. The analyses reported here were based on the remaining trials. A minimum of four observations per condition was required for inclusion in the analysis; as noted earlier, this led to the exclusion of the data of four children with DLD. The average number of trials per condition (out of 16) for each group were as follows: TD: $M = 11.53$, $SD = 2.07$, range 8–15; DLD: $M = 9.22$, $SD = 2.85$, range 4–15. The average number of trials per condition was similar across conditions.

Intercoder Reliability

To assess intercoder reliability, 20% of the data were randomly selected for recoding by the first author (sessions of three children from each group). Following Fernald, Zangl, Portillo, and Marchman (2008), we computed intercoder agreement as (a) the proportion of frames on which coders agreed on gaze location (frame agreement) and (b) the proportion of shifts in gaze on which coders agreed within one frame (shift agreement). The coding software computes reliability over comparable trials only; that is, it does not include trials that differ in the sequence of events recorded by the two coders. Because a comparison based only on comparable trials could inflate the reliability estimate, the two coders viewed these trials together, came to a consensus on the events, and recoded the trials independently. On the basis of the resulting 100% comparable trials, these analyses yielded the following results: mean frame agreement: TD, 99.30%; DLD, 99%; mean shift agreement: TD, 98.60%; DLD, 98%.

Measures/Data Analysis

Accuracy and reaction time (RT) are the measures most commonly reported in LWL studies. Both measures have been shown to correlate strongly with language development in young children (Fernald, Perfors, & Marchman, 2006), and both are predictive of later language and cognitive attainments (Marchman & Fernald, 2008). In this study, we focused on accuracy during the pre-noun and noun portions of the sentence in the two groups. Accuracy is defined as the time spent looking at the target picture as a proportion of the time spent looking at either the target or the distractor (Fernald et al., 2008). Mean accuracy is computed across the analysis region for each trial and then averaged over trials for each child.

The second measure, RT, is computed over a subset of trials—only those on which the child is looking at the distractor or the target at the onset of the critical word. RT is defined as the latency to shift from distractor to target within the analysis window. RT is not reported here because too many children showed unacceptably low numbers of usable trials per condition (< 2 distractor-initial and/or target-initial trials) in both the pre-noun (TD: 9/15; DLD: 11/15) and noun regions (TD: 14/15; DLD: 12/15). Although RT measures provide a way to test precise predictions about incremental processing, they often result in sparse data, as was the case in our study. Accuracy provided an alternative that allowed use of all trials and, by analyzing separate regions, allowed us to capture an early, time-sensitive response to the auxiliary cue.

As described above, the pre-noun region began at the onset of *is/are* (for the T/A cue conditions) or *see* (for the no T/A cue conditions) and ended immediately before the noun onset (length of region, 1,570 ms). The noun region began at the noun onset and ended 500 ms after the noun offset (length of region, 1,125 ms). In the analysis, however, these measurement windows were shifted ahead by 300 ms to exclude looking which could not reasonably be interpreted as a response to the language the child had heard at that point (Fernald et al., 2008).

In our previous study, 3-year-old TD children showed evidence of sensitivity to the T/A cue, spending more time looking at the target in the pre-noun region in the T/A cue condition relative to the no T/A cue condition. They also showed an effect of the number of the agreeing auxiliary, favoring the plural over the singular condition. In this study, we compare the TD children's performance to that of a group of children with DLD, matched for overall sentence comprehension. We compared the two groups' effects of T/A cue and number, as well as accuracy before and after the noun was heard. The latter comparison provides evidence of general responsiveness to the task independent of the ability to use T/A cues.

Results

To examine accuracy in each region, a mixed-model analysis of variance was conducted, which included

participant group (TD, DLD) as a between-subjects variable and T/A cue (T/A cue, no T/A cue) and number (plural, singular) as within-subject variables. Proportions were arcsin-transformed for statistical analysis. Effect sizes were calculated using Cohen's *d* and partial eta squared. Cohen's *d* values of 0.2, 0.5, and 0.8 and partial η^2 values of .01, .06, and .14 are considered to be small, moderate, and large effect sizes, respectively (Cohen, 1988). Least significant difference testing at the .05 level was used for post hoc testing of these effects. Mean proportions of time spent looking to the target (accuracy) are reported in Table 1 for each group and condition in the two regions.

A significant interaction between T/A cue and group was found in the pre-noun region, $F(1, 28) = 5.20, p = .03$, partial $\eta^2 = .16$ (see Figure 1). The interaction subsumed a significant main effect of T/A cue, $F(1, 28) = 6.16, p = .019$, partial $\eta^2 = .18$. Post hoc testing of the interaction revealed that only the TD group showed significantly higher accuracy in the T/A cue condition ($M = 60.78, SD = 12.96$) than in the no T/A cue condition ($M = 51.23, SD = 11.38; d = 0.78$). Children with DLD did not appear to make use of the T/A cue in this early region (T/A cue: $M = 53.19, SD = 14.22$; no T/A cue: $M = 52.71, SD = 14.63; d = 0.03$). There was also a main effect of number, $F(1, 28) = 36.38, p < .001$, partial $\eta^2 = .56$, with accuracy higher in the plural condition ($M = 61.49, SD = 12.71$) than in the singular condition ($M = 47.46, SD = 10.83$).

Although the children with DLD showed no sign of responding to the T/A cue in the pre-noun region, it seemed possible that condition differences could be seen in the noun region. Given the ample spacing between the T/A cue and the noun created by two intervening adjectives, such T/A sensitivity in the noun region would be more likely to reflect integration than unusually slow execution of an anticipatory looking response. We therefore inspected the noun region for any evidence of greater accuracy when the T/A cue had been provided.

Analysis of the noun region revealed a significant main effect for T/A cue, $F(1, 28) = 5.83, p = .022$, partial $\eta^2 = .17$, with higher accuracy in the T/A cue condition ($M = 78.49, SD = 13.48$) than in the no T/A cue condition ($M = 74.76, SD = 12.42$). There were no other significant effects. There was no longer an interaction between T/A cue and group, $F(1, 28) = 1.15, p = .29$. Still, an inspection of means in the noun region provides little evidence that the DLD group's looking behavior was different in the two conditions (T/A cue: $M = 76.58, SD = 15.98$; no T/A cue: $M = 75.31, SD = 13.24; d = 0.09$). Instead, the difference according to condition appears to be driven by the TD children's greater tendency to look to the target in the T/A cue condition ($M = 80.39, SD = 10.33$) than in the no T/A cue condition ($M = 74.21, SD = 11.74; d = .59$; see Figure 2). This sensitivity in the noun region by the TD group could constitute the process of integration—a process that can co-occur with the prediction that these children exhibited in the pre-noun region.

Finally, as a check on children's overall responsiveness in the task, we compared children's relative accuracy

Table 1. Mean percentages of time looking to the target (and standard deviations) for the two participant groups.

	Pre-noun region				Noun region			
	Plural cue	Plural no cue	Sing. cue	Sing. no cue	Plural cue	Plural no cue	Sing. cue	Sing. no cue
TD	.67 (.13)	.57 (.11)	.55 (.10)	.45 (.08)	.79 (.12)	.79 (.12)	.82 (.08)	.70 (.11)
DLD	.62 (.13)	.59 (.12)	.44 (.08)	.46 (.14)	.80 (.14)	.78 (.10)	.73 (.18)	.73 (.16)

Note. TD = children with typical language development; DLD = children with developmental language disorder; Sing. = singular.

in the noun region to their accuracy in the pre-noun region. Both groups showed a large increase in probability of looking to the target upon hearing the noun (TD: from $M = 56.01$, $SD = 13.01$ (pre-noun) to $M = 77.30$, $SD = 13.01$ (noun), $d = 1.74$; DLD: from $M = 52.95$, $SD = 14.31$ (pre-noun) to $M = 75.95$, $SD = 14.56$ (noun), $d = 1.59$).

Discussion

Our three predictions based on the competing sources of input proposal were borne out. Unlike the TD children, the children with DLD gave no evidence of anticipating the target picture based on the number information contained in the fronted auxiliary. Likewise, we saw no indication of integration in the noun region for these children; means for looking in the T/A cue and no T/A cue conditions were indistinguishable ($d = 0.09$). Yet, the children with DLD complied with the demands of the task. Once the noun was heard (regardless of condition), making clear which picture was the target, these children looked much longer at the appropriate picture than at the alternative. The data also produced findings unrelated to the competing sources of input proposal: The children with DLD, like the TD children, showed a bias toward pictures depicting plural as opposed

to singular subjects. Previous studies have reported this bias and have discussed its possible linguistic and nonlinguistic sources (see Brandt-Kobele & Hohle, 2010; Lukyanenko & Fisher, 2016).

We discuss our findings by addressing three basic questions. First, we ask whether the observed group differences should be treated as meaningful given that the two groups were so similar in their standardized sentence comprehension test scores. More precisely, was our task measuring receptive language abilities that are distinct from those measured by typical sentence comprehension tests? Second, we examine the logic in assuming that problems in using number cues in fronted auxiliaries might contribute to inconsistent use of T/A. Finally, we ask what the underlying problem might be that prevents children with DLD from recognizing the relevance of this information.

Was Our Task Measuring a Distinct Receptive Language Ability?

Given that the children with DLD were no different from the younger TD children in their sentence comprehension test scores, we should ask whether our task was measuring a distinct ability. Our choice of tasks was predicated

Figure 1. Proportion looking to the target in the pre-noun region, according to the tense and agreement (T/A) condition, with Cohen's d values for between-conditions differences for each group (TD = typical development; DLD = developmental language disorder).

Figure 2. Proportion looking to the target in the noun region, according to the tense and agreement (T/A) condition, with Cohen's d values for between-conditions differences for each group (TD = typical development; DLD = developmental language disorder).

on the fact that more conventional tests of sentence comprehension are not designed to approximate the kind of ability of interest to us, that is, relating grammatical information contained in the fronted auxiliary to upcoming structure. For example, most comprehension tests require off-line responses. We have no doubt that, by the end of each question asked in our task, all of our children could correctly answer (*yes* or *no*)—simply because they would have heard the necessary information to do so. The child's response, however, would come too late to differentiate sensitivity to the early auxiliary number cue from an interpretation based on the entire sentences (subject noun, verb, etc.). There may be other ways to assess the degree to which children treat fronted auxiliaries as structurally inseparable from the rest of the question. However, our on-line task seemed to measure one aspect of this process, because anticipatory looking presumably reflected the children's knowledge that grammatical information in the auxiliary provided cues to information that would appear later in the question.

Can Difficulties Grasping the Structural Relevance of Fronted Auxiliaries be a Source for T/A Inconsistency?

As noted earlier, questions occur in child-directed input quite frequently (Cameron-Faulkner et al., 2003). Their frequency seems sufficient to influence children's productions if, as suggested, the children fail to grasp the constraints that fronted T/A forms placed on the remainder of the question. Auxiliary *is/are* questions such as those used in this study are by no means the most common. Recall that they were used in our study because they could shed light on the possible source of the well-documented productions of subject-nonfinite verb sequences by children with DLD.

Questions with fronted copula forms (e.g., *Is the doggie hungry?*) are the most frequent form of questions, followed by questions with fronted auxiliary *do* (e.g., *Do you want another cookie?*). These children's ability to interpret the T/A information in fronted copula forms is not yet known. Based on the study by Lukyanenko and Fisher (2016), TD children, with approximately the same age as our TD children, do show anticipatory looking based on the number information in fronted copula forms. Based on the T/A similarities between auxiliary *is/are* and copula *is/are*, we would expect that our TD participants would also show anticipatory looking to the copula *is/are*. To our knowledge, studies of anticipatory looking for auxiliary *do*-fronted questions have not yet been reported. However, Leonard et al. (2015) found that children with DLD who used T/A inconsistently inappropriately extracted (or directly modeled their verb use on) nonfinite novel verbs in these kinds of questions (e.g., *Does the cat tell?*). It is important to point out that these extracted productions occurred in declarative contexts (e.g., *Every day the monkey tell*), even though the novel verbs were heard exclusively in questions. We do not find this unusual; Theakston et al. (2003) found similar extraction by younger TD children (who themselves marked

T/A inconsistently) after hearing questions such as *Will it mib?* English-speaking children hear casual questions in declarative word order (e.g., *He's going home now?*; Fitzgerald, Hadley, & Rispoli, 2013), so there is already a basis for assuming that input with the pragmatic function of asking a question can also be used in a declarative context. This would seem especially likely if children have not yet learned the structural ties between a fronted T/A form and the remainder of the utterance.

Why Might Children With DLD Have This Particular Problem With Input Utterances?

By definition, "fronted" auxiliaries are no longer adjacent to their associated lexical verbs and are usually separated from these verbs by the subject noun phrase. It is this separation that allows subjects and nonfinite lexical verbs to appear in adjacent positions while at the same time express meaningful propositions (e.g., *girl eating, dog barking*). According to the competing sources of input proposal, this configuration is a key ingredient in leading children to extract subject-nonfinite verb sequences and produce them as free-standing utterances.

However, whereas the competing sources of input proposal implies a morphosyntactic problem involving particular types of dependency relationships, the separation between the fronted auxiliary and the later-appearing subject-nonfinite verb sequence also invites an interpretation centered around working memory. There is a substantial literature on the working memory limitations of children with DLD, including studies that report relationships between these children's working memory abilities and their sentence comprehension. Some investigators have sought to find relationships of this type by manipulating length and structure systematically. For example, Deevy and Leonard (2004) found that children with DLD had more difficulty than younger TD children in responding to questions such as *Who is the happy brown dog washing?* However, when questions of the same structure were short or did not involve a separation between the *wh*-word auxiliary and the lexical verb, the two groups performed in a similar manner.

Computational modeling studies have demonstrated that when constraints are placed on the processing span of the model (with a bias toward material at the end of the input sentence), the output of the model provides a good approximation of the period when children alternate between producing T/A morphemes appropriately and omitting them in obligatory contexts (e.g., Freudenthal, Pine, Aguado-Orea, & Gobet, 2007). Although these models worked well, the strong "right-edge" bias built into the models was eventually accompanied by the inclusion of a weaker "left-edge" bias. The latter could simulate primacy effects in processing and could handle the fact that young children often produce questions such as *Where the boy going?* that lack the fronted T/A auxiliary but contain the *wh*-word in utterance-initial position.

We acknowledge the potential role that working memory may play in the inconsistent use of T/A by children with

DLD. However, an argument can also be made for a weakness of a morphosyntactic nature. We assume that fronted T/A forms are heard and understood as affecting the pragmatic force of the utterance. Similarly, we are confident that *wh*-words in utterance-initial position are not only heard but understood (approximately) for their semantic content. However, they might well be understood and used initially as an adjunct—simply attached to the beginning of a sentence. Radford (1990) has proposed this as a possible explanation for young TD children's use of similar questions, such as *What kitty doing?* Some evidence consistent with this idea is the finding by Leonard (1995) that children with DLD who are inconsistent with T/A morphology are more likely than younger TD children to use *wh*-questions with the T/A form in declarative order (e.g., *Where the boy is going?*). This finding holds even when the children with DLD make less use of T/A overall.

If fronted auxiliaries constitute adjuncts that primarily serve the pragmatic function of signaling a question, we would not expect the T/A information in the auxiliary to boost the degree of looking at the target even when the noun appears. That is, in this case, there would be no structural connection to the subject noun that would lead to integration.

If a morphosyntactic deficit lies at the heart of the extraction problem, we do not believe it is limited to questions, in which T/A forms are fronted. Though less frequent than questions in the input, there are other structures that contain subject–nonfinite verb sequences that resemble the utterances produced by children with DLD. These include structures as seen in *Let's help him do the dishes* and *I saw her walking to the store*, among others. Extractions from structures of this type could lead to documented production errors such as *Him do that* and *Her walking*. Productions with accusative pronouns in subject position such as these cannot be derived from questions (e.g., *Will he do that? Is she walking?*). What all of these structures have in common with questions is that they contain a verb form (e.g., *is*, *does*, *help*, *saw*) that constrains the form of the verb that appears later in the same utterance. Apart from this shared characteristic, these structures are quite different and might have to be acquired separately. Some children might begin to appreciate the structural connections in questions with fronted auxiliaries before (or after) they learn the structural ties in these other utterance types. As a result, the development of T/A forms such as auxiliary *is* and *are* might be an incremental process, growing with each new structure that is learned well.

For children with DLD, then, increasing consistency in T/A marking might require increasing children's understanding of the relationships in each of these structures. Instead of focusing exclusively on increasing children's consistency in producing auxiliary forms, some portion of intervention could focus on teaching the children to appreciate the dependencies involved. The treatment study of Fey et al. (2017) provided a direct implementation and preliminary evidence in support of this approach. This grammatical intervention included a comprehension component in which children practiced answering yes/no questions that

either did or did not require attention to the fronted auxiliary to answer correctly (e.g., *Is/was the girl climbing a ladder?* vs. *Is the girl/boy climbing a ladder?*). Children whose comprehension practice required attention to the fronted auxiliary showed greater gains in their production of auxiliary *is* in declaratives. Based on the results of this study, it seems that, without such assistance, children with DLD may not be deriving this kind of information from fronted auxiliaries.

Acknowledgments

This research was supported by National Institute on Deafness and Other Communication Disorders Grant R21 DC 13334 awarded to Laurence B. Leonard. The authors wish to thank Virginia Marchman for advice on design and analysis, the children and their families for their participation, and the members of the Child Language Lab for their valuable assistance in stimulus preparation and coding: Johanna Rudolph, Brianna Toppe, Erin Boyle, Sarah Barnes, Kelsey Delacroix, and Julia Bergmann.

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