Research Article

A Clinical Evaluation of the Competing Sources of Input Hypothesis

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Purpose: Our purpose was to test the competing sources of input (CSI) hypothesis by evaluating an intervention based on its principles. This hypothesis proposes that children's use of main verbs without tense is the result of their treating certain sentence types in the input (e.g., *Was she laughing?*) as models for declaratives (e.g., *She laughing*).

Method: Twenty preschoolers with specific language impairment were randomly assigned to receive either a CSI-based intervention or a more traditional intervention that lacked the novel CSI features. The auxiliary *is* and the third-person singular suffix *-s* were directly treated over a 16-week period. Past tense *-ed* was monitored as a control.

Results: The CSI-based group exhibited greater improvements in use of *is* than did the traditional group ($d = 1.31$), providing strong support for the CSI hypothesis. There were no significant between-groups differences in the production of the third-person singular suffix *-s* or the control (*-ed*), however.

Conclusions: The group differences in the effects on the 2 treated morphemes may be due to differences in their distribution in interrogatives and declaratives (e.g., *Is he hiding/He is hiding* vs. *Does he hide/He hides*). Refinements in the intervention could address this issue and lead to more general effects across morphemes.

Children with specific language impairment (SLI) typically have a core of mild to severe deficits that affect their performance across linguistic components, including phonology, semantics, and pragmatics. Across languages, however, the domain that provides these children with the greatest challenges is grammar. For example, researchers agree that for English-speaking children, the clearest, most persistent characteristic of SLI is omission of obligatory tense and agreement morphemes (e.g., *That boy running. She eat cookies. Where he go?*; Bedore & Leonard, 1998; Rice & Wexler, 1996; Rice, Wexler, & Cleave, 1995). Over many studies and laboratories, the percentage of accurately inflected tense and agreement morphemes for groups of children with SLI is reliably less than that observed for typically developing (TD) children, even when the TD group is younger and matched by some broad index of language ability, such as mean length of utterance (MLU; Rice &

Wexler, 1996). Further, when an English-speaking child uses a tense or agreement morpheme, it is usually produced correctly. Sentences such as *That boy am/are eating* or *Those babies likes milk* in which the child misuses a tense or agreement marker are exceedingly rare. The simultaneous presence of omissions and correct uses of tense and agreement morphemes by English-speaking children with SLI results in variable surface-level production over a protracted period that can last into elementary school ages—well beyond the point of mastery for TD children.

Although there is considerable agreement on most surface-level details of the development of tense and agreement morphology usage by children with SLI, the assumed source of these deficits is widely disputed. For example, in many limited processing accounts (Ellis Weismer, 1996; Ellis Weismer et al., 2000; Moyle, Karasinski, Ellis Weismer, & Gorman, 2011), children are assumed to be able to select the correct verb and the appropriate inflection in the underlying grammar. Surface realization of appropriately inflected words and sentences (e.g., longer sentences with more complex articulatory and memory requirements and an increased need for speed) places extra demands on the weak processing skills of children with SLI. Because of their deficits in articulation, memory, and processing speed (Leonard et al., 2007), children with SLI often fail to represent the underlying target at the surface level. As the children gain familiarity with marked forms in the input and get more

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practice in their production over time, they gradually (and slowly, by comparison with TD children) become more consistent with tense and agreement marking.

In Rice's extended optional infinitive (EOI) account (Rice & Wexler, 1996; Rice et al., 1995), it is assumed that omissions of tense and agreement features arise from the children's failure to recognize that in English, verbs in main clauses must be marked for tense. Instead of characterizing omissions as output errors reflecting processing weaknesses, however, this account regards them as the result of children's optional selection of infinitive verb forms in contexts that require finiteness. The child is assumed to know how to mark tense from an early age and thus does not make many tense and agreement errors of commission. The biological mechanism associated with tense marking eventually matures to the point that the child recognizes that main verbs are not optional for finiteness but rather must be marked for tense and agreement. This maturational process is assumed to be especially slow for children with SLI.

Another approach that assumes a biological basis for tense and agreement inconsistency in SLI is the representational deficit for dependent relations (RDDR) account (van der Lely, 1998; van der Lely & Battell, 2003; see also van der Lely & Pinker, 2014). This approach covers a broader range of symptoms than the EOI account, including problems with *wh*-questions and passives as well as with tense and agreement features. The basic problem is characterized as one of optional movement, where movement is obligatory in the mature grammar. For example, an auxiliary may not move to presubject position in questions. This optionality of movement of features that is obligatory in the adult grammar is what yields a pattern of alternating correct and incorrect usage of features, such as tense and agreement. However, unlike the EOI account, the RDDR account does not view the problem as one of a protracted developmental stage but rather as a fundamental deficit in the neural mechanisms responsible for syntactic computation. As a consequence, improvement in the use of tense and agreement morphology may be limited to rote learning of surface forms, much like the acquisition of irregular past-tense forms, rather than to biologically or experientially driven development in morphology.

There are also accounts of inconsistency that adopt a linguistic framework similar to that of the EOI and RDDR accounts yet accord greater importance to linguistic input. Thus far, these approaches have emphasized typical language development, but they appear applicable to the study of SLI. Yang (2002) and Legate and Yang (2007) proposed that English-speaking children may be especially slow in acquiring tense and agreement morphemes because English uses many bare stems (e.g., *she plays* but also *I play, you play, we play, they play*). The presence in the input of so few overt forms marking tense and agreement delays the setting of the [+tense] parameter that holds for English. Rispoli, Hadley, and their colleagues (e.g., Rispoli, Hadley, & Holt, 2009, 2012) have championed a model of gradual morpho-syntactic learning that incorporates much of the Legate and Yang perspective. They have found that variation in the

frequency of input of overt tense and agreement morphemes within English will influence children's rate of development. For example, using this input informativeness principle, Hadley, Rispoli, Fitzgerald, and Bahnsen (2011) observed that young TD children's gains in tense and agreement productivity were greater if their parents had provided input that contained a greater density of overt tense and agreement forms. These scholars do not attribute the delayed tense and agreement development in SLI to low-quality input but rather assume that these children's limited grammar-learning mechanisms make them especially vulnerable to the slowing effects posed by input that contains a large proportion of finite forms that are not overtly marked for tense and agreement.

In the study reported in this article, we examine a different theoretical alternative—the competing sources of input (CSI) hypothesis—by evaluating the effects of an intervention that is based on its principles. The CSI hypothesis shares with earlier works (e.g., Croker, Pine, & Gobet, 2000; Freudenthal, Pine, Aguado-Orea, & Gobet, 2007; Kirjavainen, Theakston, & Lieven, 2009; Theakston, Lieven, & Tomasello, 2003) the view that children's use or omission of tense and agreement morphology is a function of the evidence that is present in the input and children's faulty processing of that evidence. As their language and related skills begin to grow, some well-formed simple sentences in the input that are appropriately marked for finiteness, such as *The dog's eating* and *The girl runs fast*, are sufficiently well processed and serve as the basis for the children's early finite productions, such as *He's eating* and *The man runs*.

On the other hand, children's ill-formed sentences containing omissions of tense and agreement morphology are assumed to be based on partial processing of perfectly grammatical input that contains nonfinite sequences of subject plus verb (SV; e.g., *We saw [the dog eating]; Was [the dog barking]?*). These nonfinite SV strings are licensed by English grammar when tense or agreement are found in some earlier portion of the sentence, such as a complement clause-taking perception verb (e.g., *We saw [the dog eating]; I heard [the dog barking]*) or an auxiliary verb in a question (e.g., *Is [the dog barking]? Why did [the boy laugh]?*) or when the earlier complement-taking verb is imperative (e.g., *Help [John feed the dog]*). In other words, nonfinite SV strings may occur in English but only in selected contexts. These unmarked SV strings then serve as competitors with SV clauses in which tense and agreement are obligatory. It follows, then, that until children recognize that unmarked SV sequences in English are exceptional cases that occur in limited, exclusive contexts, their presence in the input would have a slowing effect on the child's mastery of tense and agreement and other related morphosyntactic forms.

In the CSI hypothesis, we assume that whether they have language impairment or are developing typically, children experience a period during which they fail to detect and realize the importance of differences between SV sequences that appear on their own and those that are part of larger constructions. We assume further that children with SLI are slower than TD children to recognize

the complementary distribution of nonfinite SV strings at the end of adult sentences and verb forms appearing earlier in the sentences that obligate their use. Until children with SLI make this discovery, they are presumed to continue to use unmarked SV clauses on their own as stand-alone or matrix sentences in alternation with SV clauses appropriately marked for tense and agreement. Thus, just as simple finite clauses serve as the model for the child's correctly inflected finite SV clauses (e.g., *The rabbit hopped away*), certain partially processed complex sentences and questions (e.g., *Make [the rabbit hop away]*; *We can watch [the rabbit hop away]*; *Is [the rabbit hopping away]?*) serve as the basis for children's use of nonfinite SV sequences as stand-alone sentences (e.g., *The rabbit hop*; *The rabbit jump*; *The frog hopping away*).

Evidence for the CSI Hypothesis

There is a substantial body of research that has led to and supports the fundamental claims of the CSI hypothesis, stressing the role of adult input as the basis of children's error patterns as well as their complete sentences. For example, Fey and Loeb (2002) provided one group of 2- and 3-year-olds with SLI a recast-based intervention in which the children's spontaneous subject-verb-object sentences were recast as auxiliary-fronted interrogatives (Child: *Dog barking*. Adult: *Is the dog barking?*). An attention control group received no language intervention, and questions with fronted auxiliaries and copulas were avoided in intervention contexts. Contrary to expectations, results revealed no statistically reliable differences between groups, and there was a trend favoring the control group in the acquisition and use of auxiliaries. Fey and Loeb posited that if the children in the recast intervention were incapable of processing the sentence-initial auxiliary, the recasts would have served as unconstrained models of nonfinite SV strings. By the CSI hypothesis, such models would be expected to prolong the time period during which the children use nonfinite SV strings as stand-alone sentences.

In several studies (Finneran & Leonard, 2010; Leonard, Fey, Deevy, & Bredin-Oja, 2015; Theakston et al., 2003), investigators have examined the outcomes of attempts to teach nonsense action verbs to preschoolers with and without SLI while controlling the finiteness contexts in which the verbs are presented. In this general method, one set of verbs is introduced either exclusively in a finite form (e.g., *All day long, [the bird mabes]*; *Do you think [the bird mabes]?*), whereas exposures of the other set are always in the nonfinite form (e.g., *We saw [the bird rell]*; *Does [the bird rell]?*) After such exposures, the children respond to probes, some of which require them to produce the finite form of the verb (i.e., Adult: *Every day, the cat ...* Child: *mabes*) and some of which require the nonfinite form (i.e., Adult: *We wanna watch the cat ...* Child: *mabe*). The CSI predictions were that the children with SLI would be more likely than the TD children to produce the target verb in the form in which they had heard it in the input. This has consistently been found to be the case. When the exposure type used to teach

the verb (e.g., inflected verb: *Do you think [the bird rells]?*) matched the demands of the probe (e.g., a prompt for an inflected verb: *Every day, the cat ...*), the form used was more likely to be correctly marked. With a mismatch (e.g., uninflected exposures: *Does [the bird rell]?* plus prompts for finite forms: *Every day, the cat ...*), there were more errors. This effect has been especially pronounced for children with SLI (Leonard et al., 2015).

There is considerable evidence from studies using several different research methodologies that attest to the difficulties children with SLI have with the processing of complex sentences that contain a relationship between nonfinite subordinate SV strings and forms earlier in the sentence that require their presence. For example, Leonard and Deevy (2011) and Souto, Leonard, Deevy, Fey, and Bredin-Oja (2016) provided children with simple declarative sentences (e.g., *The girl is sleeping*) and required them to identify the picture from a set that also included three foils (e.g., a boy sleeping on a couch, a girl reading on a couch, a boy reading on a couch). Under these conditions, children with SLI were as accurate as younger, comprehension-matched TD participants in identifying the target picture. At the same time, the children with SLI were significantly less likely than the TD participants to point to the correct picture (e.g., a man looking at a girl sleeping on the couch) when the target sentence included an SV clause as the complement of a matrix perception verb (e.g., *The dad sees [the girl sleeping]*).

Because it is placed before the sentence subject, the auxiliary verb in yes/no questions can provide competent listeners with a cue to the number of the subject (e.g., *is* vs. *are*) at a point before the subject noun is produced. Looking while listening methodology offers the ability to observe children's online processing of this information by tracking children's eye gaze over time from the production of the auxiliary to the production of the subject and beyond. Deevy, Leonard, and Marchman (2014) used this method to examine the ability of preschoolers with SLI and that of age- and comprehension-matched TD children to anticipate number marking on the sentence subject in yes/no questions (e.g., *Is/Are the nice little dog/dogs running?*). As expected on the basis of the CSI hypothesis, the children with SLI showed no evidence of anticipatory looking, unlike both groups of TD children, and exhibited consistent looking at the target only after the noun (e.g., *dogs*) had been heard. Thus, the children with SLI exhibited less sensitivity to the relationship between the fronted auxiliary verb and the nonfinite SV sequence found in questions. The study of fronted auxiliaries in questions is especially important because questions represent approximately 32% of child-directed utterances during this period (Cameron-Faulkner, Lieven, & Tomasello, 2003) and would be the most common source of nonfinite SV sequences containing nominative case pronouns (e.g., *She running*).

Purdy, Leonard, Weber-Fox, and Kaganovich (2014) observed that children with SLI produced a brain wave pattern, called the P600, indexing their recognition of misuses of agreement morphemes when they were presented

in simple sentences, such as *Every day, the girls drives home*. Thus, their processing of verb morpheme errors was like that for TD children in single-clause sentences. In contrast, the children with SLI were significantly less sensitive to these types of errors than were TD participants when detection of the errors required processing a long-distance relationship in a complex sentence, as in *The dad watches [the boy eats cookies]*.

Earlier, it was noted that children with SLI score lower than younger sentence comprehension-matched TD children in their comprehension of sentences such as *The dad sees [the girl sleeping]* (Leonard & Deevy, 2011; Souto et al., 2016). The children with SLI in these studies also show lower levels of use of tense and agreement morphemes such as auxiliary *is*. This is expected by the CSI hypothesis given that confusion with certain nonfinite SV sequences is assumed to contribute to the slow progress of tense and agreement morpheme development.

Likewise, it is assumed that when children with SLI are found to use tense and agreement morphemes less frequently than younger MLU-matched TD children, the latter group should show greater comprehension of complex sentences containing nonfinite SV sequences. This was seen indirectly by Leonard et al. (2015). In this study, children were first introduced to novel verbs in tense and agreement contexts (e.g., *All day long the cat tomes*). Then they were asked to use the same novel verb in a nonfinite SV context (e.g., *Let's watch the dog ... tome*). Under this condition, the children with SLI were significantly more likely to produce the (incorrect) inflected form (e.g., *tomes*) than were the younger TD children. This is an indication that the children with SLI were less knowledgeable about sentences with nonfinite complement clauses and the relationship between clauses in such sentences with respect to their marking of finiteness. Likewise, using a grammaticality judgment task, Redmond and Rice (2001) found that children with SLI were more likely than younger MLU-matched TD children to accept as appropriate sentences such as *He made the space guy fell/falled into the pool*.

Because children with SLI rarely produce sentences such as *Let's watch the dog runs* in their own speech, it might be argued that the results from studies using novel verbs and grammaticality judgments were simply artifacts due to the tasks used and that these children do not ordinarily ignore the relationship between SV sequences and the finite forms that precede them in the same input utterance. Evidence for such a view could come from Redmond and Rice (2001), who found that only 6% of the productions requiring a nonfinite SV sequence were produced inappropriately with a tense and agreement form by children with SLI. Younger MLU-matched TD children showed only 2% errors of this type.

We do not find this argument compelling for several reasons. First, in simple declarative sentences, children with SLI are more likely than younger MLU-matched control children to omit tense and agreement forms. Given that omissions are the most likely type of error made by children with SLI, one would not expect that the children in the

Redmond and Rice (2001) study would make more commission errors (6%) in complement clauses than the younger TD children (2%). Second, at a point when children with SLI show inconsistency in using tense and agreement forms, they also have significant difficulty constructing complex sentences. Owen and Leonard (2006) found that children with SLI were less accurate than both younger TD children and age-matched peers in producing sentences with complement clauses regardless of whether these clauses should have been finite or nonfinite. Sentences requiring nonfinite complement clauses were often incorrect due to the omission of the complementizer *to* (e.g., *Ernie told Elmo pick up the box*). However, examples such as *Ernie told Elmo picked up the box* were also seen. Errors such as this and those reported by other investigators (e.g., Eyer & Leonard, 1995; Schuele & Tolbert, 2001) can give the appearance that the two clauses were simply merged, suggesting that they were produced with little understanding of the finiteness constraints that the matrix verb places on the subsequent verb.

Last, children with SLI are not as proficient as younger TD children in using fronted auxiliaries in questions. For example, Leonard (1995) found that when children with SLI used auxiliaries in questions, they were more likely than younger MLU-matched TD children to use them in declarative word order, with the auxiliary placed between the subject and the lexical verb. Such a pattern could have reflected limited understanding of the role that auxiliaries play when separated from the SV sequence.

Clinical Implications of the CSI Hypothesis

The CSI account of tense and agreement errors in English-speaking children with SLI has significant clinical implications. In particular, the CSI account provides the motivation for each of three broad principles of intervention. First, clinicians should increase the frequency with which the child hears models of obligatory tense and agreement marking (e.g., in simple declaratives). This principle can be justified by most any theory of slow morphosyntactic development, including those that posit a strong neuro-maturational component, such as the EOI account. One possible exception is the RDDR account, which does not view the problem as slow development but rather as an intrinsic impairment that may require compensatory learning strategies.

Second, the use of questions and complex sentences that supply the child with potentially competing nonfinite SV models should be limited. The EOI and RDDR accounts would have no basis for such a treatment strategy. In fact, because questions and complex sentences involve movement operations, frequent exposure to these structures would appear to be a legitimate therapy activity from these theoretical perspectives. The input informativeness approach of Rispoli and Hadley would be compatible with limiting the presentation of nonfinite SV clauses in complex sentences because these clauses have no overt tense and agreement marking. However, only the CSI approach is consistent with limiting the presentation of auxiliary-fronted questions.

Because questions such as *Is the girl playing tennis?* and *Does the boy play tennis?* contain overt marking for tense and agreement within the same clause, the input informativeness approach would have no provision for regarding them as problematic. The CSI and input informativeness accounts differ in yet another way in which they view input. In the latter approach, zero-marked finite verb forms as in *I play tennis* and *They play tennis* are also potentially troublesome because tense and agreement are not marked overtly. The CSI hypothesis makes no such assumption. Given that children only rarely make errors such as *I plays tennis*, it would appear that children are registering person and number information in the subjects that are used with verbs. Thus, although the input informativeness account calls for limiting particular forms in the input, it differs in encouraging auxiliary-fronted questions and discouraging grammatical zero-marked finite verb forms in simple declarative sentences, whereas the CSI hypothesis discourages auxiliary-fronted questions and has no basis for excluding grammatical zero-marked forms.

Third, on the basis of the CSI, clinicians should engage children in activities that require them to recognize that to form a grammatical sentence containing a nonfinite SV string, the SV string must be preceded by some earlier appearing verb form on which the SV string is dependent. In other words, activities should be developed to help the child eliminate the tendency to extract embedded nonfinite SV sequences and use them as stand-alone sentences. As an example of such an activity, we created a computer-based game that required the children in the CSI group to watch the unfolding of an action and then answer a question about whether the action occurred in the present or the past (e.g., *Is/was the boy building a tower?*). In other words, accurate responding required interpretation of the tense of the question as represented by the sentence-initial auxiliary. We submit that this game meets the specifications of the CSI but that no other theory motivates such an intervention activity.

In the present study, we evaluated the CSI account of the development of tense and agreement morphology by testing the efficacy of one example of an intervention that is based on these principles. The 3- and 4-year-old participants generally were weak in expressive grammar and were making limited or no use of the two target morphemes, auxiliary *is* (e.g., *The baby is crying*) and the third-person singular present-tense morpheme (3S; e.g., *That baby cries*), or the untreated control, the regular past-tense morpheme (*-ed*; e.g., *The baby cried*). We compared the response to the intervention of nine children with SLI who were randomly assigned to the CSI-based intervention with the response of 11 children with SLI who were randomly assigned to a traditional focused stimulation intervention (TRAD) containing none of the CSI-based features. The basic question we asked was whether a group of children with SLI assigned randomly to a CSI-based intervention would develop greater use of auxiliary *is* and 3S compared with a group randomly assigned to receive a TRAD that provided an equivalent number of models and recasts but made none of the CSI-based modifications.

Method

Participants

Children were referred to the project primarily by speech-language pathologists and parents who had seen brochures or other announcements about the project. The Human Subjects Committees of the University of Kansas Medical Center and Purdue University monitored and approved all aspects of the study. Twenty children with SLI participated in the investigation. Children ranged in age from 39 to 55 months ($M = 45$ months) at the beginning of the study. Fourteen of the children were boys and six were girls; all children were White and came from monolingual English-speaking homes and were judged to be acquiring the mainstream dialect characteristic of northeastern Kansas and north central Indiana. Prior to enrollment, all children passed a hearing screening at 20 dB HL for each ear at 500, 1000, 2000, and 4000 Hz. Each child scored above 85 on the Primary Test of Nonverbal Intelligence (Ehrler & McGhee, 2008). In addition, all children scored well below the range of autism disorder (>30) on the Childhood Autism Rating Scale ($M = 16.53$; Schopler, Reichler, & Renner, 1988).

To qualify, children had to have sufficient phonological ability to produce the targeted grammatical morphemes clearly. Each child had an accuracy score of at least 80% on a 53-item screening test of word-final /s/, /z/, /t/, and /d/ in monomorphemic words (e.g., *fox*, *cheese*, *tent*, *wand*).

Participants also demonstrated a significant delay in expressive language ability as measured by a standard score of 87 or less on the Structured Photographic Expressive Language Test–Preschool: Second Edition (Dawson, Eyer, & Fonkalsrud, 2005). This cutoff was empirically derived in the study of Greenslade, Plante, and Vance (2008). Standard scores on the test ranged from 60 to 87. All qualifying children also had a Developmental Sentence score below the 10th percentile (Lee, 1974).

Last, children were required to demonstrate an accuracy of 33% or less on a past-tense *-ed* elicitation probe and an accuracy of 33% or less on the 3S probe, the auxiliary *is* probe, or both. Performance on one of the latter two probes as high as 80% was acceptable as long as performance on the other probe was no higher than 33%. In the end, only six children had scores above 30% for any probe, and no child had scores above 30% for both of the treated morphemes.

Receptive language ability was not part of the selection criteria. All children were administered the Peabody Picture Vocabulary Test–Fourth Edition (Dunn & Dunn, 2007), however, and scores ranged from 83 to 128 ($M = 103.05$).

Experimental Groups

After preexperimental testing was completed and a child was determined to qualify for the study, a computer program was used to assign the child randomly to either the CSI-based or the TRAD group. Eleven children were assigned to the TRAD group, and nine were delegated to the CSI-based group in this manner. At Time 1, there was

one statistically reliable difference between the groups: MLU in morphemes. As shown in Table 1, none of the other key preexperimental or Time 1–dependent variables differed between groups.

Administration of Probes

The grammatical morpheme production and comprehension probes that served as dependent variables (see descriptions below) were administered to each child at three points: prior to randomization and treatment (i.e., Time 1), at the midpoint testing 12 intervention sessions (approximately 6 weeks) later (i.e., Time 2), and at the postintervention testing an additional 12 sessions (approximately 6 weeks) later (i.e., Time 3). All digitally recorded probes were sent electronically to the opposite treatment site for scoring (i.e., Purdue audio files went to the University of Kansas Medical Center and vice versa).

Dependent Variables

Comprehension of Present- and Past-Tense Question Probes

To determine each participant's understanding of present- and past-tense forms of auxiliary BE and DO as they appear in yes/no questions, children's scores on two comprehension probes served as dependent variables. Both 15-item tasks were administered to each participant at each test period. Three sample probe items for auxiliary BE are provided in Figures 1a–1c. Using Microsoft PowerPoint on an iPad, each trial was presented as three points in a single action involving a single character. First, Picture 1 appeared for 2 s. At the end of the delay, Picture 1 was

Figure 1. Examples of (a) *is*-yes, (b) *was*-yes, and (c) *is*-no items from the auxiliary BE production probe.

Table 1. Preexperimental participant characteristics after random allocation to intervention groups.

Preexperimental characteristics	CSI-based group (<i>n</i> = 9)		TRAD group (<i>n</i> = 11)		<i>p</i>	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Key variables at program entry						
Age (months)	45.76	5.14	44.95	3.20	.67	0.19
Sex (<i>n</i>)					.78	
Male	6		8			
Female	3		3			
PTONI (SS)	104.00	12.07	110.73	17.35	.34	−0.44
CARS	16.78	0.97	16.68	1.27	.85	0.09
PPVT-4	99.78	10.07	105.73	13.18	.28	−0.50
SPELT-P2	78.11	7.83	73.45	9.72	.26	0.52
DSS	4.11	1.05	3.73	1.10	.44	0.35
MLU (morphemes)	3.84	0.25	3.51	0.39	.04*	0.98
Dependent variables at Time 1						
3S probe (% correct)	0.16	0.20	0.17	0.19	.91	−0.05
Auxiliary <i>is</i> probe (% correct)	0.15	0.20	0.15	0.25	.97	0.00
Past-tense probe (% correct)	0.12	0.11	0.09	0.08	.38	0.32
<i>is</i> -no comprehension probe (correct/5 trials)	1.67	1.87	1.45	1.51	.78	0.13
<i>did</i> -no comprehension probe (correct/5 trials)	2.78	2.10	2.64	1.75	.87	0.07

Note. CSI = competing sources of input; TRAD = traditional focused stimulation intervention; PTONI = Primary Test of Nonverbal Intelligence; SS = standard score; CARS = Childhood Autism Rating Scale; PPVT-4 = Peabody Picture Vocabulary Test–Fourth Edition; SPELT-P2 = Structured Photographic Expressive Language Test–Preschool: Second Edition; DSS = Developmental Sentence score; MLU = mean length of utterance; 3S = third-person singular present-tense morpheme.

**p* < .05.

covered with a semitransparent screen, making it only slightly visible while Picture 2 appeared. Two seconds after Picture 2's appearance, it also was covered with a semitransparent screen as Picture 3 appeared. After the appearance of Picture 3, with Pictures 1 and 2 only barely visible, the examiner asked a question from one of three subsets of comprehension questions.

Each probe contained three subsets of five items delivered in a quasirandom manner. We refer to the first subset of five questions from the BE test as *is-yes* questions (see Figure 1a for an example). The answer to the question *Is the cat cleaning the room?* in Figure 1a must be *yes* because in Figure 1a Picture 3 (the only clearly visible picture at the time of the question), the cat is indeed cleaning the room. Note that the child does not have to pay even cursory attention to the fronted auxiliary and its relationship with the following nonfinite SV sequence to get these items right. Instead, a child who identifies the actor and the action from the question and recognizes that combination in the third and clearest picture would be expected to produce a *yes* response and receive a perfect score. As a consequence, we expected most children to get four or five items correct prior to an intervention if they were attending and responding to the task cooperatively.

Another subset of five questions from the BE test, which we call *was-yes* questions, is illustrated in Figure 1b. Following the action in Figure 1b, the question *Was the cat painting the wall?* should be answered *yes* because the cat was painting the wall (in Pictures 1 and 2 of Figure 1b) but is no longer doing so (in Picture 3). These questions might have posed a greater challenge than the *is-yes* subset because they involved a past-tense auxiliary and the answer could not be obtained solely by attending to the most obvious picture (Picture 3). Again, however, note that the children did not need to correctly interpret the auxiliary *was* or even pay attention to the auxiliary to answer *was-yes* questions correctly. All the child needed to do was identify the actor and action from the question and respond *yes* if there was a matching picture, which there had been (in Pictures 1 and 2). Again, we expected most children to get four or five of the five *was-yes* questions correct prior to any intervention if they participated cooperatively.

The final subset of items for the BE question comprehension test is exemplified in Figure 1c. In these items, referred to as *is-no* questions, Picture 1 shows a character involved in an incomplete action, such as building a clearly unfinished tower. The second and third pictures show the same character no longer involved in that action. As with the *is-yes* questions, when asked an *is-no* question (e.g., *Is the boy building a tower?*), the child must identify the actor and action from the question. Unlike the other subtypes, however, mapping this scene onto any picture containing the named actor and action (Picture 1 in this subset) does not lead to a correct response. This is because the boy was building a tower in Picture 1 but no longer is building in Pictures 2 or 3. To get these questions right, then, the children had to recognize that *is* refers to activities in the present and that it marks tense for the SV sequence that follows.

The child had to respond *no* even as he or she looked at the scene with the named actor and action in Picture 1.

The second comprehension test was designed to test the child's ability to recognize fronted *does* or *did* as the tense marker for the following SV sequence in questions involving the third person, as in *Does/Did the boy dive into the pool?* The test was structured and administered in a nearly parallel fashion to the BE test just described. Three examples representing the three subsets of items from this second test are provided in Figure 2. Figure 2a is a member of the *does-yes* class. Although the members of this subset were in the present tense, the children did not have to accurately attend to the tense marker to respond to these items with the correct response, *yes*. To get the item in Figure 2a right, the children had only to note that the scene described in the stimulus question involved a boy drawing, match that to Picture 3, and then respond *yes*.

Figure 2b displays an example of the *did-yes* subset. As was the case for the *was-yes* items, the first two pictures showed a character performing an action (e.g., a cat climbing to the roof of a house). In the third picture, this action was clearly no longer sustained or repeated. As long as the children noted that the agent and action from the question matched those in Pictures 1 and 2 (e.g., *Did the cat climb to the roof?*), they could be expected to answer *yes*. Thus, as long as they were attentive and cooperative, the children

Figure 2. Examples of (a) *does-yes*, (b) *did-yes*, and (c) *did-no* items from the auxiliary DO production probe.

should have scored high from the outset on *does-yes* and *did-yes* questions.

Figure 2c displays the structure of the *did-no* subset of the DO comprehension probe. In these items, the character is not engaged in any particular action in Pictures 1 and 2. Picture 3 shows the same character preparing to engage in the action named in the question. For example, in Picture 3 in Figure 2c, the boy is preparing to take a bath but has not yet done so. Thus, the answer to the question *Did the boy take a bath?* and to all *did-no* questions was *no*. Note that the correct answer to these questions could not be generated without sensitivity to tense. The same immature strategy that enabled the children to respond correctly to the *does-yes* and *did-yes* questions without making use of tense cues could not lead the children to the correct answer for the *did-no* subset of items. Thus, we expected that the only true challenge for the comprehension probes would be the five *did-no* and five *is-no* items.

It can be noted that the third set of auxiliary DO items (i.e., *did-no*) would have been more like the third set of auxiliary BE items (i.e., *is-no*) if we had used present-tense *does-no* items instead. We opted not to do so because in pilot testing for *does-no* with different picture arrangements, both children and adults tended to respond *yes* instead of the desired *no* on these trials. The acceptability of these responses is reasonable and can readily be explained. Consider the arrangement in Figure 1c. In Picture 1, a boy is shown building a tower. Pictures 2 and 3 show the same boy no longer building. Thus, the answer to the question *Is the boy building a tower?* must be *no*. If we show the same picture set and ask the question *Does the boy build a tower?*, a *yes* response is acceptable because even though there is no building taking place in Picture 3, it is clear from Picture 1 that the boy does in fact build towers and may do so again. It might be assumed that the question is a query about whether the character frequently or habitually carries out the labeled action (as in *Does the child build every day?*). With either of these interpretations, *yes* cannot be ruled out as an acceptable response. Because they are the only items that required the children to attend to and make use of tense and agreement marking, we needed a subset of our *does-did* probe to generate negative responses. The configuration in Figure 2c as part of a *did-no* question subset yielded the most consistent *no* responses by children and adults in our pilot testing and was therefore adopted. It is clear, however, that aspect (i.e., the extent to which the actions were shown in the pictures to have been completed) was nearly as important a variable as tense, especially in performing the *does-did* comprehension probe. It is also worth noting at this point that there is a major difference between fronted BE and DO auxiliaries that might have influenced our results and interpretations.

Note that for BE, the simple declarative surface form includes the BE allomorph between the subject and verb (e.g., *The girl is eating dinner*). The question form can be described as movement of the BE allomorph to the presubject position. In contrast, DO questions do not have the same type of surface-level relationship between the interrogative

form (e.g., *Does the girl eat dinner?*) and the simple declarative form (e.g., *The girl eats dinner*). These different auxiliaries could differ greatly in their potential to help children recognize that in questions, the use of nonfinite SV sequences depends on the presence of an earlier form that carries tense.

Grammatical Morpheme Production Probes

The dependent variables for production were the percentages correct on three production probes: use of 3S, auxiliary *is*, and regular past-tense *-ed* morphemes. These probes were the same as those used by Leonard and colleagues (Leonard, Camarata, Pawłowska, Brown, & Camarata, 2006, 2008). Each finiteness probe included 18 different verbs and required the child first to watch a scripted performance (or “show”) with toys and props and then to describe the event to a turtle puppet who had missed it because he was hiding in his shell. For a response to be scorable, the child had to either (a) produce both the target subject and verb or (b) complete a cloze in which the examiner provided the subject (Examiner: *Tell Shy Turtle about the dog. Every day, the dog ...* Child: [*The dog*] *hides*). Stimuli were repeated when the child failed to respond or failed to use the target verb. When the child produced only a nontarget verb, the attempt was judged scorable if the verb had a meaning similar to that of the target (e.g., [*the dog*] *go in his house*). To avoid the child’s use of the target morphemes on a limited number of stems, no verb was counted as scorable more than three times. Because not all children produced 18 scorable responses, the number of correctly marked verbs was divided by the total number of scorable responses, yielding a percentage correct. These percentages were used as the dependent variables.

To start each of the three probes, Shy Turtle was introduced. Then the examiner acted out the script and asked the child to help the turtle, who had missed the show. Each of the three probe types is described in greater detail below.

Auxiliary is. This task was adapted from McShane and Whittaker (1988). Children were required to produce both the subject and the verb, marked with the progressive morpheme *-ing*.

Experimenter: *Here’s a dog and here’s a cow. The dog says, “I want to drive.” The cow says, “I want to drive too.” But only one can do the show. (Makes the dog drive around continuously for 12 s)*

Experimenter as Turtle: *I can’t see. Please tell me about the show.*

Experimenter: *Tell the turtle. Right now, the _____.*

This task proved to be too difficult for some children, who were unable to supply the subject and the verb with the progressive marker. When this was the case, an alternate script was used.

Experimenter: *Look, the dog is driving. Now the cow is drawing. (Raises a barrier so the child cannot see and performs one target action [i.e., driving] behind the barrier)*

Experimenter: *Guess which one. Is the dog driving, or is the cow drawing? Right now, the _____.*

If the child answered incorrectly, the experimenter directed the child to tell the puppet about, for example, the dog.

Experimenter: *Tell the turtle about the dog. Right now, the _____.*

Third-person singular –s. The task used to assess 3S production was adapted from Schütze and Wexler (2000).

Experimenter as girl character: *I'm getting tired.*

When I get tired, I sleep. (Lays girl in bed)

Experimenter as Turtle: *Oh-oh, I didn't see. What does the girl do when she's tired?*
She _____.

Past-tense –ed. The task used for this morpheme was also adapted from Schütze and Wexler (2000).

Experimenter: *Cookie Monster has a lot of beads.*

He wants to fill up something.

Experimenter as Cookie Monster: *Should I fill up my cup or my bottle?*

Child: *His cup.*

(Cookie Monster performs action)

Experimenter: *Grover wants to open something.*

Experimenter as Grover: *Should I open my bag or my jar?*

Child: *His jar.*

(Grover performs action)

Experimenter as puppet: *I didn't see what happened.*

Can you tell me what just happened?

Experimenter repeats each action and then prompts:
Cookie Monster filled up his cup and Grover _____.

Each item was designed to elicit the child's use of the target verb followed by a particle that began with a vowel, an indefinite article, or a possessive pronoun. This created phonetic contexts that facilitated the transcriber's judgment of whether the child's verb production was appropriately inflected (e.g., *Grover filled up his bag*). If the child did not produce the targeted material immediately after the verb, the item was prompted again to get an unambiguous production.

Basic Organization of Intervention Sessions

The basic structure of each intervention session is schematized in Figure 3. Intervention was provided in two 30- to 40-min individual sessions per week for 12 weeks and a total of 24 sessions. Both 3S and auxiliary *is* were treated sequentially in each session, and order of target was alternated after every two sessions. The only time-constrained section was the recast section, which was required to be between 5 and 10 min in length for each morpheme. Each intervention session contained three sections—comprehension, story model, and retell–recast—for each target morpheme (i.e., auxiliary *is* and 3S) for a total of six sections per session.

Figure 3. The basic structure of intervention sessions. CSI = competing sources of input; TRAD = traditional focused stimulation intervention; 3S = third-person singular present-tense morpheme.

Comprehension Segment

The first intervention segment was a brief presentation of a 10-item comprehension game, delivered on an iPad, using scenes and question stimuli similar to the comprehension probe (see Figures 1 and 2). The pictures were arranged so that answers to questions for the CSI-based group required interpretation of the tense-marking auxiliary, whereas those for the TRAD group depended on detecting matches and mismatches of spoken and pictured characters and actions unrelated to time.

CSI-based group. For the CSI-based group, comprehension practice was designed to teach the child to attend to the fronted auxiliary verb in the clinician's question, apply its tense to the scene represented by the following SV sequence, and answer the question accordingly. In other words, the children were taught to apply tense, which in questions is marked by the fronted auxiliary, to the following actor–action scene. Figures 1 and 2 also exemplify basic trials in the comprehension intervention task, with the exception that the specific items in the probe never reappeared in the teaching task. The 10-item comprehension teaching task that began each session utilized two of the three subsets of the comprehension task items (e.g., *is–no* vs. *was–yes*) at a time until a performance criterion was met. For the first treatment session, clinicians identified the two comprehension subsets that appeared to be giving the child the greatest difficulty on the basis of the most recent comprehension probe or teaching session. They then administered 10 of the items in clusters of three trials

per subset (e.g., three *is-no*, three *was-yes*, two *is-no*, and two *was-yes* = 10 trials). When performance on either of these subsets reached four out of five over 2 days, that subset was replaced by the third subset until the child achieved at least four of five correct on the remaining subsets. Once this was accomplished, all three types were represented in the teaching for the remainder of the intervention sessions. Regardless of the child's performance within the session, clinicians presented only 10 trials, after which the session progressed to the story task.

In the comprehension probes, the clinician accepted each of the child's *yes* or *no* responses and moved to the next item with no feedback. In contrast, in the comprehension teaching trials, feedback was provided after each child response. For correct answers, the clinician produced a general positive response (e.g., *Yes, that's right*). Most answers to *is-yes* and *does-yes* questions were correct. For incorrect answers, feedback was instructive. For example, for *is-no* questions, the interventionist pointed to the third picture, in which the character is no longer performing the action, and responded, *No, I asked, "Is the boy diving into the pool." And see, right now he's not*. For *was-yes* questions, the interventionist pointed to the first two pictures and said, *No, I asked, "Was the girl climbing to the roof?" And see, before she was*. The same types of corrective feedback were applied to the *does/did* questions.

TRAD group. Comprehension teaching items for the TRAD group required the children to match the actor and action found in the stimulus question with the correct actor and action in the correct picture. Correct answers were never contingent on the children's determination of the tense marked by the sentence-initial auxiliary. Consider an example of a *yes* teaching trial for a present- or past-tense question (e.g., *Is/Was the boy cleaning the room?*). Picture 1 showed a boy standing still, and both Pictures 2 and 3 showed the boy cleaning the room. In this case, *yes* must be treated as correct whether the child is thinking of the present-tense form (i.e., attending to Picture 3) or the past-tense form (i.e., attending to Picture 2). In other words, regardless of the tense of the question stimulus, *yes* is still the correct response because the target actor was performing the target action in Picture 2 and is performing that action in Picture 3. There were virtually no errors on these items.

Comprehension teaching items requiring a *no* response were designed to have a mismatch in the actors and actions in the questions and the pictures. For example, pictures appearing for the item *Was the girl riding to the park?* showed a girl standing still in Picture 1, a boy riding to the park in Picture 2, and a girl filling a glass in Picture 3. Correction of errors on these items required the clinicians to contrast the actors and actions found in target and foil pictures but never involved highlighting time differences in pictures that were otherwise identical. An erroneous *yes* answer to the example would have been followed by an explanation of the mismatch—for example, *I asked, "Was the girl riding to the park? And see, the boy was riding, not the girl*. As an alternative, the interventionist might have responded, *The girl is filling the glass, not riding to the park*.

Short Story Modeling Segment

In the second segment of the intervention sessions, the interventionist read a short story to the child while acting it out with toys, dolls, and other props (see examples in Table 2). The stories were written to provide focused stimulation on the morphemes treated in this study. To avoid competing stimuli, for the CSI group, stories for auxiliary *is* and 3S treatment contained 12 models of the target morpheme in declarative sentences. For the TRAD group, the

Table 2. One story prepared for children in the CSI-based group and one for children who received the TRAD intervention.

3S CSI-based story: *Clumsy Tyler*

Finite target verbs: *play, kick, fall, lose, jump, step, trip, fix*

Materials: two boy dolls, mom doll, soccer ball, glasses, soccer goal

Hi Tyler! Every day, Tyler **plays** soccer. Tyler always **kicks** the ball the best.

To his friends, to the other side of the field, quickly back and forth.

Today during the soccer game, Tyler **kicks** the ball so hard that he **falls** on his back and he **loses** his glasses! Whoops!

Tyler **jumps** up, but he **steps** right on the glasses. CRUNCH!

Oh no! Tyler can't see the ball without his glasses!

Tyler's friend **kicks** the ball to him, but Tyler **trips** on the ball and he **falls**!

Oh no! He really cannot see the ball!

Quickly, Tyler's Mom **fixes** the glasses for him.

Wow—what a difference!

Now Tyler can see again!

Tyler **kicks** the ball really well at the game!

To his friends, to the other side of the field, quickly back and forth.

Into the goal!! Yay Tyler! This could be his best game yet!!

3S TRAD story: *Clumsy Tyler*

Finite target verbs: *play, kick, fall, lose, jump, step, trip, fix*

Nonfinite target verbs: *play, jump, kick*

Materials: two boy dolls, mom doll, soccer ball, glasses, soccer goal

Hi Tyler!

Does Tyler play football? Nope ...

Does Tyler play basketball? No ...

Does Tyler play soccer?

Yes! Tyler **plays** soccer every day. Tyler always **kicks** the ball the best.

To his friends, to the other side of the field, quickly back and forth.

Today during the soccer game, Tyler **kicks** the ball so hard that he **falls** on his back and he **loses** his glasses! Whoops!

Does Tyler jump back up?

Yes, Tyler **jumps** up, but he **steps** right on the glasses. CRUNCH!

Oh no! Tyler can't see the ball without his glasses!

Does anyone kick the ball to him?

Yes, Tyler's friend **kicks** the ball to him, but Tyler **trips** on the ball and he **falls**!

Oh no! He really cannot see the ball!

Quickly, Tyler's Mom **fixes** the glasses for him.

Wow—what a difference! Now Tyler can see again!

Does Tyler kick the ball better now?

Yes! Tyler **kicks** the ball really well at the game! To his friends, to the other side of the field, quickly back and forth.

Into the goal!! Yay Tyler! This could be his best game yet!!

Note. CSI = competing sources of input; TRAD = traditional focused stimulation intervention; 3S = third-person singular present-tense morpheme.

stories for auxiliary *is* were modified so that they contained six declarative models of the target as well as six interrogatives. Because auxiliary *is* appears on the surface in both declaratives and interrogatives, this manipulation introduced a competing source of input for the children in the TRAD group (i.e., the interrogatives) while keeping the total number of models of auxiliary *is* the same across groups (i.e., 12). In contrast with auxiliary *is*, third-person simple present tense is represented in interrogatives by pre-subject positioning of the DO form *does* (e.g., *Does Jack find Roscoe?*). Thus, adding six interrogatives in the third person does not add any models of 3S. To maintain the standard of 12 models per story, TRAD group stories for the 3S target were revised to contain 12 declaratives plus six interrogatives with the irregular form *does*. Adding six such interrogative models and holding the declaratives at 12 had the effect of adding competitive input for the TRAD while making the number of models of 3S the same for both groups.

Retell–Recast Segment

For the third intervention segment, the interventionist provided eight recasts of child utterances in declarative sentences during 5 to 10 min of play with toys, props, and events taken from the story of the day. Children were not required to literally retell the story. Rather, the clinicians used story props and story events to prompt children to talk about their favorite story parts. When they did, their sentences were easy for clinicians to follow, with recasts containing either auxiliary *is* or 3S. To be considered a recast, the adult's utterance had to immediately follow the child's platform utterance, use the same subject and verb used by the child, and contain the target form. To ensure recasts were provided at a density high enough to be considered therapeutic, all recasts were required to be delivered between a period of no less than 5 min and no more than 10 min, or a rate of 0.8 to 1.6 recasts/min (Fey, Krulik, Loeb, & Proctor Williams, 1999). Models of auxiliary *is* and 3S that were not part of a clinician recast (and all uses of regular past tense) were considered violations of the treatment protocol. For the CSI-based group, all eight recasts were required to be declaratives. In contrast, children in the TRAD group received some of their recasts in interrogative form. For the auxiliary *is* target, the recasts were evenly divided between four declaratives and four interrogatives, resulting in eight examples of the surface form. For the 3S target, the children in the TRAD group received eight declaratives containing the surface 3S form and four interrogatives with the auxiliary-fronted *does*.

Fidelity of Treatment

All treatment sessions were audio-recorded, and a copy of each was sent to the alternate study site for fidelity checks within a few days of the recording. Two successive intervention sessions, each including both auxiliary *is* and 3S targets, were then blocked together, forming four options per session pair (i.e., either the auxiliary *is* or 3S morpheme

in either the first or second session for each pair of sessions). Next, within each pair of sessions, one of the four options was selected at random for analysis of treatment fidelity. Thus, 25% of the randomly selected recorded intervention data was subjected to fidelity evaluation. For each selected session, an associate researcher or graduate assistant listened to the audio recordings of the sessions and tallied the interventionists' use of targeted procedures (e.g., models and recasts of auxiliary *is* and 3S). They also identified the interventionists' use of language that was to be avoided, including use of nonrecast models of auxiliary *is*, 3S, and subordinate clauses with SV structure during the retell task or use of copula *is* or regular past-tense *-ed* at any time during the session.

The output of these tallies is presented in Table 3. The data in columns 1–5 demonstrate that the interventionists were highly successful in reaching the target numbers of models and recasts planned for each group. Thus, the CSI-based intervention faithfully provided targeted numbers of models and recasts with virtually no competing sources of input, whereas the TRAD intervention supplied the targeted amounts of models and recasts, one half to one third of which was presented in competing interrogative form. The data in columns 6–9 of Table 3 represent use of nuisance language forms that, if used frequently, could have compromised any planned outcomes of the CSI-based intervention. A close look at these columns illustrates that the numbers of these nuisance behaviors used unintentionally by the interventionists were both microscopically small and highly similar across groups.

Reliability of Scoring

At each test site (Purdue and University of Kansas Medical Center), probes were delivered and audio-recorded by the primary research associate, who also delivered the intervention. All scoring was performed using the digital audio-recorded samples. The children's responses to the two comprehension probes were scored for correct answers, and the three expressive probes were scored for accuracy of production at each of the three assessment periods. All scoring was done by individuals who were unaware of the participants' group affiliation. For each of the expressive probes, the number of items for which the child accurately produced the target morpheme was calculated. If a child used a verb other than the planned response, the child was prompted a second time. If the intended verb was still not used, the response was scored if it was semantically related. For example, a response of *clean* or *cleans* was accepted in place of the intended response *sweeps*. For each target morpheme, the child's proportion correct was computed by dividing the number of productions of the appropriate morpheme by the number of scorable responses given.

To examine scoring reliability, approximately 33% of the probe sessions were randomly selected for a second scoring by an independent project assistant who was unaware of the children's group membership. Using the random effects model and the absolute agreement definition,

Table 3. Means and standard deviations for interventionist uses of targeted models and recasts that define the interventions (columns 1–5) and misuses of “nuisance language forms” that were to be avoided in both interventions (columns 6–9).

Group	1. Declarative models in the story (target: 12 or 6)	2. Auxiliary-fronted models in the story (target: 0 or 6)	3. Length of recast–retell section (min:s; target: 5–10 min)	4. Declarative recasts in retell–recast (target: 8 or 4)		5. Auxiliary-fronted question recasts in retell (target: 0 or 4)		6. Use of <i>is</i> and 3S other than recasts used in retell (target: 0)	7. Nonfinite subordinate clauses used in retell (target: 0)	8. Copula BE forms used in retell (target: 0)	9. Past-tense forms used in retell (target: 0)
CSI-based											
<i>M</i>	11.90	0.00	6:14	7.90		0.01		0.10	0.01	0.30	0.03
<i>SD</i>	0.20	0.00	0.04	0.40		0.10		0.40	0.10	0.70	0.20
TRAD				3S	<i>/s</i>	3S	<i>/s</i>				
<i>M</i>	6.10	5.90	7:10	7.80	4.20	3.90	3.90	0.10	0.02	0.40	0.02
<i>SD</i>	0.80	0.50	0.06	0.70	0.60	0.40	0.40	0.40	0.20	0.70	0.20

Note. 3S = third-person singular present-tense morpheme; CSI = competing sources of input; TRAD = traditional focused stimulation intervention.

intraclass correlations ranged across Time 1, Time 2, and Time 3 from .71 to .99, with an overall average of .92. This indicates that most of the total variance in scores was attributed to systematic differences between participants rather than to differences in judges' assignments of scores or random error.

Predicted Outcomes

We asked whether a language intervention that contained numerous features that are based on the principles of the CSI hypothesis would lead to more consistent finiteness morpheme usage than would be the case for a more traditional treatment that included the same number and type of models of targets but none of the features uniquely motivated by the CSI hypothesis. For the most part, our predictions were straightforward.

1. Significant Group $\times$ Time interactions favoring the CSI-based group on the auxiliary *is* and 3S production probes at least by Time 3. We anticipated no significant gains over time for the TRAD group.
2. Significant gains on the responses to the *is-no* and *did-no* subsets on the comprehension probes for the CSI-based group but not the TRAD group. Recall that these were the only types of questions that required the children to base their response on interpretation of the presubject position of questions. Thus, we anticipated that the children who got CSI-based intervention would outperform the TRAD group on these tasks at least by Time 3.
3. A correlation between scores on the *is-no* comprehension items and the production probes for auxiliary *is* and between the *did-no* comprehension items and scores on the 3S production probes for the CSI-based group but not for the TRAD group.
4. No group differences between the two groups in the use of *-ed* given that this morpheme was not treated directly.

Results

Outcomes of Predictions for *Is*

The groups' performances on the auxiliary *is* production probe are compared at each 6-week, 12-session interval in Figure 4a. Because the groups initially differed in their MLUs, the statistical analysis plan was to determine whether there was a significant correlation between the children's Time 1 MLUs and their performance on the production probes for auxiliary *is*, 3S, and *-ed*. None of the correlations were significantly different from zero. Thus, MLU was not used as a covariate. We first tested for intervention-related group effects on the production of auxiliary *is*, with group as a between-participants variable and time as the repeated measure. The resulting analysis of variance yielded a significant main effect for time— $F = 24.17$, $df(2, 36)$, $p < .001$ —and a marginally significant effect for group— $F = 4.20$, $df(1, 18)$, $p = .055$. More important,

Figure 4. A comparison of the competing sources of input (CSI)-based and the traditional focused stimulation intervention (TRAD) groups' performances on (a) the auxiliary *is* production probe, (b) the third-person singular present-tense morpheme production probe, and (c) the regular past-tense *-ed* probe at Times 1, 2, and 3. The asterisk indicates a significant difference between the CSI and TRAD groups at Time 3.

the Time $\times$ Group interaction was statistically reliable and very large: $F = 7.94$, $df(2, 36)$, $p = .001$. Within-participant pairwise comparisons revealed that the CSI-based group made significant gains from Time 1 to Time 2 (mean difference = 0.40, $p < .001$, $d = 1.40$) and from Time 1 to

Time 3 (mean difference = 0.61, $p < .001$, $d = 1.89$), whereas the TRAD group made no significant gains over the research period (all $ps > .18$; all $ds < .80$). The difference between groups was marginal at Time 2—mean difference = 0.33, $p = .063$, $d = 0.89$, 95% confidence interval (CI) [−0.03 to 1.81]—but was statistically significant and large at Time 3—mean difference = 0.45, $p = .009$, $d = 1.31$, 95% CI [0.34 to 2.28].

To further examine the effects of the CSI-based intervention on *is* usage, we compared the two groups on their comprehension of *is–no* questions. With our small sample size and a response range of only five trials on the *is–no* question subset, we opted to run nonparametric Mann–Whitney tests to compare the groups' *is–no* question responses at Time 2 and Time 3. Given our prediction of a directional hypothesis with higher scores for the CSI group, we adopted one-tailed testing. Our results were consistent with those for the production probe and with our hypothesis. At Time 2, the two groups were only marginally different ($U = 28.0$, $Z = -1.75$, $p = .056$, one-tailed), whereas by Time 3 the mean rank for *is–no* scores for the CSI-based group was statistically greater than that for the TRAD group ($U = 16.0$, $Z = -2.71$, $p = .005$, one-tailed). Recall from Table 1 that the two groups did not differ in their *is–no* comprehension at Time 1 ($p = .78$, $d = 0.13$).

Last, we performed one-tailed nonparametric correlational analyses to determine whether the comprehension and production scores for auxiliary *is* were correlated within each group at Time 3. Within the group of participants who got the TRAD treatment, Time 3 *is–no* comprehension scores were not correlated with auxiliary *is* production probe scores (Kendall's tau = $-.03$, $p = .46$, one-tailed). In contrast, the CSI-based group's Time 3 *is–no* scores were significantly correlated with auxiliary *is* production probe scores (Kendall's tau = $.56$, $p = .03$, one-tailed).

Outcomes of Predictions for 3S

We followed the same pattern of analyses for 3S with markedly different results. The analysis of variance, with Greenhouse–Geisser adjusted degrees of freedom, revealed a significant effect of time, $F = 7.71$, $df(1.28, 23.10)$, $p = .007$, a finding that appears to be attributable to some gains by both groups. There were no statistically reliable main group effects— $F = 0.03$, $df(1, 18)$, $p = .86$ —or interaction effects— $F = 0.43$, $df(1.28, 23.10)$, $p = .57$ —that would implicate the differences between the two interventions as reasons for the significant change over time.

Comparison of Figures 4a and 4b reveals that the performance of the TRAD group is remarkably similar across these two morphemes. In contrast, the CSI-based group's performance was much weaker for 3S than for auxiliary *is*. From these comparisons, it is clear that the absence of between-groups effects for 3S production at Time 3 reflects the CSI-based group's much smaller gains made over time in 3S compared with auxiliary *is* production rather than significant increases in the TRAD group's gains across the same morphemes.

The intervention groups were then compared on their comprehension scores in response to *did–no* questions. These items were intended as the interrogative counterparts to declarative sentences containing 3S. The *did–no* questions required the child to correctly interpret the tense of the fronted auxiliary verb and base a response of *no* on the observation that the action shown had not been completed by the end of the picture sequence. Mann–Whitney tests revealed no significant differences between groups at Time 2 ($U = 37.5$, $Z = -0.93$, $p = .19$, one-tailed), but at Time 3 the CSI-based group had reliably higher ranks than the TRAD group ($U = 26.0$, $Z = -1.84$, $p = .04$, one-tailed).

As expected, the *did–no* comprehension scores were not significantly correlated with the 3S production probe scores at Time 3 within the TRAD group (Kendall's tau = $.27$, $p = .13$, one-tailed). However, contrary to expectations, the correlation was also nonsignificant at Time 3 within the CSI-based group (Kendall's tau = $.10$, $p = .37$, one-tailed).

Outcomes of Predictions for –ed

The final analysis focused on the control morpheme: past-tense *–ed*. Neither group participated in activities that included *–ed*, and no group differences were expected at any time point for this morpheme. Time proved to be a significant main effect, $F = 4.56$, $df(1.28, 23.7)$, $p = .04$, but neither the main effect for group— $F = 1.03$, $df(1, 18)$, $p = .32$ —nor the interaction between time and group— $F = 1.28$, $df(1.28, 23.07)$, $p = .28$ —were statistically reliable. For comparison purposes, we calculated the size of the nonsignificant between-groups effect at Time 3, $d = 0.53$, 95% CI [−0.36 to 1.43].

Discussion

A Theoretical Accounting of the Outcomes for Is Intervention

The findings for intervention targeting auxiliary *is* were highly consistent with predictions. Children assigned to the CSI-based condition made greater gains in the use of auxiliary *is* than the children assigned to the TRAD condition. In addition, the CSI group made greater gains on *is–no* comprehension, and for these children (but not the TRAD group) there was a significant correlation between *is–no* comprehension and auxiliary *is* production. This difference between the two groups occurred despite equal exposure of *is* during the comprehension activity, the story, and the recasting that occurred during each intervention session.

Within the CSI framework, this set of findings can be explained in the following way. As the children in the CSI-based intervention heard a high density of instances of auxiliary *is* during the stories and recasts, they heard no instances of nonfinite SV sequences. The only times that a nonfinite SV sequence appeared during an intervention session were in the questions used during the comprehension activity. At these times, the children were required to attend

to the tense of the fronted auxiliary and to use this information to interpret the SV clause. According to the CSI hypothesis, this activity may have taught the children that nonfinite SV strings cannot be interpreted without reference to aspects of the broader sentence of which they are a part. By this account, children in the CSI group improved in their ability to comprehend auxiliary *is* questions and, as predicted by the CSI approach, improved to a related extent in their production of *is* in declaratives.

In contrast, the children in the TRAD group heard instances of nonfinite SV sequences mixed in with examples of overt, sentence-internal uses of auxiliary *is* during all portions of the intervention session. Further, during the comprehension activities, there were no requirements to relate these sequences to the fronted auxiliary form, as were present in the CSI intervention. Thus, we expected no gains in *is* comprehension and production for the TRAD group, and none were observed. By the CSI approach, this type of exposure to these nonfinite SV sequences would not facilitate development and could even stunt the children's progress in developing consistent use of auxiliary *is*.

Because none of the alternative accounts of inconsistency discussed at the outset of this article served to motivate the CSI intervention, there are no obvious reasons, from these perspectives, why one should expect children to benefit more from it than from the TRAD intervention. For example, neither the EOI account nor the RDDR account attribute special importance to the input, and according to the RDDR account, gains are not likely without special compensatory efforts. Further, features that define the CSI intervention, such as avoiding *is* in interrogatives and contrasting tense in playing the question comprehension game, would offer no advantages over the TRAD intervention according to these alternative accounts. Likewise, according to the input informativeness approach, the input provided in fronted auxiliaries should be no more problematic than the input provided in simple declarative sentences. Thus, there is no reason to expect our CSI intervention to have any advantages over the TRAD treatment by this theoretical account. Yet it did have advantages for *is*, and they were large.

Theoretical Implications of the Outcomes for 3S Intervention

In contrast to the large effects observed for auxiliary *is*, the results from 3S intervention provided no evidence that the CSI-based condition was more beneficial than the TRAD condition. The two groups did not differ in their gains in using 3S. Although the CSI group made greater gains than the TRAD group on the *did-no* comprehension probes, as expected, there was no correlation between these gains and the children's gains on 3S.

There is a possible explanation for this finding that also could have implications for interpretation of the findings for *is*. First, recall that during 3S intervention the two groups of children heard the same number of 3S forms—forms that always occur with declarative word order. In contrast, during

auxiliary *is* intervention, the CSI group heard more instances of *is* in the declarative position than did the TRAD group. This might lead to the conclusion that the critical factor in intervention was the number of target forms heard in the declarative position and that the comprehension activities were irrelevant to the children's progress in both *is* and 3S intervention. Note that this finding requires the assumption that declarative forms have special status. The same assumption might lead to the prediction that exposure to fronted auxiliary forms—at least during the period of development studied here—will have neither a facilitative nor an inhibiting effect.

This interpretation of the 3S intervention findings ignores one important element of the CSI account—namely, that input containing nonfinite SV sequences can lead children astray, resulting in inappropriate extraction of these sequences as stand-alone utterances. We believe that having 3S presented an equal number of times in the two interventions contributed to the lack of differences between the two groups; however, we suspect that our failure to observe group differences during 3S intervention had more to do with the distribution of DO questions during 3S intervention compared with the distribution of *is* questions during *is* intervention and the opaque relationship between DO questions and 3S.

With regard to distribution, DO questions constituted only one third of the input in 3S intervention for the TRAD group, whereas for this same group auxiliary *is* questions represented one half of the input in auxiliary *is* intervention (see Figure 3). Thus, any slowing effects on developmental progress due to exposure to nonfinite SV sequences might have been expected to be greatest in the *is* segment of the TRAD intervention. This, then, would have enhanced the differences between the CSI and TRAD groups on the production of *is*.

Regarding opacity, we noted earlier that auxiliary DO forms in questions do not have a declarative counterpart, as is the case for auxiliary BE forms. In the latter, it is possible to characterize the appearance of auxiliary BE in questions as the result of movement (as in *The horse is running* → *Is the horse running?*). In the case of DO, only abstract features of tense and agreement can be said to be moved to utterance-initial position. It is for this reason that auxiliary DO is referred to as a *dummy* auxiliary (e.g., Radford, 1997). Thus, although the appearance of DO questions should have had a detrimental effect overall because they contain nonfinite SV sequences, their effect on 3S use might have been less direct than the effect that auxiliary *is* questions had on auxiliary *is* use.

There are other reasons for the findings of a large intervention effect for *is* and no effect for 3S. According to the CSI account, there are multiple structures in the input that contain nonfinite SV sequences. It is likely that children's gains in using 3S are incremental because they depend on the children resolving the finiteness dependencies one structure at a time. For example, when children resolve the relationship between auxiliary DO forms and the later-appearing nonfinite verb in input questions such as *Does the*

bird sing?, they may not have yet resolved the relationship reflected in input utterances such as *She hears the bird sing*. Note that such a resolution requires children to know that perception verbs such as *hears* and *sees* allow for a nonfinite verb in the SV clause. If the children have not yet learned the distinction between perception verbs and, say, cognitive verbs such as *thinks* and *knows*, then hearing utterances such as *She thinks the bird sings* along with *She hears the bird sing* could slow children's development of 3S use even if DO questions were no longer a stumbling block. The same applies to auxiliary *is*, of course (e.g., *Is the bird singing?*; *She hears the bird singing*; *She thinks the bird is singing*). Although our CSI-based intervention for auxiliary *is* produced gains that exceeded those seen for TRAD intervention, the fact that the CSI group's postintervention use of auxiliary *is* was still not at mastery levels raises the likelihood that dependency relations in other related structures had not yet been fully worked out by the children.

Last, we monitored the children's use of past-tense *-ed* over the course of the study as a type of control, as this morpheme was never targeted. We did not expect the two groups to differ in their use of *-ed*. The numerical difference between the two groups did not reach statistical significance at any time point.

Conclusions

The outcomes of our study are generally supportive of the CSI hypothesis, and they suggest that interventions that are based on the hypothesis have considerable clinical promise. In particular, the approach of focusing on the tense value of fronted auxiliary BE forms to promote production is both novel and, we believe, potentially important for clinical application. The mixed results for auxiliary *is* and 3S, however, should serve as a reminder that the intervention is not yet ready for prime time. Before the intervention can be judged to be evidence based and applied on a wide basis, we need additional evaluations of the effects and efficacy of different manifestations of the CSI hypothesis that are designed to yield broader and more consistent outcomes under less ideal clinical conditions.

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