Published in final edited form as:
J Speech Lang Hear Res. 2011 February ; 54(1): 99–117. doi:10.1044/1092-4388(2010/10-0010).

Psycholinguistic Profiling Differentiates Specific Language Impairment From Typical Development and From Attention-Deficit/Hyperactivity Disorder

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Abstract

Purpose—Practitioners must have confidence in the capacity of their language measures to discriminate developmental language disorders from typical development and from other common disorders. In this study, psycholinguistic profiles were collected from 3 groups: children with specific language impairment (SLI), children with attention-deficit/hyperactivity disorder (ADHD), and children with typical development (TD). The capacity of different language indices to successfully discriminate SLI cases from TD and ADHD cases was examined through response operating characteristics curves, likelihood ratios, and binary logistic regression.

Method—The Test of Early Grammatical Impairment (Rice & Wexler, 2001a), Dollaghan and Campbell's (1998) nonword repetition task, Redmond's (2005) sentence recall task, and the Test of Narrative Language (Gillam & Pearson, 2004) were administered to 60 children (7–8 years of age).

Results—Diagnostic accuracy was high for all 4 psycholinguistic measures, although modest reductions were observed with the SLI versus ADHD discriminations. Classification accuracy associated with using the Test of Early Grammatical Impairment and the Sentence Recall task was equivalent to using all 4 measures.

Implications—Outcomes confirmed and extended previous investigations, documenting high levels of diagnostic integrity for these particular indices and supporting their incorporation into eligibility decisions, differential diagnosis, and the identification of comorbidity.

Keywords

phenotype; specific language impairment; attention-deficit/hyperactivity disorder; evidence-based practice; differential diagnosis

Scores of language tests and other procedures designed to identify and assess developmental language disorders are available to practitioners to help inform their diagnostic decisions. This diverse array of clinical tools is a reflection of the variety of frameworks that have been applied over the last 30 years to the evolving construct of "linguistic proficiency." These instruments vary dramatically in terms of their popularity, theoretical currency, and

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practicality. Some measures require mere minutes to administer and score, whereas others require hours and specialized training. However, to be useful from an evidence-based practice perspective, procedures that have been designed to identify developmental language disorders need to be able to accomplish two related goals. First, they must be able to consistently identify children with developmental language disorders as being affected with developmental language disorders (sensitivity). Secondly, they must be able to consistently classify children without developmental language disorders as being unaffected by developmental language disorders (specificity). Unfortunately, many of the more commonly used standardized language tests have failed to demonstrate adequate levels of discrimination (Spaulding, Plante, & Farinella, 2006). The prominent use of language testing procedures with either weak or unknown discriminative capacities is especially problematic because it raises the risks of both missed diagnosis and misdiagnosis to unacceptably high levels. In addition to squandering the time and effort of individual practitioners, diagnostic imprecision seriously undermines attempts to evaluate the effectiveness of treatment regimens, to develop risk registries, and to establish prognostic indicators.

The risk for missed diagnosis may be particularly problematic for children with *specific language impairment* (SLI). SLI represents the most common developmental language disorder, affecting approximately 5% to 7% of the school-age population, and refers to those cases of language impairment that exist in the absence of identifiable perceptual, cognitive, or environmental deficiencies (Johnson et al., 1999; Tomblin et al., 1997). Results from several longitudinal studies converge on the presence of long-standing communicative and academic difficulties for a substantial portion of individuals with SLI (Beitchman et al., 2001; Conti-Ramsden, 2008; Law, Rush, Schoon, & Parsons, 2009; Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998; Tomblin, 2008). However, in spite of the high incidence of SLI and the recognized costs associated with leaving SLI untreated, SLI is likely to be underdiagnosed. For example, of the 288 second graders identified at kindergarten through epidemiological sampling procedures as having SLI, Zhang and Tomblin (2000) found that only a small minority (17.8%) of their study sample had received either school-based or clinic-based services. Similarly, Johnson et al. (1999) reported that although language impairments were still prominent at age 19 years within their epidemiological sample of 103 children with SLI identified at kindergarten, only 44.9% of these children had received intervention during their academic careers.

Interests in the genetic and environmental contributors to SLI have prompted investigators to identify more effective indices of impaired language development. Evidence accumulating over the past decade indicates that tense marking, nonword repetition, and sentence recall represent three promising markers for the psycho-linguistic profiling of developmental language disorders (e.g., Archibald & Joanisse, 2009; Bishop, North, & Donlan, 1996; Bishop et al., 1999; Conti-Ramsden, 2003; Conti-Ramsden, Botting, & Faragher, 2001; Dollaghan & Campbell, 1998; Ellis Weismer et al., 2000; Rice, Wexler, & Cleave, 1995; SLI Consortium, 2002; Spaulding et al., 2006; Tager-Flusberg & Cooper, 1999). Tense marking and nonword repetition have proven to be particularly useful for establishing genotype/phenotype correspondence in linkage and association analyses of SLI

(Falcaro, Pickles, & Newbury, 2008; Monaco, 2007; SLI Consortium, 2002; Rice, Smith, & Gayan, 2009).

The ability to produce and comprehend narratives represents another important language index that might also be helpful for the psycholinguistic profiling of developmental language disorders. Some researchers have advocated for the inclusion of narrative measures into assessment protocols because the ability to recall, interpret, and produce stories taps into ecologically valid and educationally relevant dimensions of linguistic proficiency (Bishop, 1997; Fey, Catts, Proctor-Williams, Tomblin, & Zhang, 2004; McFadden & Gillam, 1996). Unfortunately, narrative tasks have encompassed a broad range of specific measures (e.g., mean length/complexity of T-units, co-reference, episode structure, informational density, inferential reasoning, etc.). Asa result, much less is known about the capacity of specific narrative measures to serve as clinical markers, relative to the evidence available on tense marking, nonword repetition, and sentence recall. However, narrative composite measures that are based on performance across multiple skills have been shown to effectively differentiate children with persistent rather than transient language delays as well as predict future reading ability (e.g., Bishop & Edmundson, 1987; Fey et al., 2004; Paul & Smith, 1993; but see Pankratz, Plante, Vance, & Insalaco, 2007, for confuting evidence).

Many times, practitioners find themselves engaged in decisions where the distinction needed is not between typical or atypical status but between different kinds of atypical designations. To be useful in these contexts, indices of language impairment must be able to differentiate poor performance that is due to the presence of a developmental language disorder from other developmental difficulties that could compromise children's performances. One developmental condition that needs to be taken into account during the process of identifying diagnostic measures for developmental language disorders is *attention-deficit/ hyperactivity disorder* (ADHD). ADHD is a highly prevalent psychiatric disorder, affecting approximately 3%–5% of the school-age population (National Institutes of Health [NIH] Consensus Development Panel, 2000; Scahill & Schwab-Stone, 2000). The diagnosis of ADHD is based on the presence of a persistent pattern of developmentally inappropriate levels of inattention, hyperactivity, and impulsivity that cause functional impairments in multiple settings (American Psychiatric Association, 1994). Elevated levels of difficulty in these areas represent potential contributing factors to the emergence of social and academic difficulties and, for some children with ADHD, might play a role in compromising their language development, as well. However, the relationships between attention difficulties and language impairments in individual children's profiles are often equivocal, raising the risk for misdiagnosis. In some cases, the presence of ADHD might be sufficient to disrupt children's performances during conventional language assessments in a way that mimics developmental language disorder, particularly on those tasks that rely heavily on working memory capacities and other executive functions (cf. Denckla, 1996; Oram, Fie, Okamoto, & Tannock, 1999; Tannock & Schachar, 1996). Similarly, the presence of receptive semantic or syntactic difficulties could easily be misattributed to children's inattention by teachers and other clinical referral sources (Redmond, 2002).

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There is some evidence that psycholinguistic profiling based on clinical markers of SLI could be useful for the differentiation of developmental language disorder from ADHD. However, clarity has been limited by the presence of very few direct comparisons of the linguistic phenotypes associated with these two high-incidence populations. Important gaps remain. Redmond (2005) examined the similarities and differences in past-tense marking and sentence recall proficiencies in children with SLI, children with ADHD, and TD controls (age range = 5–8 years). Children's accuracy with past-tense marking on regular and irregular verbs was examined using the past-tense elicitation procedure developed by Rice and colleagues (Rice et al., 1995; Rice & Wexler, 2001a). Two different sentence recall indices were considered: the Sentence Imitation subtest from the Test of Language Development—Primary, Third Edition (TOLD–P:3; Newcomer & Hammill, 1997) and a sentence recall task designed for the study. Results indicated that tense-marking deficits were apparent only in the SLI participants. Children in the ADHD group displayed age-appropriate proficiency with past-tense forms. In contrast, both the SLI and the ADHD group means on the sentence recall measures were lower than those of the control group (SLI < ADHD < TD).

Luo and Timler (2008) used oral narratives taken from the Test of Narrative Language (TNL; Gillam & Pearson, 2004) to examine episodic coherence in children with ADHD, children with SLI, children with ADHD plus developmental language disorder (ADHD +DLD), and TD controls (age range = 8–12 years). Results indicated that participants in the ADHD group performed similarly to the TD participants in their deployment of story grammar elements (initiating events, internal responses, goals, attempts, outcomes). Only those children with ADHD+DLD and with SLI produced less organized narratives than those of the TD group.

Neither of these small-scale feasibility studies was able to examine classification accuracy, so the extent to which tense marking, sentence recall, or narratives could be effectively applied to differential diagnosis of developmental language disorder from ADHD is unknown. Another important unaddressed gap in the literature is that there are no comparisons between children with ADHD and children with developmental language disorder using nonword repetition measures. In order to advance our understanding of the phenotypic boundaries between ADHD and developmental language disorder, what is needed is an examination of tense marking, nonword repetition, sentence recall, and narratives in children with SLI and children with ADHD.

For children with developmental language disorder, the early elementary grades represent an important transition period. Within this time frame, some children will be identified for the first time as having developmental language disorder, whereas others will be dismissed from practitioner caseloads because they have apparently caught up to their peers after years of language intervention. Other children will "graduate" out of Communication Disorder or Language Impairment designations and into new clinical assignments of Reading Disability or Learning Disability to more directly address their language-based academic difficulties (Conti-Ramsden, 2008). Still others will be rediagnosed as having ADHD or given various comorbid designations (Tirosh & Cohen, 1998). Clearly, these represent high-stakes decisions that will determine the kinds of services that children will and will not receive over the course of their academic careers. It is crucial that practitioners have confidence in the capacity of the language measures that they are using to discriminate developmental language disorders from typical development and from other common disorders.

With these considerations in mind, we set out to address the following research questions:

1. To what extent do tense marking, nonword repetition, sentence recall, and narrative measures accurately classify cases of language impairment and typical development in 7- to 8-year-old children?
2. To what extent do tense marking, nonword repetition, sentence recall, and narrative measures accurately classify cases of language impairment and ADHD in 7- to 8-year-old children?
3. What is the most efficient combination of these psycholinguistic indices for identifying cases of language impairment in 7- to 8-year-old children?

Method

Participants

Approval for all aspects of this study—including participant recruitment, parental consent, and child assent procedures—was secured from the University of Utah Institutional Review Board prior to execution. Participant characteristics are displayed in Table 1. Sixty 7- to 8-year-old monolingual Standard American English speakers participated in the study. Five Hispanic and 55 non-Hispanic children participated in the study, and the sample had the following racial composition, reflecting the communities from which it was drawn: Four African American children, one Asian child, one Native American child, one Pacific Islander, and 50 Caucasian children. Three families chose not to identify themselves using ethnic/racial categories. There were 38 boys and 22 girls.

All participants demonstrated normal hearing acuity during an audiometric screening, achieved a standard score of 80 or higher on the Naglieri Nonverbal Achievement Test—Individual (NNAT–I: Naglieri, 2003), and passed the phonological screener from the Test of Early Grammatical Impairment (TEGI; Rice & Wexler, 2001a). Group equivalence was achieved on chronological age and maternal levels of education (ps = .990 and .308, respectively). In each group, average maternal education levels corresponded to *some college/college degree*, but the study sample covered the range from *some high school* to *advanced graduate degree*. Children’s nonverbal standard scores covered the “normal range” (i.e., roughly −1.0 *SD* to 1.0 *SD*) in each group; however, significant group differences, $F(2, 57) = 9.221$, $p < .001$, were observed. Sidak follow-up pairwise comparisons confirmed that differences were present between the control group and the two clinical groups but not between the ADHD and SLI groups (SLI = ADHD < TD).

Potential participants for the SLI group were recruited through the caseloads of certified speech-language pathologists (SLPs) from the Jordan and Salt Lake City school districts as well as through the University of Utah and Utah State University clinics. To be included in the SLI group (which consisted of 12 boys and eight girls), children needed to meet the following criteria: (a) be diagnosed as having a language impairment by an independent, certified SLP; (b) be receiving treatment for this language impairment during the time of the study; and (c) perform at or below the appropriate cutoff score for their age on the Clinical Evaluation of Language Fundamentals Screening Test—Fourth Edition (CELFST-4: Semel, Wiig, & Secord, 2004a). The CELFST-4 was used in this study as the reference standard for language-impaired status because it represents a reliable and efficient measure of children's overall language skills, with reported sensitivity and specificity rates for language disorder of .92 and .88, respectively, for 7- and 8-year-old children (Semel, Wiig, & Secord, 2004b, p. 25). Children with concomitant diagnoses of autism, pervasive developmental disorder (PDD), or ADHD were excluded from the SLI group.

Potential participants for the ADHD group were recruited through notices posted on the Utah chapter of Children and Adults with Attention-Deficit/Hyperactivity Disorder (CHADD) Web site (http://www.chaddofutah.com) as well as through the caseloads of community clinical psychologists. To be included in the ADHD group (which consisted of 15 boys and five girls), children needed to meet the following criteria: (a) be diagnosed as having combined-type ADHD by an independent health care professional; (b) be receiving treatment for their ADHD during the time of the study; and (c) be rated by their parents as having attention and hyperactivity difficulties within the clinical range (i.e., T score above 64) on the Child Behavior Checklist's (CBCL's; Achenbach & Rescorla, 2001) DSM–ADHD subscale. The CBCL ADHD subscale was used as the reference measure for ADHD status because it has been shown to correlate moderately well (r = .80) with *Diagnostic and Statistical Manual of Mental Disorders* (4^{th} ed.; DSM-IV) diagnoses of combined-type ADHD based on psychiatric interviews (Achenbach & Rescorla, 2001, p. 130) and has demonstrated moderate to excellent levels of sensitivity and specificity across independent investigations (cf. Hudziak, Copeland, Stanger, & Wadworth, 2004). All but one of the ADHD participants was receiving behavioral medication during the time of the study. Children with concomitant diagnoses of autism, PDD, or language impairment were excluded from the ADHD group.

Although not a requirement for inclusion in the ADHD group, all of the participants who were eligible for placement in the ADHD group performed above their appropriate cutoff scores on the CELFST–4, indicating general age-appropriate verbal abilities. In contrast, two children within the SLI group received parental ratings on the CBCL DSM–ADHD subscale that were above that instrument's clinical cutoff. These children were included because they met the inclusionary and exclusionary criteria associated with the SLI group.

Potential participants for the TD group were recruited through notices sent to families attending the same schools as those that the children in the clinical groups were attending, as well as through public notices posted at the Salt Lake City Boys and Girls Club and other community bulletins. To be included in the TD group (which consisted of 11 boys and nine girls), children needed to meet the following criteria: (a) be enrolled in regular education and not receiving any special services at the time of the study; (b) perform above the appropriate cutoff score on the CELFST-4; and (c) be rated by their parents as having attention and hyperactivity difficulties within the normal range on the CBCL DSM–ADHD subscale.

An additional 21 potential participants were screened but not enrolled in the study for the following reasons: One failed the hearing screening, three presented with concomitant diagnoses of high-functioning autism, five had nonverbal standard scores below 80, four performed above criteria on the CELFST–4, and eight had diagnoses of ADHD+DLD comorbidity.

Procedure

After securing parental consent and child assent, participants completed two testing sessions (each lasting 60–90 min). The eligibility protocol administered during the first testing session consisted of the audiometric screening, the phonological screening, the language screening, and the nonverbal assessment. In the spirit of reasonable accommodation, children in the ADHD group were administered the eligibility measures while on behavioral medication. During the first session, parents completed the CBCL and a questionnaire developed for the study confirming their children's receipt/nonreceipt of different support services.

Children who met eligibility criteria for one of the three groups were then administered the experimental protocol. To control for potential diurnal effects on children's attention levels, this protocol was administered during morning hours. Dependent measures of psycholinguistic proficiency used in this study included the regular third-person and past-tense probes from the TEGI (Rice & Wexler, 2001a), Dollaghan and Campbell's (1998) nonword repetition (NWR) task, Redmond's (2005) sentence recall (SR) task, and the TNL (Gillam & Pearson, 2004).

Scoring of the TEGI probes followed the guidelines established by Rice and Wexler (2001a). Specifically, children's responses to elicitation prompts were recorded verbatim, and those responses that contained an obligatory context for the target morphological form were used to calculate percent use of tensed forms based on tallies of "correct" and "incorrect" responses. Because the TEGI focuses on children's productions of finite forms within obligatory contexts, children are penalized for producing nonfinite verbs (e.g., *he give his mom a present*) but are not marked down for producing overregularization errors (e.g., *he gived his mom a present*) or for using alternative lexical selections (e.g., *he brought a present to his mom*). The TEGI Screening Test score was used to examine children's proficiency with tense marking and represents the pooled percent use of finite forms in obligatory contexts across the third-person singular and past-tense probes (range = 0–100). Similarly, following Dollaghan and Campbell's (1998) protocol, children's elicited productions of nonwords were transcribed phonetically, and the percentage of phonemes correctly produced was calculated using the entire set of nonwords (range = 0–100).

For the SR task, we used the scoring adaptation developed by Archibald and Joanisse (2009), in which each of the 16 sentences from the Redmond (2005) protocol were assigned either a value of 2 (*correct*), 1 (*three or fewer errors*), or 0 (*more than four errors or no response*). Thus, the range of possible scores on the SR was 0–32.

The TNL is a standardized measure of comprehension and production of connected speech used to tell stories. The TNL is an omnibus measure in that its items are designed to tap into several key dimensions associated with narrative discourse, including understanding and remembering critical information from stories, drawing inferences, using appropriate story macrostructure and episode structure, using appropriate sentence structure, and establishing cohesive ties across sentences. The TNL consists of six subtests in which children's responses to comprehension questions after listening to short passages as well as their own story productions following prompts are recorded. These responses are then given weighted values according to the manual's criteria based on their accuracy, completeness, lexical specificity, and grammaticality. The Narrative Language Ability Index (M = 100, SD = 15), a quotient score based on children's composite performance across the six subtests, was used to examine children's overall narrative proficiency. The TNL was selected over alternative narrative procedures because it has demonstrated adequate psychometric properties, including high levels of discrimination of cases of developmental language disorders from cases of typical development (Gillam & Pearson, 2004; Spaulding et al., 2006).

To allow for consideration of performance on the psycholinguistic measures across a wide range of differences in inattention, hyperactivity, and impulsivity, parents in the ADHD group were instructed to suspend their children's behavioral medication prior to the administrations of the experimental protocol. Similarly, parents from the ADHD group were instructed to rate their children's behavior on the CBCL rating scale when they are "off of their medication."

Reliability

Children's responses during the administration of the psycholinguistic measures were recorded using SONY TC-D5 PRO II tape recorders with tiepin ECM-T140 external microphones. These recordings were used by examiners to transcribe children's responses and to check their online scoring of test protocols. Scored protocols were later independently checked and corrected by a second examiner. Checked protocols from six children (two selected randomly from each group) were used to measure interrater reliability on the psycholinguistic measures. Two graduate students in the Department of Communication Sciences and Disorders served as independent judges and compared their judgments against the checked protocols. Interrater agreements were calculated separately for the transcription of children's responses and for the scoring of these responses. Intertranscriber consistency was calculated by computing the total numbers of words in agreement divided by the total number of words in agreement plus the total number of words in disagreement. This yielded the following values for the TEGI, NWR, SR, and TNL, respectively: 98.21%, 99.74%, 96.09%, and 95.33%. Similarly, interscorer consistency was calculated by computing the number of scored items in agreement divided by the total number of items in agreement plus the total number of items in disagreement. This yielded the following values for the TEGI, NWR, SR, and TNL, respectively: 97.51%, 99.73%, 88.98%, and 94.31%.

Results

With one exception, complete data were available for all participants. One participant from the SLI group exceeded the number of allowable prompts during the administration of the oral narrative sections on the TNL, providing the examiner with no verbal responses. Rather than record this participant's oral subtest scores as "zeroes" or replace these values with the SLI group's mean, this particular child's TNL protocol was removed from the analyses.

Group Differences on the Psycholinguistic Markers

Table 2 displays the group means, *SD*s, and ranges associated with the four psycholinguistic measures considered in this study. Homogeneity of variances assumption held for three of the four measures (NWR, SR, and TNL). To confirm the presence of group differences on these measures, a univariate analysis of variance (ANOVA) was conducted, and follow-up Sidak analyses were used to identify pairwise comparisons that reached the .05 level of significance. The range of TEGI scores associated with the SLI group was considerably wider than it was for the other two groups, creating unequal variances between groups. In this case, Welch's robust test of equality of means (asymptotically F distributed) was used to confirm significant group differences on the TEGI, and a follow-up Games–Howell analysis was used to identify significant pairwise comparisons. Significant group differences were observed on all four measures, and each measure demonstrated the same pattern with regard to follow-up comparisons: SLI < ADHD = TD. Eta-squared (η^2) values indicated the presence of large effect sizes for each measure. These results suggest that at the level of group comparisons, weaker performances were more consistently associated with participants from the SLI group, and children in the ADHD group were performing very similarly to the children in the TD group.

Observations of significant group differences associated with large effect sizes are encouraging, but clinical identification and differential diagnosis depends on the extent to which language measures can generate minimally overlapping distributions between affected and unaffected cases. Box plots for the TEGI, NWR, SR, and TNL are displayed in Figures 1–4. Numbers associated with outlier/extreme scores refer to individual case numbers. Figure 1 shows that there was very little overlap between the SLI group and the other two groups on the TEGI measure. The ADHD and TD groups performed close to ceiling on this measure. Indeed, variability in tense-marking performance was evident only in the SLI group, and the range for this group encompassed almost the entire scale. This outcome aligned well with Rice's (2003) contention that tense marking represents an area of "unexpected variation" within the linguistic maturation of children with SLI. The median for the SLI group (88.69) was higher than the mean (76.33), suggesting that the group average was affected by the presence of a subset of low-scoring children. As Figure 1 indicates, there were three participants in particular (Participants 1, 15, and 20) who were producing finite forms in less than 40% of their obligatory contexts, suggesting the presence of significantly arrested morphosyntactic development for these children. Interestingly, both the youngest and two of the oldest participants within the SLI group were included in this set of outliers. The wide range of scores observed in the SLI group was consistent with the results of Rice, Wexler, and Hershberger's (1998) longitudinal study of SLI, which reported that after a very protracted period of growth, many of their affected 8-year-old participants started to approach adequate levels of proficiency with tense marking, whereas a subset of participants still displayed considerable delays in this area. The strong showing of the ADHD group in the present study confirmed and extended Redmond's (2005) study of younger children, which also reported that participants with ADHD demonstrated age-appropriate levels of tense marking.

Outcomes for the NWR were similar to those of the TEGI in that variation was larger within the SLI group and the score ranges associated with the ADHD and TD groups were very similar to one another. In this case, more overlap was observed between the SLI and ADHD groups than there was with the tense-marking measure (see Figure 2). There was one outlier in the TD group whose percent phonemes correct score of 70% was considerably lower than that of the other children in the TD group. Interestingly, this participant's score was also lower than most of the children in the SLI group.

Clear differentiation between the SLI group and the other two groups were also observed with the SR measure (see Figure 3). The SLI group's distribution overlapped minimally with that of the other two groups, with the exception of one outlier case that performed close to the ADHD and TD group medians. This result replicated the outcomes of Redmond (2005), which also found that children with ADHD performed better than children with SLI on sentence recall measures. In this older study sample, however, children in the ADHD group performed more similarly to the TD controls.

TD group variability was large on the TNL measure and included some high-performing individuals (standard scores > 120), as displayed in Figure 4. However, even after taking this into account, the largest amount of overlap between the TD, ADHD, and SLI distributions was observed on the TNL measure.

Extent to Which Tense Marking, Nonword Repetition, Sentence Recall, and Narratives Accurately Classified Cases of SLI, Typical Development, and ADHD

To examine more closely the extent to which the TEGI, NWR, SR, and TNL measures could accurately place individual cases into affected and unaffected categories and thus be adequate for clinical applications of identification and differential diagnosis, receiver operating characteristics (ROC) curves were generated separately for the SLI versus TD discrimination (see Figure 5) and for the SLI versus ADHD discrimination (see Figure 6). The ROC graph is a bi-dimensional representation of the tradeoffs between sensitivity on the *x*-axis and 1-specificity (i.e., "false positives") on the *y*-axis that occur at different possible cutoff points. The lower point of the graph (0, 0) is the value that contains no false positives but also does not detect any true positives. The opposite point (1, 1) in the upper right side of the graph is the value that identifies all true positives but with a 100% false positive error rate. The upper left corner (0, 1) corresponds to perfect classification accuracy. The diagonal reference line—where the true positive rate is equal to the false positive rate—represents those values where a test is performing at chance levels.

ROC curves for the four psycholinguistic measures show that they were all well above the reference line and, in each case, were close to the edge of the upper-left quadrant, indicating excellent levels of diagnostic accuracy. This was true for both the SLI versus TD and the SLI versus ADHD discriminations, although as displayed in Figures 5 and 6, the psycholinguistic measures tended to perform less well with the SLI versus ADHD discriminations.

The area under the ROC curve can be interpreted as a general estimate of a measure's overall accuracy, where higher levels of accurate classification are indicated as values approximating 1.00 or perfect classification (cf. Akobeng, 2007; Perkins & Schisterman, 2006; Streiner & Cairney, 2007). In this case, areas under the ROC curve can be interpreted as the proportion of scores from SLI participants that were lower than scores obtained from the TD or ADHD participants. As displayed in Table 3, areas under the ROC curve were significantly higher than chance ($p < .001$) and ranged from a low of 0.875 (NWR score for SLI vs. ADHD) to a high of 0.963 (SR score for SLI vs. ADHD).

A common method for identifying the optimal cutoff point on an ROC curve is the Youden Index *(J)*, which is defined as the maximum vertical distance between the ROC curve and the diagonal reference line: J = maximum (sensitivity + specificity − 1) (Perkins & Schisterman, 2006). Table 3 shows the sensitivity, specificity, positive likelihood ratio, and negative likelihood ratio associated with each cutoff score identified using this metric. One possible outcome when examining clinical measures is that cutoff scores might require significant adjustments when they are used with different clinical groups or utilized for differential diagnosis (Streiner & Cairney, 2007). This was not the case with the present study sample. Optimal cutoff values for the SLI versus TD and SLI versus ADHD discriminations were very similar.

The predictive value of each measure's *positive clinical score* (i.e., a score lower than the cutoff score) and *negative clinical score* (i.e., a score higher than the cutoff score) can be interpreted from the likelihood ratios provided in Table 3. Positive likelihood ratios for the TEGI, NWR, and SR when the discrimination was between SLI and TD status were all close to or above 10.00, indicating that the presence of test scores below the cutoffs were "very positive" of affected status (cf. Dollaghan, 2007; Sackett, Haynes, Guyatt, & Tugwell, 1991). In other words, low scores on these measures were very likely to have come from participants with SLI and not from participants with TD. Specifically, for the TEGI measure, a participant's odds of having language impairment increased 16.8 times when they received a score below 95.75; for the NWR measure, their odds increased 9.5 times when they received a score below 85.91; and for the SR, their odds increased 9.0 times when they received a score below 14.50. In practical terms, the presence of inadequate performance on any one of these three measures would be sufficient to assign atypical language status. In contrast, a positive clinical score on the TNL was less predictive of participants' SLI status but was still well within the "moderately positive" range. Performance on the TNL below 95.50 was suggestive but insufficient to assign clinical status to the participants. This was due to the fact that some non-SLI cases also displayed performance below the cutoff score. The observed variability in our TD group may be a feature inherent in the task demands commonly associated with narrative skills. Other investigations of standardized narrative tests have revealed similar limitations in the over identification of typically developing children. For example, in their evaluation of the diagnostic accuracy of the Renfrew Bus Story protocol with 4- to 5-year-old children with and without SLI, Pankratz et al. (2007) reported adequate levels of sensitivity (.84) but weaker specificity (.78).

Negative likelihood ratios associated with the TEGI, NWR, SR, and TNL measures indicated that "negative clinical scores"—scores above the cutoff—were unlikely to have come from participants with SLI. Negative likelihood values were all close to or below 0.10 (range = 0.168–0.056), indicating that high scores were “extremely negative” of affected status (cf. Dollaghan, 2007; Sackett et al., 1991). In other words, the presence of performance above the cutoff scores was sufficient to rule out SLI.

How did the measures fare with the more challenging task of discriminating between different kinds of atypical status? With the exception of the SR measure, the value of a positive clinical score became moderated when it was used to differentiate SLI from ADHD status. Low scores on the TEGI, NWR, and TNL became less definitive of a participant’s SLI status when the distinction being made was between SLI and ADHD. This was particularly true for the NWR and TNL measures. The positive likelihood ratio for the NWR was reduced to a third of its SLI versus TD value, and the TNL was reduced to half. Interestingly, the positive likelihood ratio for the SR measure increased from 9.00 to 18.00 due to a slightly higher specificity value associated with the SLI versus ADHD discrimination. This was the consequence of fewer cases below the cutoff scores within the ADHD group than the TD group. This result indicates that low SR scores were highly predictive of children’s SLI status, and the ability to accurately recall sentences was less affected by the presence of ADHD than the other measures. This result was somewhat unexpected, given Redmond’s (2005) report that some children with ADHD had difficulty with the SR measure. Differences between Redmond (2005) and the present study may reflect age differences between the study samples.

Across all four measures, negative likelihood ratios also increased within the SLI versus ADHD discriminations, indicating reductions in their capacity to rule out SLI when discriminating between SLI and ADHD. However, for each measure, these values were still within the “moderately negative” to “extremely negative” range (Dollaghan, 2007; Sackett et al., 1991). The TEGI measure had the most modest negative likelihood ratio (0.247), indicating that the presence of a tense-marking score above the clinical cutoff was still highly suggestive but insufficient to rule out SLI status. In contrast, negative likelihood ratios were lowest for the SR and TNL measures (0.143 and 0.077, respectively), indicating that scores above the cutoff were very unlikely to have come from participants in the SLI group. Scores above the TNL cutoff, in particular, were sufficient to rule out SLI, whether discriminating SLI from TD or SLI from ADHD.

The Most Efficient Combination of Indices for Identifying Cases of SLI

Binary logistic regression analysis was used to examine the possibility that a particular combination of measures might be more effective at predicting children’s SLI status than the use of individual measures. Logistic regression procedures are frequently used when the dependent variable under consideration is whether or not a patient has a disease. These procedures can be used with categorical and continuous variables, and they require no assumptions about the distributions of the predictor variables, which made it particularly appropriate given the observed distributional differences between the TEGI, NWR, SR, and TNL measures. For this analysis, the TD and ADHD groups were combined, yielding 19 SLI cases and 40 non-SLI cases. The psycholinguistic measures were entered into a stepwise regression. Because the goal of the analysis was to maximize our hit rate with as few measures as possible rather than to identify the most unique predictors within the variable set, positive likelihood ratios associated with the SLI versus TD discriminations were used to determine the following block order: TEGI, SR, NWR, and TNL. Results of the regression analysis are displayed in Table 4.

A test of Model 1 using the TEGI versus the intercept only was statistically significant, $\chi^2(1, N = 59) = 39.76$, $p < .001$, Nagelkerke $R^2 = .685$, and provided an 88.1% overall classification accuracy, with four SLI and three non-SLI cases misclassified. A test of Model 2 using the TEGI and the SR versus Model 1 was statistically significant, $\chi^2(1, N = 59) = 16.99$, $p < .001$, Nagelkerke $R^2 = .864$. Adding the SR measure to the model increased overall classification accuracy to 94.9%, with two SLI and one non-SLI participant misclassified. A test of Model 3 using the TEGI, SR, and NWR versus Model 2 was not statistically significant, $\chi^2(1, N = 59) = 2.272$, $p = .132$, Nagelkerke $R^2 = .884$, suggesting that adding NWR to our set of predictors did not significantly improve our accuracy in assigning language status. The inclusion of the NWR measure to the TEGI and SR in Model 3 also resulted in a slight reduction in overall classification accuracy (91.5%: Three SLI and two non-SLI cases misclassified). A test of Model 4 using the TEGI, SR, NWR and the TNL versus Model 3 was statistically significant, $\chi^2(1, N = 59) = 5.53$, $p = .019$. However, using all four measures resulted in an overall classification accuracy that was equivalent to using the TEGI and the SR (94.9%: One SLI and two non-SLI participants misclassified).

Hosmer–Lemeshow tests of the null hypothesis (i.e., that there was a linear relationship between the predictor sets and the log odds of the criterion variable) indicated that each model we examined represented a “good fit” of the data (nonsignificant χ^2 values ranged from .572 to .999). However, comparisons between the models under consideration indicated that the most efficient combination of measures for predicting participants’ SLI and non-SLI status was to use both the TEGI and the SR measures (Model 2). This combination was more accurate than using the TEGI alone—the measure with the highest positive likelihood ratio in the SLI versus TD discrimination. In terms of overall classification accuracy, the TEGI and SR combination was also as accurate as using all four measures. The 0.633 and 0.665 Exp (*B*) values or odds ratios for the TEGI and SR in Model 2 indicated that the odds of SLI status were more than cut in half for each one-point increase in participants’ scores on both of these measures.

Discussion

The outcomes of this study suggest psycholinguistic profiling using tense marking, nonword repetition, sentence recall, and narratives can differentiate SLI from typical development when used with 7- to 8-year old speakers of Standard American English. In particular, the presence of scores below the empirically identified cutoff values on the TEGI, NWR, and SR measures was sufficient to assign atypical status to the participants, and the presence of scores above the cutoff on the TNL was sufficient to assign typical status to the participants.

This study represents the first examination of the performances of children with ADHD on these four important markers of impaired language development. It is also the first evaluation of the capacity of tense marking, nonword repetition, sentence recall, and narrative indices to differentiate ADHD from SLI. Within our study sample, each of these measures clearly differentiated cases of these two highly prevalent childhood disorders. Our findings confirmed and extended previous investigations and provide additional encouragement for the inclusion of these particular measures into protocols for eligibility, differential diagnosis, and the identification of comorbidity. Given concerns that SLI may be underidentified through conventional procedures and that teachers may be over-referring children for ADHD evaluations, the adoption of these measures by practitioners should increase the likelihood that children will receive the services they need. The strong diagnostic integrity demonstrated by each of these measures also motivates their inclusion into future assessments of treatment efficacy.

One practical advantage associated with the psycholinguistic indices considered in this study is that each one can be administered in a relatively short amount of time. This was probably an important contributing factor to our success with discriminating cases of SLI from cases of ADHD because overly long evaluation protocols may place children who have deficiencies in the areas of inattention, impulsivity, and distractibility at a disadvantage. The average administration times and ranges associated with each measure were as follows: NWR, time = 2:50, range = 1:22–5:38]; SR, time = 3:32, range = 2:03–6:28; TEGI, time = 9:29, range = 4:48–17:13; TNL, time = 9:49, range = 5:58–19:09. Although administration times certainly varied across participants and examiners, our results provide practitioners with some guidance on how they might optimize their resources during routine language assessments and avoid the potential problem of diminishing returns associated with overly extensive diagnostic protocols. It was not the case that the inclusion of more testing procedures led to more accurate diagnoses. This conclusion is somewhat counterintuitive and runs against conventional clinical wisdom, which tends to advocate for a “more data are always better” approach to identification. Specifically, we found that a testing protocol consisting of tense marking and sentence recall requiring approximately 15 min to administer was as effective at classifying cases and noncases as a more comprehensive protocol requiring at least twice as much time. These observations should not be interpreted as a dismissal of the important role that comprehensive language assessments can play in the identification of treatment goals for children with known language limitations but, rather, an endorsement of the potential efficiency that the careful selection of clinical markers can have for the identification of language impairments in children with unknown language and ADHD status.

The true accuracy of a diagnostic test is unknown until cutoffs have been replicated in other settings by independent investigations (Sackett & Haynes, 2002). In this study, we used ROC curves and the Youden Index procedure to locate optimal cutoff values. In contrast, previous investigations of these psycholinguistic indices have been based on conventional but ultimately arbitrary clinical cutoffs (e.g., “lower than 1.0 *SD*s below”; “below the 10th percentile”). In some cases, our cutoff values were different from what has been provided by other investigators. Discrepancies between conventional and empirically identified optimal cutoffs have been observed in other investigations of the diagnostic accuracy of language tests (e.g., Perona, Plante, & Vance, 2005).

Gillam and Pearson (2004) used the conventional cutoff of a standard score < 85 based on the distribution of their normative sample to calculate the sensitivity and specificity of the TNL (pp. 60–64). The study sample consisted of 76 children with previously diagnosed developmental language disorder whose age ranged from 5;0 (years; months) to 8;11 and 76 typically developing children matched for age and gender. Reported sensitivity and specificity values were 0.92 and 0.87. These values were similar to the ones calculated for the present study (*Se* = 0.95 and *Sp* = 0.80), but the optimal cutoff score that we identified (95.50) was much higher than the one used by Gillam and Pearson (2004). Using a standard score of 85 with our study sample yielded sensitivity and specificity values of 0.63 and 0.90 (for both the TD and ADHD discriminations). Possible explanations for these discrepancies include age differences between the study samples, the inclusion of affected cases with low non-verbal IQ scores in the Gillam and Pearson sample, and differences between the studies in how cutoff values were determined. However, the identification of cutoff scores higher than the cutoffs suggested by the TNL distribution may also have been mathematically inevitable because children with language impairments and other clinical conditions represented 13% of the test's normative group (Gillam & Pearson, 2004, p. 38), whereas our comparison groups consisted exclusively of children with typical language and cognitive abilities. Pena, Spaulding, and Plante (2006) showed through mathematical simulations the implications of using cutoff criterion based on mixed (i.e., normal and clinical cases) versus normal-only normative samples. In each case, the resulting sensitivity and specificity for a cut-point was dependent upon whether the normative sample contained clinical cases. Mixed normative samples consistently provided much lower sensitivity rates (*Se* difference ranged from 19.6 to 11.5 for different cutoffs), even though the complimentary increases in false positives associated with the normal-only samples was relatively small (*Sp* difference ranged from 4.2 to 2.8). As these investigators point out, the composition of normative groups is not inherently good or bad but, rather, depends on how practitioners use them to support their diagnostic decisions. When the goal is to determine the severity of developmental language disorders or to examine profiles of relative strengths and weaknesses across different language skills in known cases of language disorder, then a mixed group is advantageous because the addition of impaired cases broadens the variability within the normative group. However, when the goal is to identify developmental language disorders in children with unknown status, tests that include mixed norms are less preferred because they are more likely to underidentify affected cases. Thus, our results encourage practitioners to be cautious in their interpretation of TNL standard scores in the 86–96 range when this level of performance is being used to rule out developmental language disorders in 7- to 8-year-old children.

Inclusionary criteria, age range, and cutoff differences probably accounted for the discrepancies between the present study and those of Dollaghan and Campbell's (1998) and Ellis Weismer and colleagues' (2000) examinations of NWR. Dollaghan and Campbell's sample consisted of 85 children, ranging in age from 5 to 12 years (44 cases of developmental language disorders). Language intervention status was used as the sole criterion for language impairment. Several different cutoff values were examined, but these investigators determined that a cutoff of 70% yielded the best balance of sensitivity and specificity (*Se* = .61, *Sp* = .98). Using this particular cutoff with the present study sample yielded similar outcomes for both the SLI versus TD and SLI versus ADHD discriminations (SLI vs. TD: *Se* = .74, *Sp* = .95; SLI vs. ADHD: *Se* = .68; *Sp* = 1.00). However, if we consider the 80% cutoff with Dollaghan and Campbell's sample, this would provide values for sensitivity and specificity (*Se* = .96 and *Sp* = .70; see Dollaghan and Campbell, p. 1143) that more closely approximate our results, whereas a cutoff of 85% was identified using the Youden Index.

Ellis Weismer et al. (2000) examined proficiency with NWR within their epidemiological sample of 581 children, including 81 children with SLI. Similar to the present study sample, this study sample consisted of 7- to 8-year-old children. Poor performance on norm-referenced tests was used to identify children with language impairments, regardless of their receipt of services. Even though methods of ascertainment were different between studies, these investigators reported NWR means and *SD*s for their sample of children with SLI, which were very similar to what we observed in the present study sample (Ellis Weismer et al. study: *M* = 76.8, *SD* = 10.8; present study: *M* = 75.8, *SD* = 9.25). By comparison, our TD group's performance proved to be somewhat higher than expected (Ellis Weismer et al. study: *M* = 83.3, *SD* = 9.1; present study: *M* = 90.5, *SD* = 7.0). One possible explanation for this difference was the relatively high nonverbal abilities associated with our TD group (see Table 1). However, this explanation is complicated by the fact that our ADHD group's NWR performance was also higher than that of Ellis Weismer et al.'s control group (*M* = 88.5, *SD* = 6.08), even though our ADHD group's nonverbal abilities were very similar to the performance levels observed in both SLI study samples. A more likely explanation for the differences in TD groups is the fact that Ellis Weismer et al. included some children with a history of earlier language impairment (i.e., resolved cases of developmental language disorder) in their control group. This design feature may also explain why the 70% phonemes correct cutoff provided Ellis Weismer et al. with sensitivity and specificity values that were different from those of either Dollaghan and Campbell or the present study (*Se* = .25, *Sp* = .91).

Archibald and Joanisse (2009) used the 10th and 15th percentiles as criterion scores to examine the sensitivity and specificity of Redmond's (2005) SR task and the Dollaghan and Campbell's (1998) NWR task in their community-based screening sample of 400 5- to 9-year-olds. Archibald and Joanisse assessed NWR using total items correct rather than the more commonly used metric of percent phonemes correct, which prevents a direct comparison between their results and those of Dollaghan and Campbell (1998), Ellis Weismer et al. (2000), and the present study. However, we can directly compare their SR results to those of the present study. Archibald and Joanisse reported SR scores of 12.00 and 13.33 for the 10th and 15th percentile cutoff values associated with their 7-year-old participants and 14.00 and 15.67 for their 8-year-old participants. The cutoff values identified in the present study through ROC curve analysis were similar: 14.50 and 15.50.

Archibald and Joanisse (2009) calculated sensitivity and specificity using a subset of low scorers (*n* = 52) and average scorers (*n* = 38) sampled across a 4-year age range; therefore, similar to Gillam and Pearson's (2004) TNL study sample, a direct comparison with the present study is not possible due to age differences between the samples. However, Archibald and Joanisse did examine whether a combination of the NWR measure and SR measure yielded higher accuracy rates for predicting children's language-impaired status than using only one of these measures. These investigators found, like we did, that incorporating the NWR had the unintended consequence of compromising diagnostic accuracy. Archibald and Joanisse reported that the criteria of SR performance below the 15th percentile provided them with the most optimal level of diagnostic accuracy (*Se* = .962, *Sp* = .758).

Our ROC curve analysis of TEGI scores indicated that 95.75 and 93.70 represented optimal cutoffs for the SLI versus TD and for the SLI versus ADHD discriminations, respectively. These values were very similar to the suggested cutoffs of 94 and 97 for 7- and 8-year-olds provided by the TEGI manual (Rice & Wexler, 2001b). Rice and Wexler (2001a) also extrapolated their cutoff scores using an ROC curve analysis.

Psycholinguistic Profiling and the Phenotypic Boundaries Between SLI and ADHD

Even though the capacity of tense marking, nonword repetition, sentence recall, and narratives to differentiate SLI from ADHD proved to be quite good, it was relatively harder to discriminate SLI from ADHD than it was to discriminate SLI from TD. This difference could have simply been a sampling artifact—a reflection of the slight but nonsignificant advantage that the TD group had over the ADHD group in terms of their general language abilities (see Table 1). Another explanation for this difference might be that the TD group's higher nonverbal scores made it easier to segregate them from the SLI group, whereas the cross-clinical comparisons were based on the more challenging task of segregating children with more similar levels of nonverbal abilities. To test this possibility, we combined the ADHD and TD groups and examined the correlation between children's nonverbal IQ scores and their performances on the psycholinguistic indices. None of the correlations were significant at the $p = .05$ level, and r values ranged from .10 to .245, suggesting that within the range of scores observed in the ADHD and TD groups, nonverbal abilities probably contributed very little to the observed language variation in the unaffected participants. A more speculative possibility is that the presence of ADHD had compromised children's language performances but did so inconsistently and/or in subtle and specific ways that were different from the pervasive breakdowns in tense marking, non-word repetition, sentence recall, and narrative that were emblematic of the SLI group. Given the reductions in observed specificity values, this might have been particularly true for the NWR and TNL measures.

Although not a requirement of our study, participants in the ADHD group performed above criteria on our reference measure of language impairment, the CELFST–4. Because children with salient behavioral problems—such as ADHD—may receive more scrutiny in other areas of development, the exclusion of children with frank comorbid designations may have greatly reduced the likelihood that our participants with ADHD could have had co-occurring weaknesses on our language indices. However, previous investigations of the language abilities of children with ADHD receiving clinical services have often reported high levels of unsuspected language impairments(e.g., Cohen, Davine, Horodezky, Lipsett, &Isaacson, 1993; Love & Thompson, 1988; Tirosh & Cohen, 1998), so it is probably not the case that the absence of language limitations in our ADHD sample was a foregone conclusion built into the subject selection process. The prominence of unsuspected language impairments in children receiving clinical services has been taken by some reviewers as evidence for overlapping phenotypes or shared risk factors between ADHD and developmental language disorder (Baker & Cantwell, 1982; Beitchman, Nair, Clegg, Ferguson, & Patel, 1986; Gillam & Hoffman, 2004; Gilliam, Montgomery, & Gillam, 2009; Love & Thompson, 1988; Melamed & Wozniak, 1999; Windsor & Kohnert, 2009). Our results do not encourage this conclusion and instead suggest relatively clear phenotypic boundaries between SLI and ADHD. Furthermore, there are two important caveats regarding the evidence used to support the hypothesis of overlapping phenotypes. First, reports of overlap between developmental language impairments and ADHD symptoms have been remarkably unstable across investigations. Estimates of co-occurring developmental language disorders in study samples of children with ADHD have ranged from 8% to 90% (for a review, see Tannock & Schachar, 1996), and estimates of co-occurring ADHD symptoms in children with primary developmental language disorder have ranged from 4% to 35% (Cantwell & Baker, 1987; Snowling, Bishop, Stothard, Chipchase, & Kaplan, 2006). Differences in reported co-occurrence rates are probably attributable to important differences across studies in various design elements (e.g., age range, recruitment and ascertainment, inclusionary and exclusionary criteria). The results of this investigation suggest further that an accurate interpretation of co-occurrence provided by these reports depends on the diagnostic integrity of the language indices used. Another important caveat is that there are too few cross-clinical comparisons based on valid clinical markers to help interpret the nature of reported co-occurring symptoms.

Our results represent a challenge for accounts of SLI that wish to posit a strong etiological role for underlying attention and/or information processing difficulties (e.g., Gillam et al., 2009; Windsor & Kohnert, 2009). The performance levels associated with our ADHD participants demonstrate that the presence of attention deficits is probably insufficient to lead to the kinds of language impairments associated with SLI. Admittedly, this interpretation of our data is limited because we did not directly evaluate children's attention or collect information about their information processing abilities. But the results of the present study do complement other investigations. Cardy, Tannock, Johnson, and Johnson (2010) administered a battery of attention and processing tasks that have been implicated in SLI to children with SLI, ADHD, and TD (age range: 6–11 years). The clinical groups performed similarly on an auditory repetition task in which they judged the order of paired tones. Both the SLI and ADHD groups were significantly slower than the TD group. However, children in the ADHD group responded more slowly and less accurately than either the TD or SLI groups during a simple reaction time task and during a visual search task that required them to decide whether a figure in an array had or had not appeared in a previous presentation. Note that the ADHD group's language abilities were well within normal limits, and none of the ADHD participants met the criteria used for language impairment, thus ruling out the possibility that undetected comorbid language impairments had compromised the ADHD group's performance.

Main effect models linking language impairments directly to underlying attention deficits or to processing limitations cannot accommodate the results of Cardy et al. (2010) and the present study. An alternative possibility is that these links are more complex, mediated, and/or moderated by the presence of other factors (e.g., neuro-developmental variation, environmental differences). It might also be the case that weaknesses in attention and information processing are neither necessary nor sufficient agents in the aggravation of language symptoms. Additional research is needed to select between these alternatives.

Limitations and Future Directions

Four potential participants who were receiving services for their developmental language disorders were not included in this study because they performed above criteria on our inclusionary language measure. We also excluded several potential participants who presented with low nonverbal abilities. Thus, our results may not apply to children with more mild language difficulties, to children whose profiles suggest more general developmental difficulties, or to children whose difficulties lie in language domains not assessed in our protocol (e.g., pragmatic language impairments, reading disabilities). It is the case that our investigation focused primarily on measures of language form—with the possible exception of the narrative measure. Future investigations targeting language use more explicitly might reveal more overlap between these two clinical groups that could have important implications for clinical management. Eight children were screened but not included in this study due to their comorbid ADHD and developmental language disorder status. Although exclusion of these participants was necessary to address our research questions, future investigations should further examine the possibility that children with comorbid designations perform more poorly and/or differently from children with SLI designations alone. This line of inquiry will yield important contributions to both the theoretical and clinical enterprises. Given the high costs associated with missed diagnosis, misdiagnosis, and untreated comorbidity, additional research on this important issue is crucially needed.

Although we did not find any evidence that children with combined-type ADHD had particular difficulties with tense marking, nonword repetition, sentence recall, or narratives, it remains an open question whether children with various ADHD designations (predominately inattentive type; predominately hyperactive–impulsive type; combined-type; not otherwise specified) are at greater risk for difficulties in these areas relative to the general population. Future investigations should revisit the prevalence of co-occurring language impairments in children with ADHD and other psychiatric conditions using these clinical markers.

Limitations associated with the present study include the relatively small and homogenous study sample, which limits the extent to which these results may generalize to the population of children receiving clinical services for language impairments and attention deficits. The restricted age range associated with the study sample ensured that children’s psycholinguistic performances were being evaluated relative to clear and consistent developmental benchmarks, but this design feature also limited the applicability of the observed outcomes to older and younger children. It is certainly the case that different cutoff values for these measures will need to be identified and verified for different ages. It might also be the case that other measures not considered in this study prove to be more effective than tense marking, nonword repetition, sentence recall, or narratives at identifying developmental language disorder and differentiating developmental language disorder from ADHD in older or younger children. The examiners who administered the CELFST–4 that was part of the criteria for placing children into the SLI group were the same examiners who administered the index measures. A more rigorous procedure would have been to have had separate teams of examiners that had been masked to the status of the participants. Future investigations should incorporate these design enhancements as they further evaluate the diagnostic potential of tense marking, nonword repetition, sentence recall, and narrative indices.

Acknowledgments

Funding was provided by National Institute on Deafness and Other Communication Disorders Grant 5R03CD838 (“Psycholinguistic and Socioemotional Profiling of SLI and ADHD”). Portions of this study were presented at the 2008 American Speech-Language-Hearing Association (ASHA) Annual Convention, Chicago, IL.

This study would not have been possible without the generosity and patience of the participants and their families. Appreciation is extended to Christine Dollaghan for providing us with her stimuli. Appreciation is also extended to the following people for their assistance in recruiting potential participants: Rebecca Garda (Jordan School District), Lisa Holmstead (Salt Lake City School District), Linda Smith (Utah chapter of Children and Adults With Attention-Deficit/Hyperactivity Disorder), Carrie Francis (Boys and Girls Club), Janet Goldstein (University of Utah Speech, Language, and Hearing Clinic), and Sandra Gillam (Utah State University). Several graduate and undergraduate students from the University of Utah Department of Communication Sciences and Disorders assisted in various aspects of the project and deserve recognition for their contributions: Chelsea Ash, Tiffany Boman, Lyndi Ballard, Melanie Cobabe, Jamie Dressler, Britta Rajamaki, Jennifer Thinnes Whittaker, and Melissa Whitchurch.

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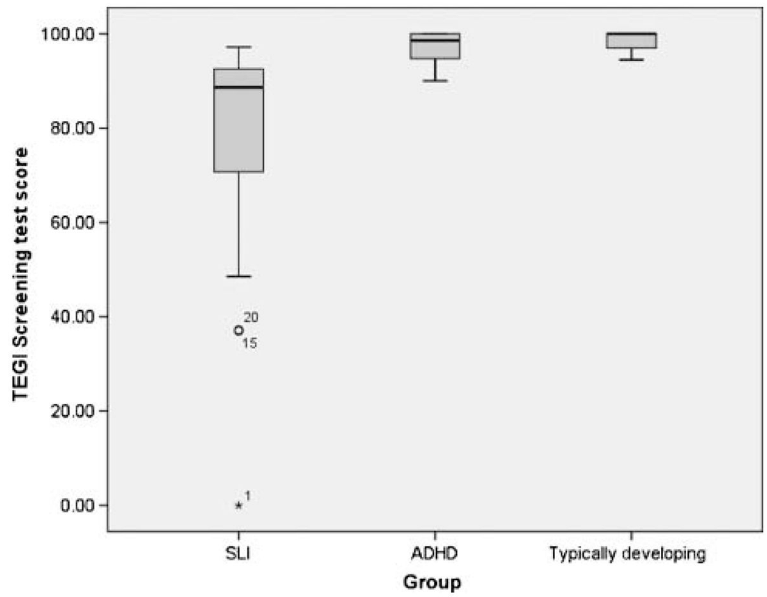

Figure 1.
Box plots for Test of Early Grammatical Impairment (TEGI) Screening Test scores, displaying group medians, first and third quartiles, 10th and 90th percentiles, outliers (○), and extreme scores (★). SLI = specific language impairment; ADHD = attention deficit/hyperactivity disorder. Numbers associated with outlier/extreme scores refer to individual case numbers.

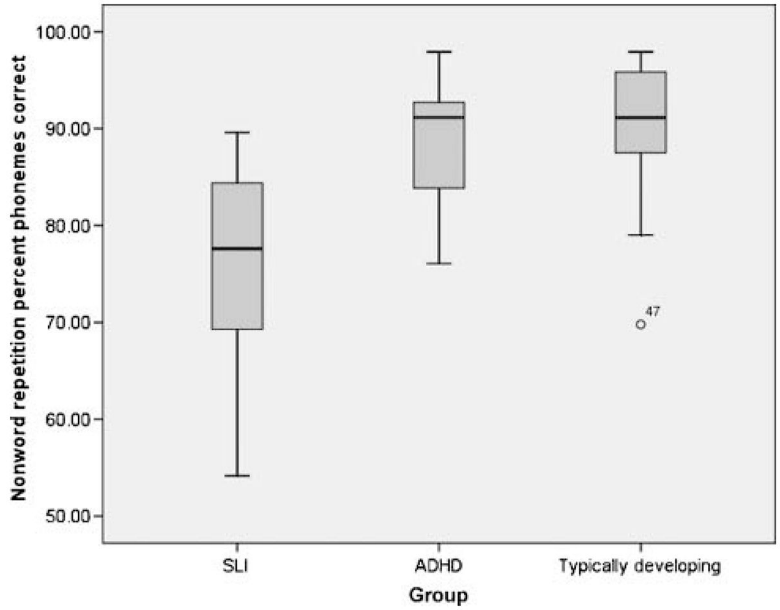

Figure 2.

Box plots for nonword repetition percent phonemes correct, displaying group medians, first and third quartiles, 10th and 90th percentiles, outliers (○), and extreme scores (★).

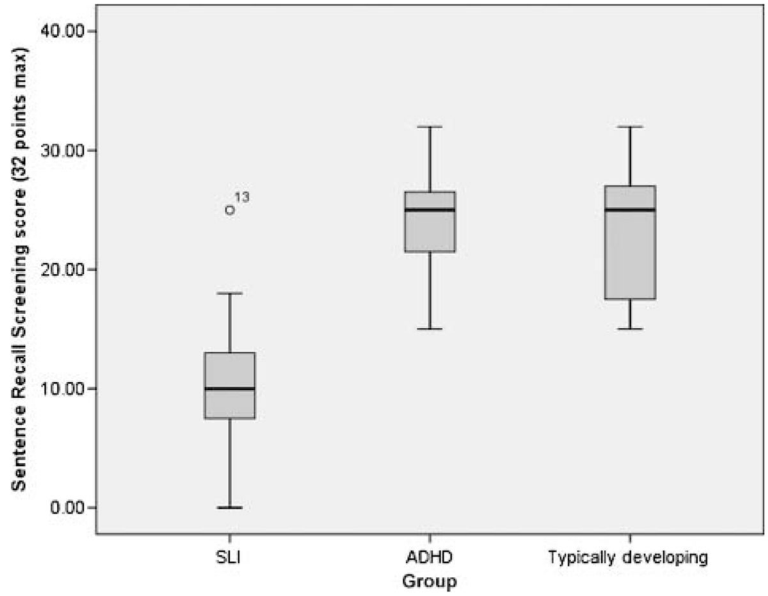

Figure 3.
Box plots for sentence recall, displaying group medians, first and third quartiles, 10th and 90th percentiles, outliers (○), and extreme scores (★).

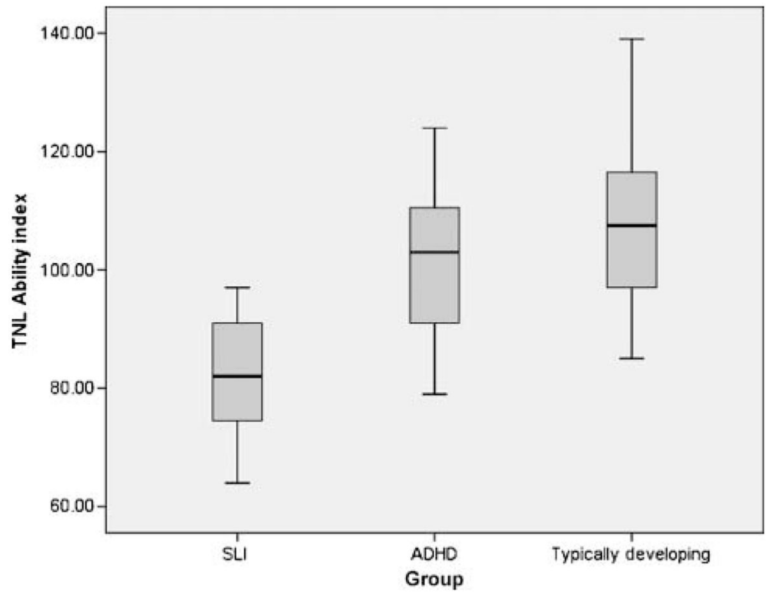

Figure 4.

Box plots for Test of Narrative Language (TNL) Ability Index, displaying group medians, first and third quartiles, 10th and 90th percentiles, outliers (○), and extreme scores (★).

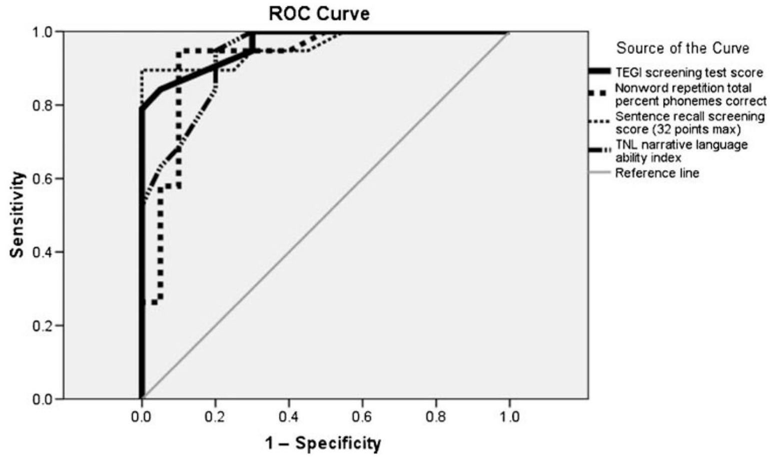

Figure 5.
Response operating characteristics (ROC) curves associated with psycholinguistic discrimination of SLI and typical developing groups (reference line indicates test accuracy at "chance"). Diagonal segments are produced by ties.

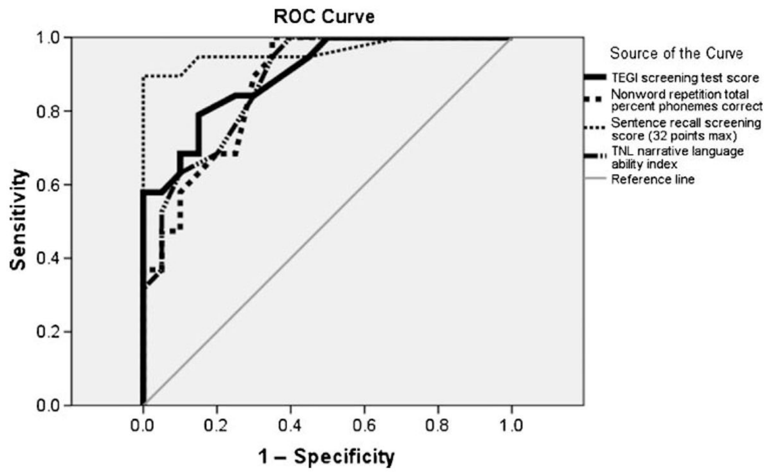

Figure 6.

ROC curves associated with psycholinguistic discrimination of SLI and ADHD groups (reference line indicates test accuracy at “chance”). Diagonal segments are produced by ties.

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Table 1

Participant characteristics.

Variable	SLI M	SLI SD	SLI Range	ADHD M	ADHD SD	ADHD Range	TD M	TD SD	TD Range	F	Contrasts
Age (months)	94.20	7.9	84–107	94.30	7.4	85–107	93.95	6.4	85–107	0.10	1, 2, 3
Maternal education[a]	3.35	0.90	2–5	3.55	0.90	2–5	3.85	1.20	1–5	1.20	1, 2, 3
Nonverbal[b]	97.75	8.2	88–120	101.15	10.34	83–120	110.35	10.4	91–126	9.92***	1, 2 < 3
Verbal[c]	12.50	2.72	8–17	20.90	2.71	17–25	22.60	2.82	17–27	77.24***	1 < 2, 3
Behavior[d]	56.80	7.70	50–73	72.75	5.24	67–80	53.30	4.56	50–63	61.81***	1, 3 < 2

[a] 1 = *some high school;* 3 = *some college;* 5 = *some graduate school/advanced degree*.

[b] Naglieri Nonverbal Ability Test, standard score ($M = 100$, $SD = 15$).

[c] Clinical Evaluation of Language Fundamentals—Fourth Edition, Screening Test, total score (range for 5- to 8-year-olds = 0–28; criterion scores: 7-year-olds = 16; 8-year-olds = 18).

[d] Child Behavior Checklist, DSM–ADHD syndrome scale, *T* score (higher values indicate elevated levels of attention/impulsivity difficulties; clinical cutoff = 65).

SLI = specific language impairment; TD = typically developing; DSM = Diagnostic and Statistical Manual of Mental Disorders; ADHD = attention-deficit/hyperactivity disorder.

*** $p < .001$.

Table 2

Psycholinguistic measures.

Measure	SLI			ADHD			TD					
	Group *M*	*SD*	Range	Group *M*	*SD*	Range	Group *M*	*SD*	Range	*F*	η^2	Contrasts
TEGI												
Screening Test Score	76.33	26.10	0–97.20	97.29	3.31	90–100	99.09	1.38	94.50–100	8.797***	.319	1 < 2, 3
NWR												
Percent Phonemes Correct	75.84	9.25	54.17–89.58	88.54	6.08	76.04–97.92	90.51	7.03	69.79–97.92	22.123***	.293	1 < 2, 3
SR												
Score (max = 32)	10.55	5.20	0–25	23.80	4.46	15–32	23.10	5.51	15–32	43.709***	.617	1 < 2, 3
TNL												
Narrative Ability Index	81.68	10.63	61–94	101.80	12.82	79–124	107.35	14.49	82–136	21.621***	.488	1 < 2, 3

Note. Because Levene's test of homogeneity of variances was significant for the TEGI measure, Welch's Robust Test of Equality of Means (asymptotically distributed *F*) and follow-up Games–Howell pairwise comparisons are reported. For the NWR, SR, and TNL measures, Levene's test was not significant; analysis of variance and and Sidak pairwise comparisons are reported. TEGI = Test of Early Grammatical Impairment; NWR = Nonword Repetition task; SR = Sentence Recall task; TNL = Test of Narrative Language.

*** $p < .001$.

Table 3

Diagnostic accuracy associated with psycholinguistic markers of SLI.

Measure	Discrimination	Area under the curve	*SE*	Optimal cutoff[a]	Sensitivity	Specificity	Positive likelihood ratio[b]	Negative likelihood ratio[c]
TEGI								
	SLI vs. TD	0.954***	0.025	95.75	0.84	0.95	16.80	0.168
	SLI vs. ADHD	0.900***	0.047	93.70	0.79	0.85	5.27	0.247
NWR								
	SLI vs. TD	0.924***	0.046	85.91	0.95	0.90	9.50	0.056
	SLI vs. ADHD	0.875***	0.054	84.90	0.90	0.70	3.00	0.143
SR								
	SLI vs. TD	0.959***	0.031	14.50	0.90	0.90	9.00	0.111
	SLI vs. ADHD	0.963***	0.032	15.50	0.90	0.95	18.00	0.105
TNL								
	SLI vs. TD	0.936***	0.036	95.50	0.95	0.80	4.75	0.063
	SLI vs. ADHD	0.882***	0.053	95.50	0.95	0.65	2.71	0.077

Note. SE = standard error.

[a] Optimal cutoff was based on the TEGI Screening Test score (max = 100), the NWR Percent Phonemes Correct (max = 100), the SR Screening score (max = 32), and the TNL Narrative Language Ability Index (M = 100, SD = 15), and was determined using the Youden Index *(J)*, where J = maximum (Sensitivity + Specificity − 1).

[b] Positive likelihood ratio = Sensitivity/(1 − Specificity): Values of 1 = *neutral*, 3 = *moderately positive*, ≥ 10 = *very positive*.

[c] Negative likelihood ratio = (1 − Sensitivity)/Specificity: Values of 1 = *neutral*, ≤ 0.30 = *moderately negative*, ≤ 0.10 = *extremely negative*.

*** $p < .001$.

Table 4

Binary logistic regression analysis of psycholinguistic markers of SLI.

Variable	*B*	*SE*	Wald	Exp (*B*)	95% CI For Exp (*B*)		Classification accuracy (%)		
					Lower	Upper	SLI	Not SLI	Overall
Model 1							78.9	92.5	88.1
TEGI	−0.476	0.132	12.97***	0.621	0.479	.805			
Model 2							89.5	97.5	94.9
TEGI	−0.457	0.215	4.522*	0.633	0.414	0.965			
SR	−0.408	0.151	7.285**	0.665	0.495	0.894			
Model 3							84.2	95.0	91.5
TEGI	−0.465	0.243	3.668*	0.628	0.390	1.011			
SR	−0.402	0.171	5.496*	0.669	0.478	0.936			
NWR	−0.115	0.086	1.819	0.891	0.753	1.054			
Model 4							94.7	95.0	94.9
TEGI	−0.688	0.368	3.493	0.503	0.244	1.034			
SR	−0.522	0.275	3.597	0.593	0.346	1.018			
NWR	−0.122	0.109	1.054	0.894	0.722	1.107			
TNL	−0.387	0.264	2.153	0.679	0.405	1.139			

* $p < .05$.

** $p < .01$.

*** $p < .001$.