Overlap Between Autism and Specific Language Impairment: Comparison of Autism Diagnostic Interview and Autism Diagnostic Observation Schedule Scores

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Autism and specific language impairment (SLI) are developmental disorders that, although distinct by definition, have in common some features of both language and social behavior. The goal of this study was to further explore the extent to which specific clinical features of autism are seen in SLI. The children with the two disorders, matched for non-verbal IQ, were compared on the Autism Diagnostic Interview—Revised (ADI-R) and the Autism Diagnostic Observation Schedule (ADOS). In the SLI group, 41% met autism or autism spectrum cut-offs for social or communication domains either on the ADI or ADOS or both. No relationship was found between the language deficits exhibited by the children with SLI and their scores on the ADI and ADOS. These findings contribute to evidence that there is some overlap in social and communicative deficits between autism and SLI, supporting the view that autism and SLI share etiologic factors. This continuum of pathology between SLI and autism appears to range from structural language abnormalities as seen in individuals with SLI to individuals with SLI with both structural and social abnormalities to individuals with autism with pragmatic impairment and language abnormalities.

Keywords: autism; specific language impairment; developmental disorders; etiology; Autism Diagnostic Interview-Revised; Autism Diagnostic Observation Schedule

Introduction

Autism and specific language impairment (SLI) are developmental disorders that, although distinct by definition, have in common some features of both language and social behavior. Autism is characterized by impairment in the domains of communication, social interaction, and repetitive/restrictive behaviors and interests [American Psychological Association, 1994]. SLI is diagnosed on the basis of impairment in language abilities not due to sensory, neurological, or intellectual impairment. Although the symptoms of SLI are heterogeneous, deficits may be apparent in both expressive and receptive domains [Bishop, 1998], some children displaying both expressive and receptive language deficits and others displaying either expressive or receptive deficits.

In an early, seminal study comparing the two disorders, Bartak, Rutter, and Cox [1975] compared 48 boys with autism or SLI who had both receptive and expressive deficits. The samples were matched on age and non-verbal IQ (NVIQ). While most cases could be clearly differentiated, there were areas of overlap. Thus, over 40% of the group with SLI did not use gesture as a means of non-verbal communication. Moreover, five children (about 10% of the sample) exhibited characteristics of both disorders [Bartak, Rutter, & Cox, 1977]. By adolescence [Cantwell, Baker, Rutter, & Mawhood, 1989], the boys with SLI had improved communication skills; however, their use of stereotyped utterances had increased. They were also having more social problems than previously, such as difficulty joining group activities and making friends. In contrast, these behaviors had either improved or remained unchanged in the autism group. Mawhood, Howlin, and Rutter [2000] re-examined these individuals again at ages 23–24 and noted that some individuals in the SLI group continued to show social difficulties. Overall, the differences between the autism and SLI groups had decreased over time and were quantitative rather than qualitative in nature. This set of studies suggested that that there is some overlap between autism and SLI, and that there is a mixed group that has characteristics of both disorders. Whereas the findings are provocative, it is

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difficult to generalize them to other children with SLI because of the small sample size and the severity of language impairment in the SLI participants, which included severe deficits in receptive language.

Other studies, conducted with less-impaired children with SLI, supported the findings by Bartak and colleagues. A longitudinal study of 18 children diagnosed with language disorder [Paul & Cohen, 1984; Paul, Cohen, & Caparulo, 1983] found that half the children showed characteristics of autism, particularly in the area of language and communication**.** Over time, the children in the original sample whose comprehension abilities were better than their expressive abilities showed improvement in social relations. In a later study, Paul, Looney, and Dahm [1991] found low scores on the socialization domain of the Vineland Adaptive Behavior Schedule in 2–3-year-old toddlers with delayed onset of speech, even when language-related items were not considered. More recently, Bishop, Chan, Adams, Hartley, and Weir [2000] analyzed conversations with adults in the children with SLI and typical children, finding that the children with SLI use less non-verbal communication than typical children. Conti-Ramsden and Botting [2004] examined peer relationships in a large group of 11-year-old children with SLI. Forty percent of the children (68/168) demonstrated difficulty in socializing with their peers, including not having friends and having difficulty making friends, as reported by their teachers on a measure of peer competence. Almost one-third of the sample (54/168) were found to have difficulties in peer relationship on a measure of peer problems. These difficulties included a tendency to play alone and fighting with other children. One-third of the participants were bullied in school by other children. Similarly, Redmond and Rice [1998] found that the children with SLI had more social difficulties than controls, based on teacher report. Other studies report that very young children with SLI tend not to initiate interactions with their peers [Rice, Sell, & Hadley, 1991], and that they are viewed as the least popular children by their peers [Gertner, Rice, & Hadley, 1994]. Farmer [2000] found that the children with SLI attending special schools for the children with speech and language difficulties had lower ratings on social cognition and social competence than age- and language-matched typical controls.

Ford and Milosky [2003] investigated the ability to recognize and infer emotional reactions in 12 children with SLI and 12 controls. They found that the children with SLI have more difficulty processing social-affective information than the children with no language difficulties. While they were able to identify emotions in line-drawn facial expressions as well as the controls, they were worse at inferring the appropriate emotion in a specific event. Social difficulties in the children with SLI have also been reported in other studies [e.g., Brinton, Fujiki, & McKee, 1998; Donlan & Masters, 2000; Hart, Fujiki, Brinton, & Hart, 2004].

The overlap between autism and SLI is also evident in patterns of language abnormality. While the language skills of individuals with autism vary significantly, many show language delays and difficulties [Bailey, Phillips, & Rutter, 1996; Lord & Paul, 1997]. Kjelgaard and Tager-Flusberg [2001] investigated language performance using standardized language tests in a group of 89 children and adolescents with autism, and found that about half of the children with an overall high level of functioning had significant impairments in structural language. The profile found in this group of children with autism (the most severe difficulties in grammar and semantics, and vocabulary and non-word repetition below average but slightly better than grammatical and semantic skills) resembled the pattern that is found in the children with SLI [Tomblin & Zhang, 1999]. These similarities were further confirmed by Roberts, Rice, and Tager-Flusberg [2004] in a study of tense-marking in the children with autism and follow-up studies on non-word repetition [Tager-Flusberg, 2006].

In addition to overlaps in socialization and structural language, it is now clear that some children classified as having language disorders also have pragmatic abnormalities, a hallmark symptom of autism. Deficits in pragmatics, defined as the use of language, prosody, and gesture for social communication, are virtually universal in autism and were thought to distinguish autism from SLI. In recent years, however, a series of studies by Bishop have demonstrated both social and pragmatic abnormalities in the children attending a school specializing in language disorder. These studies were designed to test the hypothesis [Bishop & Rosenbloom, 1987] that a subtype of language impairment exists in which expressive language is intact, but the social aspects of language are impaired. This followed a similar proposal by Rapin and Allen [1983], and the condition they described is now known as pragmatic language impairment (PLI). Bishop [1989] identified pragmatic errors in 25% of the children attending the special school. In a later study, at least half of the group of children with SLI who had pragmatic difficulties [Bishop et al., 2000] had difficulty in ''responding to and expressing communicative intents'' that went beyond their difficulties with structural aspects of language.

Two studies have investigated how many language-impaired children with pragmatic deficits may also meet the criteria for autism. Bishop and Norbury [2002] administered the Autism Diagnostic Interview—Revised [ADI-R; Lord, Rutter, & Le Couteur, 1994] and the Autism Diagnostic Observation Schedule [ADOS; Lord et al., 2000] to a group of 13 children with PLI and 8 with

typical SLI, in order to examine whether they met the diagnostic criteria for an autism spectrum disorder (ASD). Several children in both the PLI and SLI groups in the study met the criteria for autism or one of the ASDs. However, the sample was small and the children previously diagnosed with autism were not excluded from the study. Conti-Ramsden, Simkin, and Botting [2006] administered the ADI-R and ADOS to a large group ($N = 76$) of 14-year-old children with a documented history of SLI. They found that almost 4% met the criteria for autism on both instruments and about 25% had some symptoms of ASD or met the criteria on only one of the diagnostic instruments.

The goal of this study was to follow up on this earlier work to further explore the extent to which specific clinical features of autism are seen in the children with SLI. We directly compared a sample of children with autism and SLI who were matched on NVIQ using the ADI-R and ADOS and examined their profiles and severity of symptomatology on subscales of the ADI-R [Tadevosyan-Leyfer et al., 2003]. The participants for this study were selected to try to minimize diagnostic overlap related to ascertainment bias.

Methods

Ascertainment of Cases

The data including the ADI-R and ADOS on probands were collected as part of a family study designed to examine genetic contributions in autism and SLI. Two sites participated, the Tufts-New England Medical Center (Tufts-NEMC) and the University of Iowa. SLI families from the Iowa site were members of a longitudinal cohort [for the description of the cohort [see Tomblin, Zhang, Buckwalter, & Catts, 2000] that had been sampled from a cross-sectional population sample of kindergarten children [Tomblin et al., 1997]. Because we wished to avoid bias toward ascertaining SLI families who were concerned that their child may have symptoms of autism, SLI families at the Boston site were recruited through classes and services specifically for the children with language impairment or language-based learning disorders. The autism recruitment was carried out through services for the children with autism and Asperger syndrome at both the Iowa and Boston sites. After recruitment, as part of the consent process, the families were notified that the purpose of the study was to examine genetic contributions to autism and SLI, and they understood that once enrolled in the study, the children would be assessed both for autism and SLI.

Entry Criteria/Proband Definition

All probands were between the ages of 6 and 16 and had a verbal IQ (VIQ) of 60 or above as measured on the abbreviate version of the Wechsler Intelligence Scale for Children, Third Edition [WISC-III; Wechsler, 1991]. The cut-off was selected to ensure that the children could complete the testing battery without floor effects. Both parents agreed to participate, and the family's first language was English.

Autism group: The autism probands scored at or above the threshold on the social and communication domains of the ADI-R diagnostic algorithm [Lord et al., 1994], and at threshold or one point below on the repetitive behaviors domain. If the individual did not meet on the third domain, case-by-case decisions were made by an expert clinician (S. E. F.) based on the ADOS and other clinical materials. The ADOS was video-taped, and some of the scoring was completed from video observation. Inter-rater reliability was established for the raters at both sites and rechecked annually.

SLI group: SLI was defined by a standard score of below 85 (more than one standard deviation below the mean) on the Total Language Score of the Clinical Evaluation of Language Fundamentals—Third Edition [CELF-III; Semel, Wiig, & Secord, 1995] *or* a standard score of below 7 (more than one standard deviation below the mean) on the Non-Word Repetition subtest of the Comprehensive Test of Phonological Processing [CTOPP; Wagner, Torgesen, & Rashotte, 1999] and a documented history of delayed language acquisition. For the participants at the Boston site, delayed language acquisition was assessed during the telephone screen and included a history of delay in major language milestones and a history of receiving speech therapy. The probands in Iowa had been recruited at age 5, for an epidemiological study of SLI [Tomblin et al., 1997], selected based on language, speech, and performance IQ measures.

The non-word repetition task is a sensitive and specific psycholinguistic marker for SLI [Conti-Ramsden, Botting, & Faragher, 2001; Tager-Flusberg & Cooper, 1999], and it detects a history of SLI in over 50% of school-aged probands who, by that age, often score above the threshold on standardized language tests [Conti-Ramsden et al., 2001]. In the SLI group, 20 children met the criteria for language impairment on both tests, 2 children met only on the CTOPP, and the remainder of the children met only on the CELF-III. Of the children in the SLI group, 35 (81.4%) demonstrated deficits on both receptive and expressive domains of the CELF-III, 4 (9.3%) demonstrated deficits on the expressive domain only, and 3 (7%) only on the receptive domain. All the participants had sufficient language ability to be tested on the full battery.

Exclusion Criteria

Exclusion criteria included diagnosis of fragile-X syndrome, congenital rubella, phenylketonuria, neurofibro-

matosis, tuberous sclerosis, familial mental retardation, severe birth trauma, or brain injury. We also excluded families where probands had no specific medical diagnosis but had significant dysmorphic features or serious illness in early life that could have caused their disorder. Families with more than one child with autism were included only if there was also a non-autistic sibling in the required age range.

Sample

The autism group included 43 children aged 6–15, and the SLI group consisted of 45 children aged 6–13. Despite taking great care not to mention autism when recruiting families for the SLI sample, one individual in the SLI group met the criteria for the ADI-R and ADOS and was excluded from the analyses. This child had not been diagnosed previously with an ASD. Of the children with autism, 24 (55.8%) met the criteria for SLI. Of these children, 16 (66.7%) demonstrated deficits on both receptive and expressive domains of the CELF-III, 3 (12.5%) demonstrated deficits on the expressive domain only, and 1 (4.2%) on the receptive domain. The remaining four children met the criteria for SLI only on the CTOPP non-word repetition task.

The characteristics of the two groups are presented in Table I. The children in the SLI group were significantly older than the children in the autism group [$t(85) = -3.21$, $p = 0.002$]. The probands' intelligence was assessed by using two verbal subtests (vocabulary and similarities) and two performance subtests (block design and picture arrangement) of the WISC-III [Wechsler, 1991]. There was no significant difference in NVIQ between the two groups [$t(85) = 1.08$, $p = 0.284$]; however, VIQ in the autism group was significantly higher than that in the SLI group [$t(85) = 3.79$, $p < 0.001$]. The children with autism scored significantly higher than the children with SLI on the expressive and receptive subscales of the CELF-III as well as on the Non-Word Repetition subtest of the CTOPP (Table I). The children with SLI scored significantly higher on the CELF-III receptive than expressive language subscales.

Table I. Sample Demographics

	Autism group ($N = 43$)			SLI group ($N = 45$)		
	Mean	SD	Range	Mean	SD	Range
Age	9.7	2.4	6–15	11.1	1.5	6–13*
Males (%)	86.4			58.8		
Females (%)	13.6			42.2		
Ethnicity (%)						
Caucasian	88.6			91.3		
Other	11.4			8.7		
FSIQ	95.0	21.0	56–140	84.0	12.0	62–111*
VIQ	94.0	19.0	65–146	84.0	11.0	62–113**
NVIQ	86.0	13.0	48–152	90.0	15.0	62–115
CELF						
Total	86.3	23.9	55–145	72.3	8.2	57–95*
Receptive	88.8	22.7	59–140	76.7	8.4	60–100*
Expressive	86.4	21.9	59–141	73.3	9.2	59–91*
CTOPP						
Non-Word Repetition	2.3	0.3	3–13	1.7	0.3	2–10*

SLI, specific language impairment; FSIQ, full scale IQ; VIQ, verbal IQ; NVIQ, non-verbal IQ; CELF, Clinical Evaluation of Language Fundamentals; CTOPP, Comprehensive Test of Phonological Processing.
*Significant at $p < 0.01$; **significant at $p < 0.001$.

Instruments and Procedures

Autism Diagnostic Interview—Revised (ADI-R). The ADI-R is an investigator-based, semi-structured interview that is administered to an informant [Lord et al., 1994], usually the mother. This study utilized the short version. It covers a range of behaviors related to social and language abnormalities, and repetitive behaviors, as well as other features common in autism but not part of the diagnostic criteria. The subjects are rated on the presence and severity of each behavior and symptom for ages 4–5 and for the time of the interview. Some items are coded if they were ever present (''ever'' code) instead of at ages 4–5. The scores range from zero, indicating the absence of the particular behavior, to three, indicating the presence of the behavior at high severity. The ADI-R includes a diagnostic algorithm, which is linked to *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*, criteria of autism; subjects must score at or above the threshold on all three domains to meet the criteria for autism. The items in the ADI-R algorithm (except for social chat and reciprocal conversation) are based on ratings of behaviors at ages 4–5 or ''ever'' as opposed to the behaviors at the times of the interview. Thus, algorithm scores do not provide information about change over time. The ADI-R scores were therefore recalculated using the ''current'' ratings of the algorithm items in order to note any differences between the groups with development.

ADI-R Cluster Scores. We used ADI Cluster Scores developed in a study in which the ADI-R was subjected to a principal component analysis, for which the best solution included six clusters: Language, Social Intent, Savant Skills, Developmental Milestones, Compulsions, and Sensory Aversions [Tadevosyan-Leyfer et al., 2003]. In order to compute the Cluster Scores, the values of each item in the cluster are added. Then these scores are converted to a proportion of the total possible score for that cluster. The scores thus vary from 0 to 1, allowing for the same range of scores for each cluster, despite the different number of items within each. Each cluster forms a scale. This analysis was carried out to provide a measure of autism severity that could be used as a continuous variable or scale.

The Cluster Scores differ from the ADI-R algorithm domain scores, which were derived to maximize the discriminant diagnostic validity, not as scales to estimate the severity. Also, while the communication domain of

the ADI-R contains a mixture of structural language and pragmatic items, in our empirically derived scales, the social/pragmatic items from the ADI communication and social domains are grouped together in the Social Intent cluster. The ''Spoken Language'' cluster consists mainly of items related to structural language. Using these two scales, we are better able to disentangle the social (both verbal and non-verbal) and language aspects of the ADI.

Seven of 21 variables of the Social Intent cluster are not included in the ADI short form, but because the items in the cluster are highly correlated, the missing variables did not have a significant effect on the Cluster Scores. In a sample [$N = 290$; for the description of the sample, see Tadevosyan-Leyfer et al., 2003] where the long form of the ADI-R was used, the Social Intent cluster was highly correlated with the shortened Social Intent cluster ($r = 0.95$, $p < 0.0001$). The Sensory Aversions cluster was excluded from the analyses of this study because too few of its component variables are included in the short form of the ADI-R.

Autism Diagnostic Observation Schedule—Generic (ADOS). The ADOS [Lord et al., 2000] is a structured interaction between the child and the interviewer that provides presses for socially interactive behavior, conversation, and production of narrative language. It has four modules that vary according to the individual's developmental and language level, and it can be used for the participants with a wide range of chronological and mental ages. The scoring of the ADOS is similar to the ADI-R, with scores ranging from 0 to 3. Module 3, designed for the children with fluent language, was utilized with the majority of the study participants. Module 4 has the same algorithm items and is used for older children; four children in the autism group and one child in the SLI group were administered Module 4. The main difference between the two modules is whether the information about social and communication abilities is solicited in a play or an interview setting [Lord et al., 2000]. The algorithm items for Modules 3 and 4 are identical, and in the original study of the ADOS [Lord et al., 2000], these algorithms had similar sensitivity (0.90 and 0.90, respectively) and specificity [0.94 and 0.93, respectively; Lord et al., 2000] for distinguishing between autism and ASD vs. no spectrum disorder. For these reasons, both modules were included in the analyses.

Clinical Evaluation of Language Fundamentals—Third Edition (CELF-III). The CELF-III [Semel et al., 1995] was used as one of the diagnostic measures of language status. This omnibus language test examines the children's ability to understand and produce language at the lexical and sentence level. The core battery of the CELF-III provides three subtests each for receptive and expressive language. The subtests used to calculate the receptive language domain included Concepts and Directions for all ages, Sentence Structure (ages 6–8), and Word Classes (ages 9–16). Expressive language scores were calculated using Recalling Sentences for all ages, Word Structure (ages 6–8), and Formulated Sentences (ages 9–16). Norms are provided for the children between 6 and 16 years 11 months. The four scores were combined to yield a Total Language Score that was used to determine the presence of language impairment.

Comprehensive Test of Phonological Processing (CTOPP). The Non-Word Repetition subtest of the CTOPP [Wagner et al., 1999] was used as an alternative diagnostic measure of language status. The CTOPP assesses phonological processing abilities such as phonological awareness, phonological memory, and rapid naming. Because the abilities that the CTOPP assesses vary by age, it has two versions: one for individuals aged 5 and 6 and the other for individuals aged 7–24. Both versions were used in this study.

Results

Diagnostic Overlap

In addition to the child with SLI who was excluded based on meeting the criteria for autism, three children with SLI met the criteria for an ASD (but not autism) using the criteria developed by the Collaborative Programs of Excellence in Autism [CPEA; see Luyster et al., 2005]. Two of these children met the criteria for ASD scoring above the cut-ff on the social and communication domains of the ADI-R and above the cut-off for ASD on the ADOS. The third child met the CPEA criteria for ASD, scoring above the cut-off on social and communication domains of the ADI but not the ADOS. Their language characteristics are presented in Table IV.

ADI-R Algorithm Domain Scores

Table II presents the ADI-R scores for both groups. The autism group had a significantly higher mean score than

Table II. ADI-R Algorithm Diagnostic and Current Domain Scores

	Diagnostic ADI-R algorithm domain scores			Current ADI-R algorithm domain scores		
	Mean	SD	Range	Mean	SD	Range
Autism ($N = 43$)						
Social	21.3	5.0	9–41	11.7	4.7	3–21**
Communication	16.9	3.7	8–23	11.6	4.9	3–23**
Repetitive behaviors	6.6	2.7	1–12	5.1	2.7	1–10*
SLI ($N = 44$)						
Social	4.8	5.0	0–19	2.1	3.2	0–14**
Communication	3.7	3.9	0–18	2.8	3.1	0–15
Repetitive behaviors	0.4	0.7	0–2	0.2	0.5	0–2

Cut-off for social domain = 10; cut-off for communication domain = 8; cut-off for repetitive behaviors domain = 4. ADI-R, Autism Diagnostic Interview—Revised; SLI, specific language impairment. *Difference significant at $p < 0.01$; **difference significant at $p < 0.001$.

the SLI group on the social, communication, and repetitive behavior domains of the ADI-R [$t(85) = 15.31$, $p < 0.001$; $t(85) = 16.27$, $p < 0.001$; and $t(85) = 14.76$, $p < 0.0001$, respectively]. However, as shown in Figure 1, the frequency distribution of the algorithm domain scores demonstrates that approximately 14% of the SLI sample scored at or above the cut-off (10) on the social domain and 11% scored at the cut-off (8) or above on the communication domain. None of the children with SLI met the cut-off criteria on the repetitive behaviors domain (aside for the one who was excluded).

Pearson correlations were computed between language and ADI-R algorithm scores. None of the correlations reached statistical significance. We examined the distribution of language deficits (receptive and expressive) for the children with SLI who met the autism cut-off on the ADI algorithm domains, presented in Table III, using the Freeman and Halton [1951] extension of the Fisher exact probability test. No differences were found in the frequency or type of language deficits between the children who met the criteria on the social or communication domain and the children who did not.

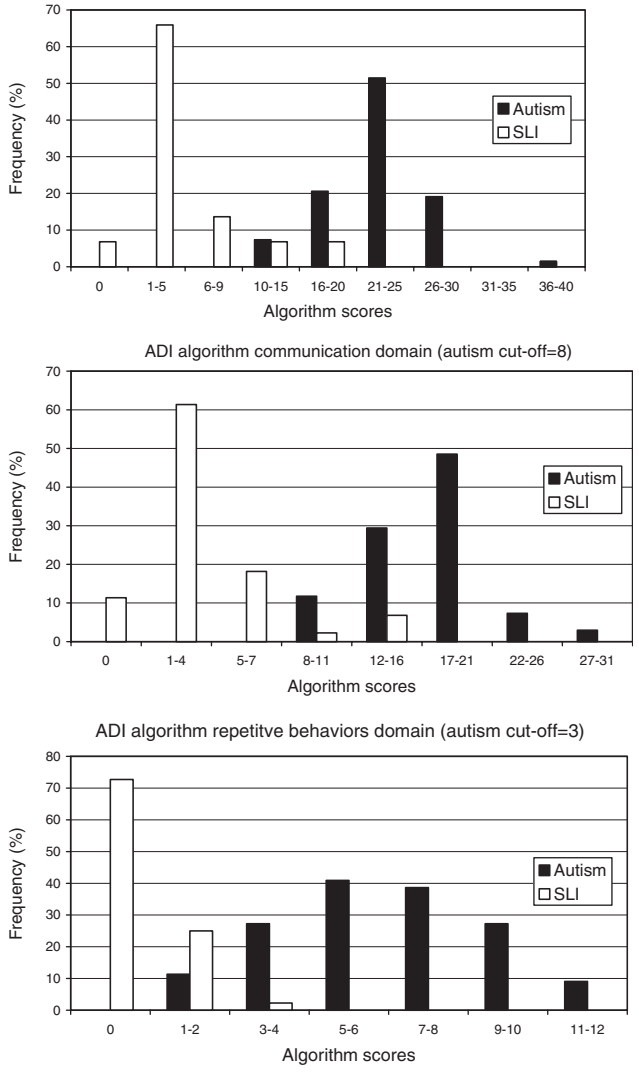

Figure 1. ADI-R algorithm score distribution: ■ autism, □ SLI. ADI-R, Autism Diagnostic Interview—Revised; SLI, specific language impairment.

ADI-R Algorithm Items Current Scores

The ADI-R algorithm scores based on the current ratings are presented in Table II. The social domain scores were significantly lower for both the autism and SLI groups when only current ratings were included [$t(85) = 9.11$, $p < 0.001$ for autism and $t(85) = 2.99$, $p = 0.004$ for SLI]. In fact, 39% of the autism group scored below the cut-off on the current ratings for the social domain. Only 4% of the children in the SLI group met the domain cut-off compared to 14% when using the diagnostic algorithm scores based mainly on behavior at ages 4–5.

The communication domain scores were significantly lower for the autism group when only the current ratings were included [$t(85) = 5.73$, $p < 0.001$; 23% of the group fell below the cut-off score]. However, no improvement was found for the SLI group [$t(85) = 1.21$, $p = 0.231$]. The repetitive domain scores were also significantly lower for the autism group when only current ratings were used

Table III. Language Deficit in the Children With SLI Who Met on Social and Communication Domains of the ADI-R and the ADOS

	Language deficit domain		
ADI and ADOS domains	CELF-expressive	CELF-receptive	CELF-expressive and receptive
ADI social—at or above cut-off	1	0	5
ADI social—below cut-off	4	5	29
ADI communication—at or above cut-off	1	0	3
ADI communication—below cut-off	4	5	31
ADI social and communication—at or above cut-off	1	0	2
ADI social and communication—below cut-off	4	5	42
ADOS social—at or above ASD cut-off	0	0	2
ADOS social—below ASD cut-off	5	5	32
ADOS communication—at or above ASD cut-off	3	1	16
ADOS communication—below ASD cut-off	2	4	18
ADOS total—at or above ASD cut-off	2	0	9
ADOS total—below ASD cut-off	3	5	25

SLI, specific language impairment; ADI-R, Autism Diagnostic Interview—Revised; ADOS, Autism Diagnostic Observation Schedule; CELF, Clinical Evaluation of Language Fundamentals; ASD, autism spectrum disorder.

[$t(85) = 2.73$, $p = 0.008$]. No differences were found for the SLI group when only the current ratings were included in the repetitive domain [$t(86) = 1.22$, $p = 0.226$].

We examined the relationship between IQ and the improvement in the algorithm scores for each group, but no significant correlations were found between full scale IQ, VIQ, and NVIQ and the difference between ever and current scores on the ADI domains for either group.

Table IV. ADI-R Clusters

Cluster 1: Spoken Language	Cluster 2: Social Intent
Complexity of non-echoed utterances—current	Conventional/instrumental gestures at ages 4–5
Overall level of language	Nodding at ages 4–5
Pronominal reversal—current	Head shaking at ages 4–5
Pronominal reversal—ever	Attention to voice at ages 4–5
Neologisms/idiosyncratic language—current	Affection at ages 4–5
Neologisms/idiosyncratic language—ever	Quality of social overtures at ages 4–5
Inappropriate questions or statements—current	Offers comfort at ages 4–5
Inappropriate questions or statements—ever	Greeting at ages 4–5
Verbal rituals—current	Coming for comfort at ages 4–5
Verbal rituals—ever	Imitative social play at ages 4–5
Reciprocal conversation—current	Conventional/instrumental gestures—current
Intonation/volume/rhythm/rate—current	Coming for comfort—current
Vocal expression—current	Greeting—current
Cluster 3: Compulsions	Quality of social overtures—current
Stereotyped utterances—current	Appropriateness of social response—current
Stereotyped utterances—ever	Range of facial expressions used to communicate—current
Unusual preoccupations—current	Sharing other's pleasure and excitement—current
Unusual preoccupations—ever	Curiosity—current
Compulsions/rituals—current	Hand and finger mannerisms—current
Compulsions/rituals—ever	Hand and finger mannerisms—ever
Resistance to trivial changes in the environment—current	**Cluster 4: Developmental Milestones**
Resistance to trivial changes in the environment—ever	Walked unaided
Unusual attachment to objects—ever	Acquisition of bladder control: daytime
Cluster 5: Savant Skills	Acquisition of bowel control
Visuospatial ability—current	Acquisition of bladder control: night
Visuospatial ability—ever	Age of first single words
Computational ability—current	Age of first phrases
Computational ability—ever	Sat unaided on flat surface
Memory skills—current	
Memory skills—ever	
Musical ability—current	

ADI-R, Autism Diagnostic Interview—Revised.

ADI-R Variable Cluster Scores

In our empirically derived ADI-R variable clusters (see Table IV for the items in each cluster), many of the items from the social and communicative ADI-R algorithm domains clustered together on the "Social Intent" cluster; other items from both domains clustered on the "Spoken Language" cluster [Tadevosyan-Leyfer et al., 2003]. Thus, it was possible that the high social and communication scores on the ADI algorithm found in the SLI cases were due mainly to language difficulties. In order to better separate language and social difficulties in the SLI cases, we compared the groups using these ADI-R variable clusters as given in Table V. There was a significant difference in the mean scores for the autism and SLI groups on all five clusters. However, only 27 and 32% of the children with SLI received a score of zero on the Spoken Language and Social Intent factors, respectively.

ADOS Domain Scores

Scores on the ADOS are presented in Table VI. The children with autism scored significantly higher on the social and communication algorithm domain scores than the children in the SLI group. Nonetheless, approximately 25% of the children in the SLI sample met the ADOS cut-off for ASD on the communication domain. Slightly less than half of these children (11% of the sample) scored at the autism cut-off or above. Eighteen percent of the SLI sample met the autism spectrum cut-off on the reciprocal social interaction domain (see Fig. 2).

We calculated the Pearson correlations between the ADOS and language scores for both groups. No significant correlations were found between the ADOS domain scores and the expressive and receptive language scores as well as the CTOPP non-word repetition scores for the children with SLI and the children with autism. We then examined the nature of language difficulties in the

Table V. ADI-R Cluster Scores

	Autism group ($N = 43$)			SLI group ($N = 44$)		
	Mean	SD	Range	Mean	SD	Range
1: Spoken Language[a]	0.20	0.13	0.07–0.61	0.06	0.06	0–0.20**
2: Social Intent	0.46	0.19	0.09–0.77	0.08	0.10	0–0.46**
3: Dev. Milestones	0.77	0.05	0.65–0.89	0.72	0.06	0.57–0.86**
4: Savant Skills[b]	0.26	0.18	0–0.84	0.02	0.05	0–0.41*
5: Compulsions	0.38	0.28	0–0.76	0.05	0.11	0–0.17**

ADI-R, Autism Diagnostic Interview—Revised; SLI, specific language impairment. *$p < 0.05$; **$p < 0.001$.

[a]Higher scores indicate more severe symptoms.

[b]Autism $N = 38$, SLI $N = 39$.

Table VI. ADOS Scores

	Autism group ($N = 43$)			SLI group ($N = 44$)		
	Mean	SD	Range	Mean	SD	Range
Communication	3.9	1.6	0–7	1.1	1.1	0–5*
Social	7.9	2.8	2–13	1.6	1.9	0–8*
Total communication and social	11.9	3.9	2–20	2.8	2.9	0–13*
Stereotyped behaviors	1.4	1.6	0–6	0.14	0.5	0–1*
Imagination/creativity	1.0	0.7	0–2	0.42	0.5	0–2*

ADOS, Autism Diagnostic Observation Schedule; SLI, specific language impairment. *$p < 0.001$.

children with SLI who met least the ASD cut-off on the ADOS (Table III) using the Freeman and Halton [1951] extension of the Fisher exact probability test. No differences were found in the frequency or type of language deficits between the children who met the criteria on the social or communication domain and the children who did not.

Scores on Individual ADI-R Items

Finally, we examined the individual items on which the SLI children who met the criteria on any of the ADI-R or ADOS domains may have scored. These data are given in Table VII. Scores above zero were given to a large proportion of this group on articulation/pronunciation (63% at ages 4–5; 38% current), complexity of non-echoed utterances (75% at ages 4–5; 25% current), and language comprehension (38% at ages 4–5; 38% current). All the children from the SLI sample who had scored above the cut-off score for autism on any of the ADI-R and ADOS domains also scored above zero on the ages 4–5 rating of social vocalization/chat item, and only one child received a score of zero on the current rating. Among the children with SLI, 64%, regardless of their algorithm scores, scored above zero on social vocalization/chat at ages 4–5 (31% currently).

In addition to the above items, all of which could be construed to reflect limitations in language, a substantial number of children with SLI scored on nearly all social and language items more typical of autism, such as spontaneous imitation of actions, pointing to express interest, and interest in other children. Several children also were reported to have produced echolalia or neologisms.

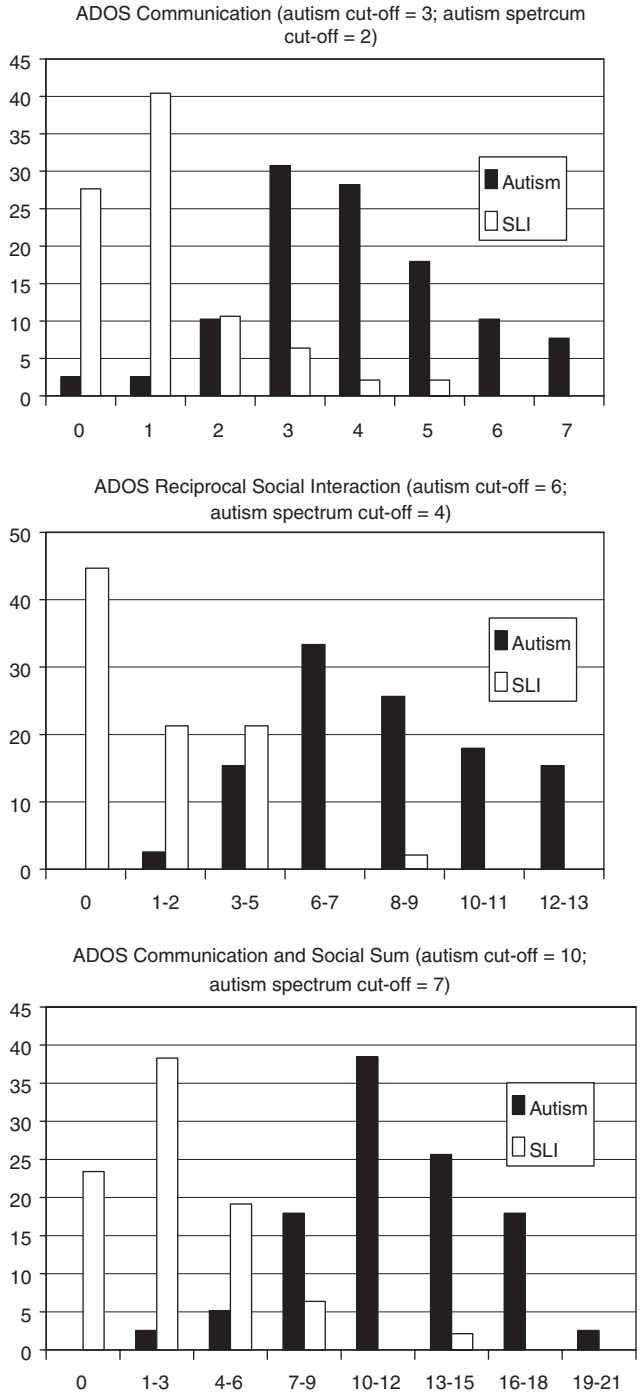

Figure 2. ADOS algorithm score distribution (%): ■ autism, □ SLI. ADOS, Autism Diagnostic Observation Schedule; SLI, specific language impairment.

Discussion

The ADI-R and ADOS algorithm scores and ADI-R Cluster Scores were compared in a group of children with autism and SLI. While the differences were significant between the two groups on all the measures, some interesting patterns were found. Despite taking great care to minimize the overlap between the two groups in ascertaining the participants, we found overlap between the two groups. In the SLI group, 41% met autism or autism spectrum cut-offs for social or communication domains either on the ADI or ADOS or both. Although the Cluster Scores from the principal component analysis of the ADI

Table VII. Percentage of Children With SLI Who Scored on Various ADI-R Social and Language Items

	Current total ♯ > 0	%	Ever or 4–5 total ♯ > 0	%
Use of other's body to communicate	1	2.2	5	11.1
Immediate echolalia	1	2.2	5	11.1
Stereotyped utterances/delayed echolalia	1	2.2	1	2.2
Inappropriate questions at home	9	20.0	10	22.2
Pronoun reversal	2	4.4	8	17.8
Neologisms/idiosyncratic language	2	4.4	4	8.9
Spontaneous imitation of actions	2	4.4	13	28.9
Pointing to express interest	11	24.4	13	28.9
Conventional/instrumental gestures	9	20.0	7	15.6
Nodding to mean "yes"	10	22.2	10	22.2
Shaking head to mean "no"	16	35.5	9	20.0
Attention to voice	0	0.0	18	40.0
Direct gaze	0	0.0	13	28.9
Social smile	10	22.2	14	31.1
Show/direct attention	3	6.7	5	11.1
Offering to share	13	28.9	16	35.6
Seek to share enjoyment	5	11.1	14	31.1
Offers comfort	2	4.4	9	20.0
Quality of social overtures	8	17.8	6	13.3
Range of facial expression	4	8.9	6	13.3
Inappropriate facial expression	7	15.6	5	11.1
Appropriateness of social response	9	20.0	8	17.8
Initiating appropriate activities	11	24.4	11	24.4
Imaginative play	1	2.2	13	28.9
Imaginative play with peers	2	4.4	17	37.8
Social play	0	0.0	9	20.0
Interest in other children	2	4.4	23	51.1
Response to approaches	2	4.4	15	33.3
Group play with peers	2	4.4	16	35.6
Friendships	6	13.3	6	13.3

SLI, specific language impairment; ADI-R, Autism Diagnostic Interview—Revised.

also demonstrated significant differences between the groups, more than half of the SLI group received a Cluster Score of higher than zero on either the Spoken Language or Social Intent cluster or both.

Overall, our findings confirm, using standard diagnostic instruments in a larger sample, the findings of Bartak et al. [1975, 1977] as well of those of [Paul et al., 1983, 1991]. The percentage of the children with SLI who met the criteria for an ASD both the ADI-R and ADOS are similar to that reported in Conti-Ramsden et al. [2006] and Bishop and Norbury [2002], the two earlier studies that also used standard diagnostic instruments to assess autism features in a sample of children with SLI. The present study expands on the previous findings by including a comparison group of children with autism and excluding the children with SLI who met the full criteria for autism (in our study, one child) in order to examine the overlap in characteristics between the two groups. Additionally, by using the Cluster Scores derived from the ADI-R, this study was better able to differentiate between social and language features in the children with SLI.

Interestingly, the receptive and expressive language subtest scores on the CELF-III did not correlate with the ADI-R and ADOS-D domain scores for the children with either SLI or autism. Moreover, no difference was found in the frequency of language deficits between the children who scored at or above the cut-off on the ADI and ADOS social and communication domains. Overall, it appears that social and communication difficulties in these children are not related to language ability. It is further apparent in the examination of the individual ADI-R items, which showed that many of the children with SLI display difficulties in social behaviors such as pointing to express interest, social smile, nodding and head shaking, direct gaze, spontaneous imitation of actions, and showing interest in other children. It is possible that the high scores of the children with SLI on the social-reciprocal domain are a reflection of social difficulties unrelated to autism-like symptomatology. However, the participants did not have a known history of any difficulties that could explain these findings. Future studies are needed to examine emotional and behavioral predictors of these scores for the children with SLI.

As mentioned in the Introduction, the potential overlap between autism and language disorders has been widely discussed, and the category of PLI has been suggested to define the children who exhibit pragmatic difficulties in the absence of expressive language difficulties [Rapin & Allen, 1983]. Although we did not specifically ascertain the children with PLI for this study, it is possible that some of the SLI participants met Bishop's [2000] or Rapin's [1996] definition for this disorder. In this regard, our findings are somewhat similar to those reported in Bishop and Norbury [2002], who found that some children with PLI meet the criteria for ASDs, while others only exhibited difficulties in the communication domain. Pragmatic difficulties were apparent in some of the SLI participants in our study as apparent in such ADI-R items as echolalia, use of neologisms, and pronoun reversal. However, in the present study, a subgroup of children with SLI ($n = 3$) exhibited impairment only in the social domain, in the absence of communication difficulties, once again suggesting that there are no clear boundaries between autism, SLI, and PLI [Bishop, 2000].

One aspect of autism, repetitive and compulsive behaviors, was rarely seen in the children with SLI. About 75% of the children in the SLI group received a score of zero on the ADI repetitive behaviors domain. Over 90% of the children in the SLI group received a score of zero on the ADOS repetitive behaviors domain, and almost 90% of the SLI children received a score of zero on the Compulsions ADI-R cluster scale. The repetitive behavior

items that make up the Compulsions cluster include stereotyped utterances, compulsions and rituals, resistance to change, and unusual attachment to objects, but not repetitive motor behaviors [Tadevosyan-Leyfer et al., 2003].

The comparison of the diagnostic ADI algorithm domain scores with those using only the ratings for current behaviors on the algorithm items showed a significant improvement on the ADI-R for all three domains for the autism group and on the social domain for the SLI group. This finding appears to contradict the findings of Cantwell et al. [1989], who reported that language skills of the children from the Bartak et al. [1975] sample with developmental language disorder improved over time, while their social difficulties worsened. This finding was confirmed by Mawhood et al. [2000] when the sample was followed to adulthood. The cases in the current study are still young and, as a group, have milder deficits than those included in Bartak et al.'s sample, in particular higher VIQ for both the autism and SLI groups. However, no relationship was found between IQ scores and the degree of improvement on the ADI-R.

It is clear now, based on converging evidence from this and several earlier studies, that the clinical features of autism and SLI overlap considerably. The children with autism [Kjelgaard & Tager-Flusberg, 2001] and their family members [Folstein et al., 1999] can have language impairments typical of SLI, and the children with SLI and their family members can have social impairments typical of autism. Hafeman and Tomblin [1999] reported that 3% of the siblings of children with SLI met the criteria for autism. A study comparing the parents of the children participating in the current study found that the parents of the children with autism and the parents of the children with SLI displayed notable difficulties in social communication and did not differ from each other [Ruser et al., 2007].

These findings contribute to evidence supporting the view that autism and SLI share etiologic factors. Both disorders are most likely caused by the interaction of several genes. Moreover, the particular genes that contribute to each disorder are likely to vary from one family to the next [Abrahams & Geschwind, 2008; Folstein & Rosen-Sheidley, 2001]. It is possible that genes associated with social and communication deficits contribute to both disorders. In fact, genetic studies have demonstrated evidence of linkage to the same region on chromosome 7q and 13q for both autism and SLI [Alarcon, Cantor, Liu, Gilliam, & Geschwind, 2002; Ashley-Koch et al., 1999; Bartlett et al., 2002; CLSA, 2001; Tomblin, Hafeman, & O'Brien, 2003]. In a sample of twins, Dworzinksi et al. [2007] found that autism-like traits may be predicted by language abilities, suggesting some shared genetic factors.

We would further hypothesize, based on the existing evidence, that the genes shared by the two disorders would not be related to compulsions since these were rare in the SLI subjects. Features of rigidity and difficulty with change have been reported in the parents of autistic children [Bolton et al., 1994; Piven, Palmer, Jacobi, Childress, & Arndt, 1997; Piven et al., 1994], but there are no comparable studies of the parents of children with SLI. In summary, based on the ADI-R and ADOS, there is some overlap in social and communicative deficits between autism and SLI, confirming the previous studies and supporting Bishop's [2000] dimensional model. This continuum of pathology between SLI and autism appears to range from structural language abnormalities as seen in individuals with SLI to individuals with SLI with both structural and social abnormalities to individuals with autism with pragmatic impairment and language abnormalities.

Some studies have noted that the language difficulties observed in the children with autism and SLI do not reflect an etiological overlap, but rather a relationship between autism symptoms and language development [Whitehouse et al., 2007, 2008]. Of particular interest in this matter is non-word repetition, which has been identified as a defining feature of the SLI phenotype [e.g., Conti-Ramsden et al., 2001]. Whitehouse et al. [2008] have suggested that non-word repetition may be impaired in children with autism as a function of severity of autism symptoms. In a study examining linguistic abilities in the parents of the children with autism and SLI, Whitehouse et al. [2007] found that the parents of the children with autism displayed deficits in the area of language use, while the parents of the children with SLI exhibited difficulties in the structural aspect of language, concluding that the linguistic difficulties in individuals with autism may result from the impairment in the social, communication, and repetitive behavior domains. However, our findings did not demonstrate a relationship between the non-word repetition score on CTOPP and autism symptoms for the children with either autism or SLI. We also did not find a relationship between the CELF-III expressive and receptive scores and autism symptoms in either group. Moreover, the findings of Whitehouse et al. [2007, 2008] studies do not explain autism symptoms found in the children with SLI [e.g., Conti-Ramsden et al., 2006] or PLI.

The present findings have important implications for studies of etiology and mechanism of the two disorders, and further examination of behavioral characteristics of family members of individuals with SLI, autism, and PLI will contribute to studies of genes contributing uniquely to these conditions. Determining the nature of the relationship between ASD and SLI will have important implications for how the two disorders are conceptualized.

Our findings also have important implications from the standpoint of diagnosis, because it is apparent that not all children with social and pragmatic difficulties have an ASD. If a child exhibits such difficulties, a possibility of autism should be considered, but the diagnosis must be based on the entire clinical picture. As suggested by Botting and Conti-Ramsden [2003], the children who exhibit criteria that are not clear-cut (e.g., social difficulties and language impairment) may be diagnosed inconsistently by various professionals. The diagnosis will subsequently drive the choice of interventions and services for the child.

On the other hand, the overlap between autism and SLI demonstrated in this and other studies suggests that diagnosis may not be the only criterion affecting the choice of interventions. For example, although only three children with SLI in the present study met the criteria of ASD, the children with SLI as a group exhibited multiple deficits in the area of social behaviors, which emphasizes the importance of interventions targeting non-structural aspects of language for the children with SLI, including social cognition and non-verbal communication. The presence of autism-like symptoms in the children with SLI as well as SLI symptoms in the children with autism may present distinct sets of difficulties requiring different interventions and suggesting different prognoses for these children.

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