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An investigation of language impairment in autism: Implications for genetic subgroups

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Autism involves primary impairments in both language and communication, yet in recent years the main focus of research has been on the communicative deficits that define the population. The study reported in this paper investigated language functioning in a group of 89 children diagnosed with autism using the ADI–R, and meeting DSM–IV criteria. The children, who were between 4 and 14 years old, were administered a battery of standardised language tests tapping phonological, lexical, and higher-order language abilities. The main findings were that among the children with autism there was significant heterogeneity in their language skills, although across all the children, articulation skills were spared. Different subgroups of children with autism were identified on the basis of their performance on the language measures. Some children with autism have normal language skills; for other children, their language skills are significantly below age expectations. The profile of performance across the standardised measures for the language-impaired children with autism was similar to the profile that defines the disorder specific language impairment (or SLI). The implications of this language impaired subgroup in autism for understanding the genetics and definition of both autism and SLI are discussed.

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Autism is diagnosed on the basis of abnormalities or impaired development in three areas: social interaction, communication, and a severely restricted repertoire of activity and interests, present before the age of 3 (American Psychiatric Association, 1994). In the domain of communication, one criterion that is used to document the presence of autistic disorder is the delay or absence of spoken language. Indeed, this feature is important in differentiating between autism and another related developmental disorder, Asperger's syndrome, which is only diagnosed when there is no clinical delay in language (APA, 1994; Szatmari, 1998; Volkmar & Klin, 1998). Problems in language are central to our understanding of autism: they are often the first presenting symptom (Kurita, 1985; Lord & Paul, 1997); they vary widely in the population; and are the most important feature for predicting the prognosis and developmental course of children with this disorder (Rutter, 1970; Ventner, Lord, & Schopler, 1992).

Despite the significance of language impairment in the diagnosis of autism, in recent years few studies have addressed this area of functioning. Instead, research on the nature of the language and communication deficits in autism has focused almost exclusively on those aspects that are universal and specific to this disorder (Tager-Flusberg, 1996). Beginning with Baltaxe (1977), studies have explored the pragmatic deficits that are apparent in conversations and other discourse contexts, identifying those features that distinguish communication problems in autism from those found in other clinical groups. This body of research has led to the consensus that children with autism are seriously limited in their communicative abilities (see Lord & Paul, 1997; Tager-Flusberg, 1999; Wilkinson, 1998; for recent reviews). These limitations are evident in their restricted range of speech acts (e.g., Loveland, Landry, Hughes, Hall, & McEvoy, 1988; Wetherby, 1986), and impaired conversational and narrative skills (Loveland & Tunali, 1993; Tager-Flusberg & Sullivan, 1995). At a theoretical level, these communicative impairments have been related to deficits in understanding other minds and to other features of the disorder, particularly in social functioning (Capps, Kehres, & Sigman, 1998; Tager-Flusberg, 1993, 1996, 1999).

In contrast to the universal nature of these communicative deficits, language functioning in autism is much more variable. At one end, there are children with autism whose vocabulary, grammatical knowledge, and articulation skills are within the normal range of functioning, while at the other end a significant proportion of the population remains essentially non-verbal (Lord & Paul, 1997). Two decades ago psycholinguistic studies did investigate these aspects of language by comparing verbal children with autism to other children with general developmental delays or other syndromes such as Down syndrome (e.g., Bartolucci & Pierce, 1977;

Bartolucci, Pierce, & Streiner, 1980; Bartolucci, Pierce, Streiner, & Eppel, 1976; Boucher, 1976, 1988; Pierce & Bartolucci, 1977; Tager-Flusberg, 1981, 1985; Tager-Flusberg et al., 1990). The conclusions drawn from these studies, which relied on natural language samples or experimental tasks, were that autism does not involve *specific* deficits in phonology, syntax or lexical knowledge, because the children with autism were comparable in their performance to the control groups matched on language and general cognitive ability. However, these studies included small, perhaps unrepresentative, samples of children with autism. Furthermore, they did not provide a systematic evaluation of the profile of abilities or deficits across the different domains of language, leaving much unknown about the language impairments that may be present in the majority of children with autism.

Only one set of studies during this period did provide a broader assessment of language abilities in a group of children with autism (Bartak, Rutter, & Cox, 1975, 1977). The autistic children in these studies were compared to a group of children with severe receptive language disorder matched on non-verbal IQ. All the children were selected on the basis of having a serious problem in language comprehension. Among the total sample of children about 10% were classified as "mixed", in that they showed atypical disorder with some autistic features. Language abilities were measured using the Reynell Scales, the Peabody Picture Vocabulary Test (PPVT—a measure of receptive vocabulary), and a natural language sample. Although the autistic children had significantly lower PPVT scores, and were lower on the Reynell comprehension scale, there were no differences between the groups in measures of production such as mean utterance length or grammatical complexity. This pattern suggests that comprehension may be more seriously impaired in autism than production. However, because the autistic sample for these studies was pre-selected for the presence of difficulties in language comprehension, it is not clear whether this pattern holds across the population. Furthermore, although there were some similarities in the language profiles of the autistic and language disordered groups, numerous features did distinguish between the populations (e.g., presence of echolalia and pronoun reversals in the autistic group). A follow-up study, conducted when the children were in middle childhood indicated that the autistic group made less progress in language acquisition than did the language disordered group, but now this latter group had more signs of social deficit, making them in some ways more similar to the children with autism (Cantwell, Baker, Rutter & Mawhood, 1989).

There has been one recent study that investigated the profile of language abilities in a group of 120 children all of whom had behaviours that met DSM-IV criteria for autism. However, only about half had received a formal diagnosis of autism (Jarrold, Boucher, & Russell, 1997), and 10 received a diagnosis of Asperger's syndrome. The remaining children received formal diagnoses of severe communication and language disorder, semantic–pragmatic disorder, or the presence of autistic features. The children, ranging in age from 5 to 19, had participated in other experimental studies and had been administered some standardised measures of vocabulary and grammar as part of the test protocol. The measures, which varied somewhat across the studies and children, included vocabulary comprehension (the British Picture Vocabulary Test; the Renfrew Word Finding Vocabulary Scale) and production (Action Picture Test Information) and grammatical comprehension (Test for Reception of Grammar) and production (Action Picture Test of Grammar). The main findings were that the children's performance was equivalent across all the measures. Unlike other reports in the literature (e.g., Bartak et al., 1975; Lord & Paul, 1997; Tsai & Beisler, 1984) this study found that receptive abilities were similar to expressive abilities, and vocabulary was no different from grammatical knowledge. The authors also concluded that there was no significant heterogeneity in the language profiles of the children in their study; however they acknowledge that this was only tested in an indirect way.

Although this is an important study because it is the first to investigate language profiles in a large sample of children with autism, it is limited in a number of ways. First, the diagnoses of most of the children in the study by Jarrold et al. (1997) were not well documented, and the criteria used for autism and Asperger's syndrome were not clearly defined, even for those children receiving a clinical diagnosis. Second, the standardised language data were collected under different testing conditions, and did not include the same tests across all the participants. Third, the main analysis of the data involved converting raw scores to mental age equivalents and conducting all the test pair-wise comparisons that were possible. There are several methodological problems with this approach. The comparisons were made across tests that were normed across different samples of children. Mervis and Robinson (1999) have recently pointed out the problems in comparing age equivalents in this way, because, they argue, one cannot assume that the expected rates of growth on each test will be the same. Instead, a more appropriate approach to profile analysis should be done on the basis of standard scores, where possible using tests that have been normed on the same sample of children.

The goal of our study was to re-examine the language profiles of a large well-defined sample of children with autism. We included a broader range of language measures, including measures of phonological representation and production, lexical knowledge, semantics, and grammar. We were especially interested in revisiting the provocative findings from the earlier studies by Bartak et al. (1975, 1977) which suggested some similarity between autism and developmental language disorder (nowadays referred to as specific language impairment—SLI). SLI is a developmental disorder that is diagnosed on the basis of language levels that fall significantly below age expectations, but in the absence of other conditions (e.g., hearing loss, mental retardation, or evidence of organic pathology). While there is considerable heterogeneity in the pattern of language skills found in children with SLI (e.g., Tomblin & Zhang, 1999), it is generally defined in children whose non-verbal IQ scores are within the normal range, but whose performance on language tests (on measures of vocabulary and/or grammatical ability) fall more than one standard deviation below the mean. We included in our test battery standardised measures that are used in defining SLI, including an omnibus test of receptive and expressive language, the Clinical Evaluation of Language Fundamentals, as well as measures of vocabulary (Tager-Flusberg & Cooper, 1999; Tomblin & Zhang, 1999). We also included a measure that is considered highly sensitive to the diagnosis of SLI—a non-word repetition test (cf. Bishop, North, & Donlan, 1996; Dollaghan & Campbell, 1998; Gathercole & Baddeley, 1990).

Our study was designed to address the following questions. First, what is the relationship between expressive and receptive abilities among children with autism? Second, what is the profile of language ability across measures of phonology, vocabulary and higher order language skills (including semantics and syntax)? Third, how can we best characterise the heterogeneity of language abilities among children with autism? And finally, do children with autism who have impaired language skills resemble the profile of language disability that is found among children with SLI?

METHOD

Participants

The total sample of participants included 89 children with autism who were part of a multi-project investigation. There were no a priori selection criteria set, however one aim was to recruit at least 70 children for a study that required some language skills, thus biasing our sample toward the inclusion of more verbal children. The children were between the ages of 4 and 14, and included 80 boys and 9 girls. All the children were administered the Autism Diagnostic Interview—Revised version (Lord, Rutter, & LeCouteur, 1994) and the Autism Diagnostic Observation Schedule—Generic (DiLavore, Lord & Rutter, 1995) to document the diagnosis of autism. In addition an expert clinician observed all the children to confirm that they met DSM–IV criteria for autistic disorder.

The children's IQ scores were assessed using the Differential Abilities Scales (either the Preschool or School Age version, depending on the child's age and ability level), by a clinical neuropsychologist or clinical psychology intern. Table 1 presents the main characteristics of all the participants in this study.

Procedures

The children were administered a standard battery of language tests testing their phonological, lexical, and higher order semantic and grammatical language abilities. Because of the wide variability in the language skills of the children, in many cases not all the tests were given.

Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 1986). The Goldman–Fristoe sounds-in-words subtest measures the accuracy of productive phonology for the consonant sounds of English. The test presents the child with a series of pictures, such that across the set of pictures, all the consonant sounds of English are tested in the word initial, medial, and final position. Norms are provided for children between the ages of 2;0 and 16;0 in percentile ranks.

Peabody Picture Vocabulary Test–III (PPVT) (Dunn & Dunn, 1997). The PPVT–III tests lexical comprehension by presenting an auditory word and asking the participant to pick the correct picture from an array of four pictures. Norms are available for the children over the age of 2;6, through adulthood.

Expressive Vocabulary Test (EVT) (Williams, 1997). The EVT measures expressive vocabulary by asking the child to name pictures. As the test advances to more difficult items, participants are asked to produce synonyms for words represented in pictures. The norms for this test were derived from the same representative sample as the PPVT–III, and are available from 2;6 through adulthood.

TABLE 1
Participant characteristics

	N	M	SD	*Range*
Chronological age (months)	89	88.07	28.55	48–167
Full-scale IQ	84	68.49	24.38	25–141
Verbal IQ[1]	63	76.29	19.05	51–133
Non-verbal IQ[1]	66	82.95	20.92	43–153

[1] Note that scores on subdomains of IQ are only available for children who tested in age level on the Differential Abilities Scales.

Clinical Evaluation of Language Fundamentals (CELF): Preschool (Wiig, Secord, & Semel, 1992) or III (Semel, Wiig, & Secord, 1995). The CELF is designed to measure morphology, syntax, semantics, and working memory for language and is comprised of six subtests that are used to calculate measures of receptive and expressive language skills. There are three subtests in each of the domains, receptive and expressive. The Preschool version is suitable for children between the ages of 3;0 and 6;11, while the CELF–III covers the age range of 6;0 to 21;11. Norms are provided for these ages for the total CELF scores and for receptive and expressive domain scores.

Repetition of Nonsense Words. We used the sub-test from the NEPSY, which is a comprehensive developmental neuropsychological assessment battery (Korkman, Kirk, & Kemp, 1998). This test assesses the ability to analyse and reproduce phonological knowledge by asking the child to repeat nonsense words that are presented on an audiotape. This test is normed for children aged 5;0 to 12;11.

In most cases the tests were given in the following order: PPVT, EVT, Goldman–Fristoe, CELF, and Repetition of Nonsense Words. Testing was typically conducted on two different days, providing the children with numerous breaks. All the language tests were administered and scored by a certified speech-language pathologist. The test data were all checked by a second coder, under the supervision of a speech-language pathologist.

RESULTS

For each test, the child's standard score was computed. For the PPVT, EVT, and CELF, the procedures described in the test manuals were followed to obtain standard scores, which are based on a mean of 100 and a standard deviation of 15. The Goldman–Fristoe percentile ranks and the Repetition of Nonsense Words standard scores were converted to the standard score scale of the other tests in order to be able to compare means across the measures. We should note however, that the tests are not all equivalent in that they have different floor and ceiling scores.

Children completing language tests

Table 2 presents the numbers of children who were able to complete each of the language tests included in the battery above the basal level, and provides the means and standard deviations for each test. Across the tests more than 90% of the total sample of children were able to complete the PPVT, EVT, and Goldman–Fristoe. In contrast only about half the children were able to complete the CELF (49%) and the Repetition of

TABLE 2
Performance on language measures

Measure	N	M	SD
Goldman–Fristoe	79	90.17	17.03
PPVT	82	70.37	22.68
EVT	81	68.99	23.62
CELF	44	72.32	17.71
Repetition of Nonsense Words	40	81.88	13.89

PPVT, Peabody Picture Vocabulary Test; EVT, Expressive Vocabulary Test; CELF; Clinical Evaluation of Language Fundamentals.

Nonsense Words (45%). The latter test was not attempted with children below the age of 5, since norms are not available for younger children.

We compared the children who were able to complete the CELF to those who were not. While there were no significant differences in age ($t[87] = .91$), the children who did complete the CELF had significantly higher IQ scores ($M = 85$, SD = 17.3) than the children who did not ($M = 50$, SD = 16.8), $t(82) = 9.4$, $p < .0001$. We also found that the scores of the PPVT and EVT were significantly higher for the children completing the CELF compared to those not completing the CELF. On the PPVT the means for the two groups were: $M = 85.6$, SD = 17.8, and $M = 52.8$, SD = 12.9, $t(80) = 9.44$, $p < .0001$; and on the EVT the means were : $M = 84.9$, SD = 17.5, and $M = 50.1$, SD = 14.1, $t(79) = 9.7$, $p < .0001$.

Finally we checked whether there were differences in the numbers of children who completed each test who were younger (below age 7) or older (over age 7). These data are summarised in Table 3. The only test that fewer young children completed was the Repetition of Nonsense Words. As noted earlier, the norms for this test only begin at age 5, so 14 children in our sample who were 4 years old, were not given the test. For all the other language measures, there were no differences in the numbers of younger and older children completing the tests.

Receptive vs. expressive abilities

The first set of analyses investigated whether there were significant differences between receptive and expressive abilities, using the lexical measures and the CELF. The standard scores from the PPVT ($M = 71.13$, SD = 22.43) and EVT ($M = 69.35$, SD = 23.55) were compared for the sample of 80 children who completed both tests using a two-tailed t-test: $t(79) = 1.342$, $p = .18$. The vast majority of children, 64, representing 80% of the sample, did not show more than one standard deviation

TABLE 3
Comparison of children under age 7, and age 7 and older, completing the language tests

	Under 7 N = *50*		Over 7 N = *39*	
Measure	N	%	N	%
Goldman–Fristoe	44	88	35	90
PPVT	46	92	36	92
EVT	45	90	36	92
CELF	28	56	16	41
Repetition of Nonsense Words	19	38	21	54

PPVT, Peabody Picture Vocabulary Test; EVT, Expressive Vocabulary Test; CELF, Clinical Evaluation of Language Fundamentals.

difference between PPVT and EVT scores. Of the 20% who did have a discrepancy of more than one standard deviation, 13 (16%) had higher PPVT scores while three (4%) had higher EVT scores. Overall, these results do not suggest that there are significant differences between receptive and expressive abilities in lexical knowledge among children with autism.

For the smaller sample of 44 children able to complete the CELF (either Preschool or III), the standard scores on the receptive subtests (M = 70.89, SD = 19.73) and the expressive subtests (M = 74.86, SD = 17.63) were also compared using a two-tailed t-test. This analysis revealed a significant difference between the receptive and expressive standard scores $t(43) = 2.445$, $p = .019$, indicating that among this group of children, expressive abilities for higher order language use were higher than receptive abilities. This pattern of higher expressive than receptive ability on the CELF held for over half the sample (25 children; 57%). Table 4 presents the scores (now with a mean of 10 and standard deviation of 3) on each of the subtests of the CELF Preschool and III. On the preschool version, the Formulating Labels (a word naming task) expressive subtest stands out as the single subtest that is higher than the others, and this was confirmed in a post-hoc analysis. On the CELF III, Word Structure (tapping grammatical morphology) and Sentence Assembly (tapping word order knowledge in children who can read) were the expressive tests that were higher than the other subtests. Nevertheless, it is important to note that there was considerable variability among the children in their performance across the subtests, and there was no clear profile that characterised the children with autism in this study.

TABLE 4
Performance on Subtests of Clinical Evaluation of Language Fundamentals (CELF) Preschool and CELF III

	N	M	SD
CELF Preschool			
Expressive subtests			
Recalling Sentences	25	4.08[1]	2.12
Formulating Labels	25	6.76	2.55
Word Structure	25	5.00	3.10
Receptive subtests			
Linguistic Concepts	25	4.08	2.58
Basic Concepts	25	5.60	3.21
Sentence Structure	25	4.56	2.40
CELF III			
Expressive subtests			
Word Structure[2]	9	7.78	3.83
Formulated Sentences	19	6.11	2.79
Recalling Sentences	19	7.16	2.95
Sentence Assembly[3]	10	7.40	3.24
Receptive subtests			
Sentence Structure[2]	9	6.11	2.67
Concepts and Directions	19	6.74	3.77
Word Classes	19	6.95	3.84
Semantic Relationships[3]	10	6.20	2.70

[1] Note that for subtests on the CELF the mean score is 10 with a SD of 3.
[2] For children aged 6–8.
[3] For children aged 9 and older.

Subgroups of language abilities in autism

The scores on each of the language tests showed wide variability among the sample of children in this study, as shown in Table 2. To explore this variability further, we created three subgroups of children, based on their PPVT scores. The 82 children who completed the PPVT were divided into those who scored within the normal range (standard scores of 85 and above, $N = 22$), those who were between one and two standard deviations below the mean (standard scores between 70 and 84, $N = 10$), and those whose scores were more than two standard deviations below the mean (standard scores below 70, $N = 50$). We refer to these groups as the normal language group, the borderline group, and the impaired group, respectively.

We examined for each of these groups the pattern of scores on the EVT, the Goldman–Fristoe and full scale IQ. We limited this profile analysis to these tests since they are the ones available on the largest number of children in the sample. Figure 1 shows the profile for each of the language groups. This profile showed that on average, children's vocabulary and IQ

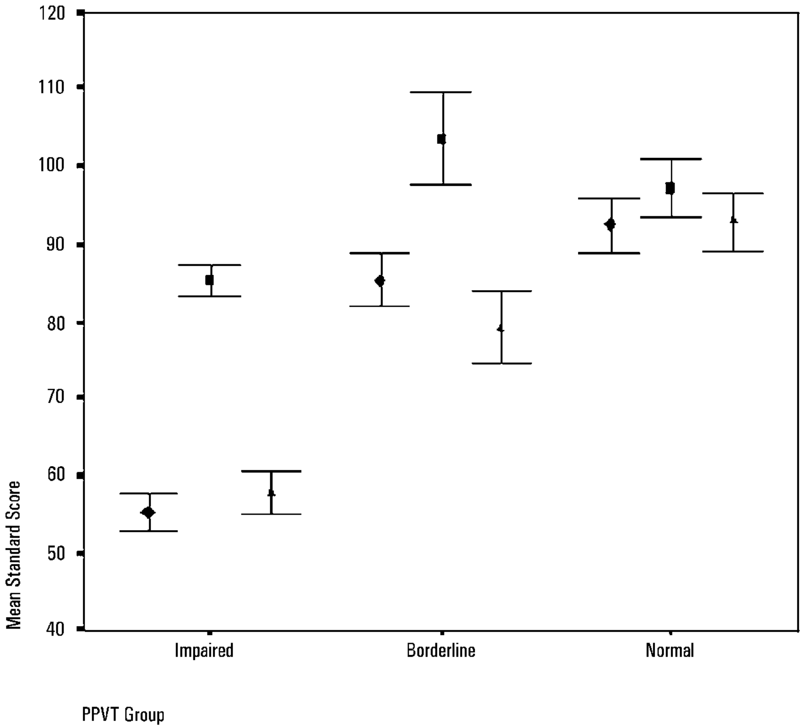

Figure 1. Profiles of Expressive Vocabulary Test (EVT) (◆), Goldman–Fristoe (■), and Full-Scale IQ (▲) in normal language ($N = 12$), borderline ($N = 10$), and impaired ($N = 50$) groups, based on Peabody Picture Vocabulary Test (PPVT) scores.

scores varied together and were lowest in the impaired group (EVT M = 55, SD = 16.82; IQ M = 58, SD 18.76), closer to normal in the borderline group (EVT M = 85, SD = 13.86; IQ M = 79, SD = 14.6) and highest in the normal group (EVT M = 93, SD = 16.52; IQ M = 93, SD 17.89). The correlations between IQ and both vocabulary measures were statistically significant (for PPVT, $r(77) = 0.83$, $p < .001$; for EVT, $r(77) = 0.77$, $p < .001$), confirming the relationship between vocabulary and full scale IQ across the sample in this study. At the same time, there were 14 children in the impaired language group whose full-scale IQ scores were above 70; and 9 children who were in the normal language group whose full-scale IQ scores were in the borderline to mentally retarded range. Within the normal language group, 12 children were under 7 (26%), and 10 were 7 or older (28%). Similarly in the impaired language group, 26 children were under 7 (57%), 24 were 7 or older (67%).

The profile shown in Figure 1 also illustrates that scores on the Goldman–Fristoe were in the normal range for all three groups (impaired group, $M = 85.3$, SD = 13.86; borderline group, $M = 103.55$, SD = 18.76; and normal language group $M = 97.23$, SD = 17.2). This pattern indicates that expressive phonology at the one word level is spared in autism overall. Nevertheless, a one-way ANOVA on the Goldman–Fristoe standard scores with language group as the between subjects variable was significant ($F(2, 74) = 8.11$, $p < .001$. Post-hoc Tukey HSD analyses revealed that the impaired group had significantly lower Goldman–Fristoe scores than either the borderline or normal language groups. The number of children for whom Goldman–Fristoe scores were greater than EVT scores was 60/79 (76% of the children). Thus, across the sample of children with autism in this study, articulation skills tend to be higher than vocabulary knowledge. The Goldman–Fristoe standard scores were only moderately correlated with age ($r(77) = .22$) and IQ ($r(74) = .38$).

Language profile using the CELF

In the second profile analysis we explored children's performance across all the language measures used in this study, including all those children who were able to complete the CELF ($N = 44$). Table 5 presents the means and standard deviations of the standard scores on all the tests administered for this group of children. The IQ data indicate that this group is generally within the normal range for non-verbal IQ. Not surprisingly, verbal IQ scores are lower than non-verbal; a pattern that is typical among children with autism. The data in this table show that across all the language measures, with the exception of the Goldman–Fristoe, scores are one standard deviation or more below the mean. Performance on the CELF is lower than on the measures of lexical knowledge (between 10 and 15 points), but again, there is significant variability on the language measures among this group of high functioning children with autism.

TABLE 5
Performance on the language tests for children who completed the CELF

Measure	M	SD	*Range*
Goldman–Fristoe	97.55	17.51	67–133
PPVT	85.57	17.77	55–134
EVT	84.89	17.51	40–136
CELF–Total	72.32	17.71	50–113
CELF–Receptive	70.89	19.73	50–116
CELF–Expressive	74.86	17.63	50–116
Repetition of nonsense words	85.32	11.23	65–110
Verbal IQ	83.57	18.04	53–133
Non-verbal IQ	90.07	19.63	49–153

PPVT, Peabody Picture Vocabulary Test; EVT, Expressive Vocabulary Test; CELF, Clinical Evaluation of Language Fundamentals.

The total language summary score on the CELF was used to divide this sample of children into three groups following the same approach used in the previous analysis. Thus, children were designated as normal language if their standard scores were 85 or higher ($N = 10$), borderline, if their standard scores were between 70 and 84 ($N = 13$), or impaired, if their standard scores were below 70, or more than two standard deviations below the mean ($N = 21$). The profiles for these groups is shown in Figure 2. For these profiles we created a combined vocabulary score (averaging the children's scores on the PPVT and EVT), and also included the Goldman–Fristoe, and the Repetition of Nonsense Words. As in the previous analysis, we compared the ages of the children in each language subgroup. The average ages of the children in the groups were 6;11 for the normal language group, 7;11 for the borderline group, and 6;11 for the impaired group. In the normal language subgroup, six children were younger than 7 (60% of this subgroup) and four (40%) were 7 or older; in the impaired language subgroup, 15 (71%) were younger than 7 and six (29%) were 7 or older.

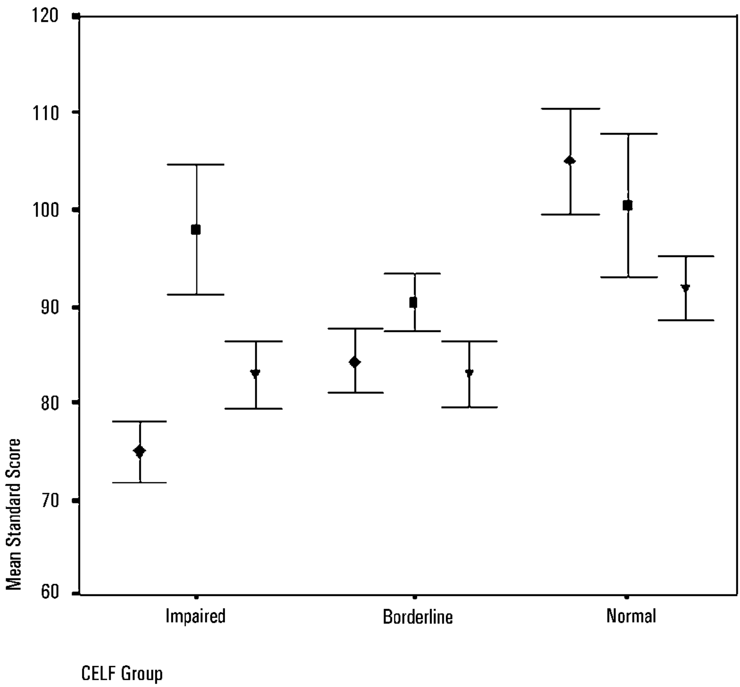

Figure 2. Profiles of Vocabulary (◆), Goldman–Fristoe (■), and Repetition of Nonsense Words (▼) scores in normal language ($N = 10$), borderline ($N = 13$), and impaired ($N = 21$) groups, based on Clinical Evaluation of Language Fundamentals (CELF) scores.

We again found that the Goldman–Fristoe standard scores were in the normal range for all three groups (impaired, $M = 98.98$, SD $= 20.29$; borderline, $M = 92.58$, SD $= 9.63$; normal language, $M = 101.56$, SD $= 19.74$). A one-way ANOVA revealed no significant differences among the language groups on the Goldman–Fristoe ($F(2, 39) = 0.82$). Repetition of Nonsense Words fell lower than one standard deviation below the mean in the impaired ($M = 82.92$, SD $= 12.15$) and borderline groups ($M = 83$, SD $= 10.85$), but not in the normal language group ($M = 91.11$, SD $= 9.28$); the differences between the subgroups on the repetition of nonsense words was not significant ($F(2, 28) = 1.77$). Vocabulary varied as would be expected, with the impaired group falling more than one standard deviation below the mean ($M = 75.43$, SD $= 11.8$), the borderline group were about one standard deviation below the mean ($M = 86.65$, SD $= 10.24$), and normal group fell in the average range ($M = 103.95$, SD $= 14.16$). These differences were highly significant ($F(2, 41) = 19.45$, $p < .0001$).

Thus, even among the children able to complete a more comprehensive language battery, most of whom had non-verbal IQ scores within the normal range (31/44 had non-verbal IQs above 80), a significant proportion of children with autism were impaired in their language skills. The pattern of impairment found for this higher functioning group mirrored what was found across the full range of IQ: articulation skills remain relatively spared, but impairments are found in vocabulary, higher order use of semantic and syntactic knowledge, and in the ability to repeat nonsense words. At the same time, it is important to note that across the full sample of children in this study, there were five children, two of whom were aged below 7 years, whose language skills, across all the measures, were well within the normal range.

DISCUSSION

The goals of this study were to explore the range of language abilities among a large group of children with autism, varying in age and IQ level. Unlike previous research in this area, this study included a broad range of standardised measures of language, and profiles of language skills were derived from a comparison of standard scores across a range of phonological, lexical, and higher order semantic and syntactic measures. One of the main findings from this study was that there is a very wide range of language abilities found among children with autism, across the IQ spectrum, confirming what has already been noted in the clinical literature (Lord & Paul, 1997). Indeed, it is striking that only about half the children in this study were able to complete all the language measures that were included; a small number were not even able to reach a basal on the simplest measure of word naming or comprehension. We return to an analysis of this heterogeneity later in the discussion.

One question that we set out to address was whether expressive language abilities are relatively more spared among children with autism than receptive abilities, as has been reported in some other studies (e.g., Bartak et al., 1975; Tsai & Beisler, 1984). We were careful to make comparisons of standard scores on tests that had been normed on the same samples of children, to eliminate possible sources of differences due to test differences rather than domain differences in the children. Our main findings were that children with autism show no receptive-expressive differences in vocabulary knowledge, thus confirming the more recent findings of Jarrold et al. (1997). We did find that expressive abilities were higher on the CELF, but this was mostly due to the children's better performance on the Formulating Labels subtest, which is a single word-naming measure. Most other expressive and receptive subtests on the CELF tap higher order knowledge of semantics and syntactic knowledge that entail integration across language domains and have a significant working memory component. On these subtests there were no differences between receptive and expressive levels of performance, suggesting that in general, verbal children with autism do not show a major discrepancy between their receptive and expressive language skills.

Although we only compared receptive and expressive abilities within tests that were normed on the same sample, it is not clear whether this kind of comparison is especially useful because children's performance on structured tests reflects not only linguistic knowledge, but also a variety of other test-dependent variables. These include attentional factors, understanding the pragmatic demands of the task, and understanding the instructions. These kinds of variables are not equivalent across different tasks, so differences in performance on receptive and expressive tests may reflect test-related factors, rather than linguistic processing.

Across the full range of children in this study, we found a significant relationship between IQ and language abilities, especially as measured by vocabulary tests. Not surprisingly, only the children with higher IQ scores were able to complete the full range of language tests that were administered, and in general, the children with higher IQ scores had better language abilities overall. Thus, IQ itself accounts for some of the heterogeneity found in language among children with autism. At the same time it is important to note that among lower IQ children, some had language skills within the normal range, and among high IQ children, many had language skills in the impaired range. Thus, language skills can be independent of IQ in autism, and may in fact be more important in understanding both the current functioning and long-term prognosis for children with this disorder (Ventner et al., 1992).

There were some children, about 10% of the sample, who were unable to reach a basal on even the most basic language test (the vocabulary and articulation tests). Although it is not clear in each case why the children could not complete the test, in general it seemed that they had great difficulty understanding the task demands. These children tended to repeat the examiner's utterance, or perseverate across stimulus items. Some children would not attend to the examiner or the stimulus materials, and some exhibited severe behaviour problems that interfered with the testing. These difficulties highlight some of the limitations of using standardised tests to assess language in children with autism (Tager-Flusberg, 2000).

In order to understand the profiles of language skills across the range of children in this study, we looked at subgroups that were defined on the basis of those children whose performance on one of the major language measures (either the PPVT or CELF), was within the normal range, and those who fell more than one or two standard deviations below the mean. These divisions parallel the method taken in the SLI literature in defining children with this disorder. In general this approach indicated that there was a group of children representing about one quarter of the whole group participating in this study (22 children) with essentially normal language skills (see Figure 1). Thus deficits in language skills are not universal in autism, although they are found in the majority of children with this disorder. This contrasts with the universal impairments that are found in communication skills in this population, and which are among the defining features of autism (Tager-Flusberg, 1996). Because our participants were not selected on the basis of an unbiased population-based sample, we cannot provide exact estimates for the proportion of children with autism who have either normal language, as defined in this study, or have significant linguistic impairments. It is likely that we are underestimating the proportion of impaired children, given that our sample was biased in favour of children with some language skills.

Interestingly, we did not find significant differences between the younger (defined as below age 7) and older children in this study in the numbers of children unable to complete the tests (see Table 3). Thus, the kinds of test-related problems that interfered with obtaining a basal score on the standardised tests did not change as the children got older. On the other hand, this may reflect a bias in the sample, in that our recruitment for children at the younger ages may have stressed the need for some spontaneous language. For the subgroup analysis that was conducted on the children who did complete the CELF, the impaired group included relatively more younger than older children: 54% compared to 38%. Table 4 also shows that the scores on the Preschool CELF (given to the younger children) were lower than the CELF III. It is not clear whether these differences reflect genuine differences in language abilities of younger children with autism, or whether they reflect test differences. There were differences in the numbers of children who completed the CELF at the different age levels, 56% of the younger children, compared to 41% of the older children. So it is possible that the subtests on Preschool version of the test are simpler to understand than the subtests on the CELF III, thus allowing more children to complete them. The problems with interpreting the differences between the different age groups reflects some of the limitations inherent in using standardised tests, especially with autistic children who are likely to be more prone to test-taking variables than other populations, on whom these tests were normed.

Among the children whose language was defined as borderline (more than one standard deviation below the mean) or impaired (more than two standard deviations), systematic profiles were found across language domains. For the children who were able to complete the language battery, we found that vocabulary skills were higher than knowledge of syntax and semantics, as measured by the CELF (see Table 5). Although one must be cautious in comparing across these different tests, this finding does not replicate the results reported by Jarrold et al. (1997) who argued that vocabulary and grammatical skills (also measured on different tests, with different norms) were equivalent in children with autism. The differences between our studies may be related to a number of factors including the sample of children participating, the language tests used, and the methods for investigating language profiles. Because we created our profiles on the basis of standard scores, rather than age equivalents, our approach avoids the problems of comparing across non-equal growth rates in the language tests (cf. Mervis & Robinson, 1999). The profiles presented in Figure 2 do suggest that among children with normal language skills, vocabulary is equivalent to semantic and syntactic knowledge; it may be that Jarrold et al. (1997) included more of these children in their study. However, among children with autism with lower language abilities (either borderline or impaired), vocabulary tends to be relatively less impaired compared to higher order linguistic knowledge.

Our profile analysis confirmed earlier studies suggesting that articulation skills, as measured here by the Goldman–Fristoe, are almost always spared in this population (e.g., Boucher 1976), despite severe deficits in vocabulary, semantic, and grammatical knowledge. In contrast, however, we found that in children with low vocabulary and CELF scores, children with autism also were impaired on a nonsense word repetition test. This finding is somewhat surprising given what has been observed regarding the echolalic abilities in children with autism. However, unlike tests of articulation skill, and echolalic language, the Repetition of Nonsense Words test does not depend on rote memory skills. Instead, it requires the child to analyse the acoustic and phonetic properties of the speech stream to derive the phonological representation, and hold the representation of the segments in working memory in order to reproduce them in a motor programme. Our findings suggest that children with autism who have impaired language as measured on tests of vocabulary and higher order syntax and semantics, also have difficulty with this kind of phonological test.

The profile of language performance found among the children with autism who have borderline or impaired language abilities mirrors what has been reported in the literature on SLI. Thus, studies of children with SLI, who are defined on the basis of the PPVT and/or an omnibus test such as the CELF, suggest that this language disorder is characterised by poorer performance on tests of grammatical ability than vocabulary (e.g., Rice, 1999; Tomblin & Zhang, 1999). Furthermore, children with SLI, even when they have good articulation skills, show systematic difficulties on tests of non-word repetition (Bishop, North, & Donlan, 1996; Dollaghan & Campbell, 1998; Gathercole & Baddeley, 1990). This pattern of deficits has been viewed as defining the phenotype of SLI (Tager-Flusberg & Cooper, 1999).

What is the significance of this SLI profile of language impairment that characterises a subgroup of children with autism? On the one hand, the parallels in language deficits may simply be superficial—that is, the language deficits in autism are fundamentally different from those in SLI, despite the similarity in profiles we have found. On the other hand, it may be that these similarities suggest something deeper that may be in common in SLI and a subgroup of autism. We would like to claim that our profile analysis may be taken as evidence for theoretically significant overlap between these disorders. Although, by definition, SLI may not be diagnosed in children who meet criteria for autism, in fact, our data suggest that some children with autism may have a parallel or overlapping SLI disorder, as indicated by their pattern of impaired performance on diagnostic language measures. Support for this argument may be derived not simply for the language data we have presented here, but also from evidence in the literature on the genetics of autism and SLI.

Autism and SLI are complex genetic disorders that have very high heritability estimates, based on family and twin studies (for recent reviews, see Santangelo & Folstein, 1999; Tomblin & Zhang, 1999). Both disorders are thought to be caused by the interaction of several genes, and family studies have found that relatives of identified probands often have only parts of the syndrome (referred to as the 'broader phenotype'). Interestingly, among family members of probands with autism, there are significantly elevated rates of documented histories of language delay and language-based learning deficits (Bolton et al., 1994; Fombonne, Bolton, Prior, Jordan, & Rutter, 1997; Piven & Palmer 1997), and co-twins discordant for autism often have language deficits resembling what has been found in SLI children (Folstein & Rutter, 1977). Among family members of SLI probands, there are elevated rates of language disorder and reading difficulties (Tomblin, Freese, & Records, 1992). More recently, Hafeman and Tomblin (1999) found a significantly elevated risk of autism among siblings of SLI probands. Thus, these family studies of autism and SLI suggest that there is significant overlap between these disorders. Although no specific gene has yet been identified as the cause of either autism or SLI, genetic studies of both disorders have shown linkage to the *same* region on the long arm of chromosome 7 (Fisher, Vargha-Khadem, Watkins, Monaco, & Pembrey, 1998; The International Molecular Genetic Study of Autism Consortium, 1998).

The cumulative evidence from both family and genetic linkage studies suggests that autism and SLI may involve one or more shared genes, arguing strongly for biological overlap between these disorders. The findings presented in this paper, suggesting parallels between the language phenotype of SLI and the profile of language impairment found in a subgroup of children with autism, are complemented by the data from genetic studies. This hypothesis, of overlapping or shared genetics and phenotypic characteristics among families with SLI and autism, clearly requires further research. Genetic studies are needed to pinpoint the specific gene or genes on 7q associated with these disorders; and epidemiological studies are needed to identify what proportion of the autistic population in fact shares the SLI language profile.

Further research is needed to replicate and extend the findings reported here on the SLI profile found among a subgroup of children with autism. The next steps should include a wider range of language measures than those reported in this paper. In particular, we have highlighted numerous limitations in the use of standardised tests for assessing language profiles in children with autism, including the difficulties encountered by some children in understanding the demands of the tests, and difficulties comparing performance across different tests. Standardized tests also do not allow for fine-grained analyses of specific items that may cause problems for children with autism, or for separating out task demands and processing difficulty from deficits in linguistic knowledge. Future research should complement data collected from standardized tests with analyses of natural language samples, and experimental probes (Tager-Flusberg, 2000) in investigations of language impairment among children with autism.

Our findings suggest that some children with autism also show the pattern of language deficits that defines SLI, which can be independent of IQ. What are the implications of these findings for considering the *specificity* of SLI? Is it possible that other children with neurodevelopmental disorders also show the same language profile as our language-impaired children with autism, and children with SLI? If so, this suggests that SLI may not be so specific, but can be found in different groups of language disordered individuals. To address these issues future studies will need to investigate the neurocognitive mechanisms underlying language processing in children with SLI, autism and perhaps other disorders, in much greater detail than we have done thus far. Such studies will help to advance our understanding of language disorder across a range of children, at both the clinical and theoretical level.

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