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Do individuals with high functioning autism have the IQ profile associated with nonverbal learning disability?

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Abstract

Previously researchers have noted a high level of occurrence of the IQ profile associated with nonverbal learning disability (NLD) in Asperger syndrome (ASP) but not in high functioning autism (HFA). We examined the IQ profile scores of a large sample of children (n = 69) and adults (n = 77) with HFA, stringently diagnosed according to ADOS, ADI-R, and DSM-IV criteria, and a corresponding sample of typical child (n = 72) and adult controls (n = 107). At least one of the three primary components of the Wechsler pattern seen in NLD were found in 17–26% of the children and 20–32% of the adults with HFA. All three components occurred in slightly more than 5% of the children and adults with autism. Overall, the VIQ > PIQ profile seen in NLD occurred in 18% of the sample of individuals stringently diagnosed with HFA. Therefore, obtaining this IQ profile is not a valid clinical discriminator between NLD and HFA.

Keywords

Autism; Nonverbal learning disability; Asperger syndrome; Wechsler intelligence scales

Individuals with high functioning autism (HFA), Asperger syndrome (ASP), and nonverbal learning disability (NLD) are all described as having difficulties in making sense of and navigating the social environment, resulting in interpersonal awkwardness (Frith, 2003; Rourke, 1989; Volkmar & Klin, 2000). In addition to problems with social functioning, all three disorders are characterized by right hemisphere language impairments such as difficulty understanding figurative language, sarcasm, and humor as well as abnormalities in prosody, facial expression, gaze, gesture, and body language (Ellis, Ellis, Fraser, & Deb, 1994; Jolliffe & Baron-Cohen, 1999; Ozonoff & Miller, 1996; Rourke & Tsatsanis, 2000; Sabbagh, 1999). The overlaps in the behavioral presentation of these three disorders create a challenge for diagnosticians.

Differentiating between the disorders is further complicated because the means by which the diagnoses of HFA, ASP, and NLD are established are different. HFA and ASP are behaviorally defined syndromes determined on the basis of agreed upon diagnostic criteria (DSM-IV; APA,

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1994; ICD-10, 1993). Structured research diagnostic instruments have been developed that operationalize these criteria and provide reliability and validity of diagnosis across sites. The diagnostic instruments consider developmental course and current expression across many domains and, in so doing, distinguish the autism spectrum disorders from other psychiatric and developmental disorders. The cognitive and neuropsychological basis of behavior was defined for HFA once the diagnosis was established with these instruments (Joseph & Tager-Flusberg, 2002; Minshew, Goldstein, & Siegel, 1997; Williams, Goldstein, & Minshew, 2006). Similar work has been completed with individuals with ASP (Klin, Volkmar, Sparrow, Cicchetti, & Rourke, 1995; Manjiviona & Prior, 1999).

In contrast, NLD was identified as a learning disability of the right hemisphere on the basis of its neuropsychological profile (Weintraub & Mesulam, 1983). Impairments in visuospatial and arithmetic abilities are one aspect of this profile and result in a Verbal IQ score that is 10 points or more higher than the individual's Performance IQ score (Rourke, 1989, 1995). Rourke and various collaborators elaborated on this syndrome with extensive studies that demonstrated a specific pattern of neuropsychological assets and deficits. Briefly, this pattern includes bilateral tactile-perceptual and coordination deficits, substantially deficient visuospatial abilities, deficits in novel problem solving and concept formation, poor mechanical arithmetic, and well-developed rote verbal capacities. Behavioral descriptions commented on deficient social perception and judgment, interaction verbosity of a repetitive nature, and problems in adapting to novel situations (Rourke & Tsatsanis, 2000).

Whether or not the cognitive and social skill behaviors associated with NLD are identical to those exhibited by individuals with HFA or ASP remains to be determined. Descriptions certainly suggest similarities in presentation, and prior reports establish sufficient overlap as to require investigation and clarification with important clinical implications. NLD has a better outcome for function, as impairments are limited to the right hemisphere. In addition, the inattention to left space, visuospatial disability, general spatial disorientation, and arithmetic disability associated with NLD result in adaptive impairments that are not commonly encountered in HFA or ASP. They require conscious awareness but are amenable to remediation through the use of cognitive strategies.

Clinicians have found it challenging to differentiate between these disorders during the diagnostic process. Whereas Rourke has provided a fuller description of NLD syndrome (Rourke & Tsatsanis, 2000) that goes beyond a pattern of IQ scores, it has been our experience that, in clinical practice, many clinicians diagnose an individual with a significant developmental social impairment without psychosis as having NLD or ASP rather than HFA whenever they obtain an IQ profile that is consistent with that of NLD or even simply a Verbal IQ that is greater than the Performance IQ. According to this practice, given similar behavioral presentations, a diagnosis of autism is assigned when a PIQ greater than VIQ profile is obtained and a diagnosis of ASP or NLD is assigned when a VIQ greater than PIQ profile is obtained. At this point, the Wechsler profile becomes diagnostic rather than descriptive. Assumptions about the relationship between an IQ profile and a particular developmental disorder have influenced clinical practice, even when the research data supporting these assumptions remains slim.

A related assumption has been that individuals with autism universally have relative strengths on the Block Design and Arithmetic subtests of the Wechsler Intelligence Scales (Shah & Frith, 1993; Siegel, Minshew, & Goldstein, 1996). Therefore, when clinicians obtain lowered scores in these areas, they consider it as evidence of a disability other than autism, e.g., ASP or NLD. However, this profile is not diagnostic, as low scores on Block Design and Arithmetic relative to other intellectual abilities have been reported to occur in individuals with autism with IQs ≥ 80 (Mayes & Calhoun, 2003; Minshew, Turner, & Goldstein, 2005).

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A limited number of previous studies have compared the profile of IQ scores in ASP and HFA. In a study of 21 children and young adults with ASP and 19 with HFA, Klin et al. (1995) reported that VIQ was higher than PIQ for all of the participants with ASP whereas no VIQ–PIQ discrepancy occurred for the individuals with HFA. Thus, the cognitive profile in ASP was similar to what is found in NLD. However, a slightly different result was reported with different ASP/HFA samples. In a comparison of the IQ profiles of 22 males with ASP and 12 males with HFA, Ghaziuddin and Mountain-Kimchi (2004) found that 82% of the ASP group had a VIQ higher than PIQ with 10 of these having a 10 point discrepancy between the scores; however, 50% of the participants with HFA also had a higher VIQ than PIQ profile, suggesting that this VIQ–PIQ relationship was not unique to ASP but also occurred in individuals with HFA. Both of these studies had relatively small ASP and HFA groups. Therefore, it would be helpful to examine the VIQ–PIQ relationship in a much larger sample of individuals with HFA to further ascertain the distribution of VIQ > PIQ profiles in HFA.

The purpose of this study was to examine how often the NLD constellation of VIQ > PIQ and low Arithmetic and Block Design subtest scores on the Wechsler Intelligence Scales was present in individuals rigorously diagnosed with HFA. A comparison ASP group was not examined, as the results of prior studies consistently reported a high occurrence of a higher VIQ than PIQ for individuals with ASP. A second purpose of this study was to evaluate the “stereotype” of the person with HFA as having exceptional arithmetic AND exceptional visuospatial abilities by ascertaining how often individuals in the sample with HFA have low Arithmetic or low Block Design scores relative to their Vocabulary scores.

1. Method

1.1. Participants

Participants with autism consisted of two groups: 69 children (ages 6–16 years) and 77 adults (ages 17–53 years). All were high functioning (FS and VIQ ≥ 70). The samples were formed using strict diagnostic criteria. Participants met criteria for autism on the Autism Diagnostic Interview (ADI or ADI-R) (Lord, Rutter, & LeCouteur, 1994) and for autism (not autism spectrum) on the Autism Diagnostic Observation Schedule (ADOS) (Lord et al., 1989, 2000). Examiner reliability in the administration and scoring of these instruments was established through ongoing training and consultation with developers of these instruments. The diagnosis of autism was verified by expert clinical evaluation in accordance with DSM-IV (APA, 1994) criteria and accepted clinical descriptions of high functioning autism. All participants with autism had evidence of abnormal development before the age of 3 years. Potential subjects were excluded if found to have an associated cause for autism such as tuberous sclerosis or fragile-X syndrome.

Two control groups with typical development were used: 72 children (ages 6–16 years) and 107 adults (ages 17–53 years) that did not differ significantly from the respective autism group in age, VIQ, or FSIQ. Controls were community volunteers recruited through advertisements in neighborhoods with the same socioeconomic level as the families of origin of the participants with autism. They were pre-screened by completing a questionnaire on demographic information and family and personal history of medical, neurological, and psychiatric disorders. Inclusion criteria were good physical health, no regular medication use, and good peer relationships based on parent or self-report and staff observations during eligibility testing. Exclusion criteria for controls were a current or past history of neurological or psychiatric disorder, premature birth, a developmental cognitive disorder, learning disability, poor school attendance, or family history in first-degree relatives of developmental cognitive disorders, mood and anxiety disorders, and autism in first-, second-, and third-degree relatives. It should be noted that because of the use of exclusionary criteria, the sample of controls was not random and was not representative of the general population. This group allowed for the examination of the occurrence of IQ profiles in individuals who did not have any previous clinical diagnosis. Demographic data for all groups are presented in Table 1.

All participants were recruited through the Subject Core of the University of Pittsburgh Collaborative Program of Excellence in Autism funded by the National Institute of Child Health and Human Development. Institutional Review Board approval was obtained for the study. Procedures were fully explained to all participants and to their parents or guardians. Written informed consent was obtained from participants or their parents or guardians and written assent was obtained from the children.

1.2. Procedure

The child participants completed the core subtests of the Wechsler Intelligence Scale for Children-Revised (WISC-R: Wechsler, 1974) or the Wechsler Intelligence Scale for Children-III (WISC-III; Wechsler, 1991). The adult participants completed the core subtests of the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) or the Wechsler Adult Intelligence Scale-III (WAIS-III; Wechsler, 1997). For the participants who received the WISC-III (Wechsler, 1991) or WAIS-III (Wechsler, 1997), the additional subtests available in those protocols were not used in the analyses. The Revised and Third Edition versions of the Wechsler tests were combined based on the presence of substantial item overlap and reports of substantial correlations between versions in the case of both children and adults (Wechsler, 1991, 1997). To verify this assumption we applied Mantel's *Z*, to directly compare the correlation matrices of the WAIS-R to the WAIS-III, and the WISC-R to the WISC-III (Mantel, 1967). Mantel's *Z* tests the hypothesis that there are no associations between the elements in two correlation matrices. Significant results suggest that the matrices are similar to each other. For both the adult and child versions of the Wechsler scales, Mantel's *Z* was significant (adult versions: $r = .63$, $Z= 16.18$, $g = 3.46$. $p = .001$; child versions: $r = .55$, $Z = 9.83$, $g = 2.87$, $p = .007$), suggesting the matrices were similar to each other.

Three decision rules were applied to operationalize the absence/presence of the NLD profile: (1) the Performance IQ score had to be more than or equal to 15 points lower than the Verbal IQ score; (2) the Arithmetic subtest scaled score had to be at least three points lower than the Vocabulary scaled score; and (3) the Block Design subtest scaled score had to be at least three points lower than the Vocabulary scaled score. The decisions rules developed by Rourke for the determination of NLD differ somewhat from these, particularly by requiring only a 10 point VIQ > PIQ difference (Drummond, Ahmad, & Rourke, 2005; Pelletier, Ahmad, & Rourke, 2001). However, a 10–12 point difference is within the confidence limits for these scores on these instruments. For this reason, we used 15 points to define a clinically significant difference. Previous studies comparing individuals with NLD to those with other clinical diagnosis have operationally defined NLD using the Wechsler scales (Petti, Voelker, Shore, & Hayman-Abello, 2003; Worling, Humphries, & Tannock, 1999). Therefore, application of these rules was thought to be capable of producing profiles consistent with what has been reported in previous NLD studies while providing a practical method for examining the presence of the NLD profile in such large participant groups.

The dependent measures for this study were the frequencies with which the profile defined by the three decision rules was observed within each participant group. Percentages of occurrence of these rules were calculated for each child and adult participant group. An analysis was made of the cases demonstrating NLD profiles, as described above, in an effort to determine whether general intelligence or demographic factors were particularly associated with the occurrence of these profiles.

2. Results

The numbers and percentages of cases following the NLD rules are presented in Table 2. Eight (8) of the children and adults with autism (5.5% of the total autism sample) and one (1) of the child controls demonstrated all three of the NLD rules. Thus, whereas small minorities of the autism and control samples demonstrated the rules, they were demonstrated more often in the autism groups. *One of the three components* of the Wechsler NLD profile occurred in 17.4–26.1% of the children and 20.8–32.5% of the adults with autism. In the control groups, one of the three components of the Wechsler NLD profile occurred in 1.4–16.8% of the cases.

To determine the statistical significance of these findings, χ^2 tests were performed, the results of which are presented in Table 3. For the children and adults, there was a significant association between presence or absence of autism and having a Performance IQ score 15 or more points less than the Verbal IQ score. That is, individuals with autism were more likely to have this profile than typical controls. There were also significant associations between group membership and having an Arithmetic score 3 or more points less than Vocabulary and an IQ profile that met all three NLD rules for the adults but not for the children. These results suggest that there is some overlap between the IQ profiles obtained for individuals with autism and the IQ profile that is considered indicative of NLD, and that this profile is more likely to occur in the autism group, particularly adults with autism, than in typical controls. Table 4 presents IQ and demographic data for cases that demonstrated the three rules in the full autism sample. These data indicate that the NLD profiles did not appear with a relatively high frequency at any particular general intellectual, age, or educational level, but rather occurred across the full spectrum of these variables.

3. Discussion

Some of the individuals who were stringently diagnosed with high functioning autism had an IQ profile that has been associated with NLD. This profile occurred in percentages that exceeded the occurrence in the control samples. Even though the occurrence of all three components of the NLD IQ pattern was rare in individuals with autism – occurring at a rate of slightly more than 5% – it was present. This rate of occurrence argues against the specificity of this IQ profile for NLD. In other words, an individual could have Performance, Verbal, Arithmetic, and Block Design scores that are consistent with the profile associated with NLD and not have NLD. Based on IQ profile alone, a percentage of individuals with the IQ profile associated with NLD would be more accurately diagnosed as having autism.

Examination of the pattern of results on the Block Design subtest indicated that not all individuals with autism have visuospatial abilities that are superior to their verbal abilities. In fact, the rates at which a Block Design greater than Vocabulary score pattern occurred in the children and adults with autism in this study was similar to the occurrence of this pattern in the child and adult controls with typical development. A small subgroup of individuals with stringently diagnosed HFA had visuospatial skills inferior to their verbal abilities. In the case of HFA, the presence of intact or better spatial-constructional skills accompanied by less well developed verbal comprehension has been so well established (Minshew, Goldstein, Muenz, & Payton, 1992; Rumsey, 1992), it is understandable that exceptions may not be considered. This study has documented that such exceptions are compatible with a diagnosis of autism. This result is consistent with an earlier examination of IQ profiles in HFA that indicated that, whereas a pattern demonstrating a lower Verbal than Performance IQ with lowest individuals' subtests scaled scores on Comprehension and highest scaled scores on Block Design was frequently found in individuals with autism, numerous other patterns were also apparent (Siegel et al., 1996). A single, prototypic IQ profile that characterizes all individuals with autism does not exist.

Another commonly held assumption about individuals with HFA is that arithmetic is an area of strength and not a deficit (Minshew et al., 1992). However, for the individuals that participated in this study, about 25% of the children and adults had Arithmetic subtest scores that were at least one standard deviation less than their Vocabulary subtest scores. That suggests that when verbal individuals with autism are seen clinically, almost one in four will present with relatively poor arithmetic skills. The expectation that all individuals with high functioning autism will have savant like strengths in arithmetic is an overgeneralization. Therefore, the presence or absence of strength in arithmetic should not be used to support or refute a diagnosis of autism. Rather, it should become a descriptive feature of the cognitive assets and deficits of that particular individual with autism.

The results of this study suggest that caution should be used when the diagnosis of a developmental disability is based on the presence or absence of a particular profile of IQ scores. Diagnosis of developmental social communication disorders, in the absence of specific laboratory indicators, are probably best made on the basis of clinical phenomenology, utilizing valid and reliable behavioral observation schedules and patient or informant structured interviews. In the case of autism, the most well established instruments are the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) and the Autism Diagnostic Interview (ADI-R; Lord et al., 1994). On the other hand, identification of subtypes of learning disability are best made through assessment of academic skills and associated cognitive abilities. These cognitive profiles describing strengths and weaknesses are of great value in specifying the type of learning disability and also in studying the neurobiology and adaptive functioning associated with various psychiatric and neurobehavioral disorders. However, autism is a neuropsychiatric disorder in which cognitive alterations result in a learning disability with a specific clinical phenomenology. Cognitive profiles do not typically relate to individual specific diagnoses, and as the authors of DSM-IV (APA, 1994) and its predecessors have pointed out, a categorical classification system based upon agreed upon diagnostic criteria is presently the most effective way of diagnosing mental disorders consistently and with high reliability. As in other mental disorders, notably schizophrenia, there is little overlap between a particular cognitive profile and the presence of the disorder. Thus, there has been little success in identifying a prototypic cognitive profile for schizophrenia (Seaton, Goldstein, & Allen, 2001), although it can be reliably diagnosed using DSM criteria. Poor performance on Performance IQ subtests should not overrule the diagnosis of autism that has been established with clinical instruments developed for this purpose. Rather such variations should be considered descriptive of that individual's particular cognitive abilities. In fact, these individual variations may be indicative of differences in neurobiological correlates of autism that should be further explored to shed light on this persistently enigmatic disorder.

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References

American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 4. Washington, DC: American Psychiatric Association; 1994.

Drummond CR, Ahmad SA, Rourke BP. Rules for the classification of younger children with Nonverbal Learning Disabilities and Basic Phonological Processing Disabilities. Archives of Clinical Neuropsychology 2005;20:171–182. [PubMed: 15708727]

Ellis HD, Ellis DM, Fraser W, Deb S. A preliminary study of right hemisphere cognitive deficits and impaired social judgments among young people with Asperger syndrome. European Child and Adolescent Psychiatry 1994;3(4):255–266.

Frith, U. Autism: Explaining the enigma. 2. Oxford: Blackwell Publishers; 2003.

Ghaziuddin M, Mountain-Kimchi K. Defining the intellectual profile of Asperger syndrome: Comparison with high functioning autism. Journal of Autism and Developmental Disorders 2004;34:279–284. [PubMed: 15264496]

Jolliffe T, Baron-Cohen S. A test of central coherence theory: Linguistic processing in high-functioning adults with autism or Asperger syndrome: Is local coherence impaired? Cognition 1999;71:149–185. [PubMed: 10444907]

Joseph RM, Tager-Flusberg H. Cognitive profiles and social-communicative functioning in children with autism spectrum disorder. Journal of Child Psychiatry and Psychology 2002;43:807–821.

Klin A, Volkmar FR, Sparrow SS, Cicchetti DV, Rourke BP. Validity and neuropsychological characterization of Asperger syndrome: Convergence with nonverbal learning disabilities. Journal of Child Psychology and Psychiatry 1995;36:1127–1140. [PubMed: 8847376]

LeCouteur A, Rutter M, Lord C, Rios P, Robertson S, Holdgrafer M, et al. Autism diagnostic interview: A standardized investigator based instrument. Journal of Autism and Developmental Disorders 1989;19:363–389. [PubMed: 2793783]

Lord C, Risi S, Lambrecht L, Cook E, Leventhal B, DiLavore P, et al. The Autism Diagnostic Observations Schedule-Generic: A standard measure of social and communication deficits associated with autism spectrum disorder. Journal of Autism and Developmental Disorders 2000;30:205–223. [PubMed: 11055457]

Lord C, Rutter M, Goode S, Heemsbergen J, Jordan H, Mawhood L, et al. Autism diagnostic observation schedule: A standardized observation of communicative and social behavior. Journal of Autism and Developmental Disorders 1989;19:185–212. [PubMed: 2745388]

Lord C, Rutter M, LeCouteur AL. Autism diagnostic interview-revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. Journal of Autism and Developmental Disorders 1994;24:659–685. [PubMed: 7814313]

Manjiviona J, Prior M. Neuropsychological profiles of children with Asperger syndrome. Autism 1999;3:327–356.

Mantel N. The detection of disease clustering and a generalized regression approach. Cancer Research 1967;7:209–220. [PubMed: 6018555]

Mayes SD, Calhoun SL. Analysis of WISC-IH, Stanford-Binet:IV, and academic achievement test scores in children with autism. Journal of Autism and Developmental Disorders 2003;33:329–341. [PubMed: 12908835]

Minshew NJ, Goldstein G, Muenz LR, Payton JB. Neuropsychological functioning in nonmentally retarded autistic individuals. Journal of Clinical and Experimental Neuropsychology 1992;14:749–761. [PubMed: 1474143]

Minshew NJ, Goldstein GG, Siegel DJ. Neuropsychologic functioning in autism: Profile of a complex information processing disorder. Journal of the International Neuropsychological Society 1997;3:303–316. [PubMed: 9260440]

Minshew NJ, Turner CA, Goldstein G. The application of short forms of the Wechsler Intelligence Scales in adults and children with high functioning autism. Journal of Autism and Developmental Disorders 2005;35:45–52. [PubMed: 15796121]

Ozonoff S, Miller JN. An exploration of right-hemisphere contributions to the pragmatic impairments of autism. Brain and Language 1996;52:411–434. [PubMed: 8653388]

Pelletier PM, Ahmad SA, Rourke BP. Classification rules for basic phonological processing disabilities and nonverbal learning disabilities: Formulation and external validity. Child Neuropsychology 2001;7:84–98. [PubMed: 11935416]

Petti VL, Voelker SL, Shore DL, Hayman-Abello SE. Perception of nonverbal emotion cues by children with nonverbal learning disabilities. Journal of Developmental and Physical Disabilities 2003;15:23–36.

Rourke, BP. Nonverbal learning disabilities: The syndrome and the model. New York: Guilford Press; 1989.

Rourke, BP. Syndrome of nonverbal learning disabilities: Neurodevelopmental manifestations. New York: Guilford Press; 1995.

Rourke, BP.; Tsatsanis, K. Nonverbal learning disabilities and Asperger syndrome. In: Klin, A.; Volkmar, FR.; Sparrow, SS., editors. Asperger syndrome. New York: Guilford Press; 2000. p. 231-253.

Rumsey, JM. Neuropsychological studies of high-level autism. In: Schopler, E.; Mesibov, GB., editors. High-functioning individuals with autism. New York: Plenum Press; 1992. p. 41-64.

Sabbagh MA. Communicative intentions and language: Evidence from right-hemisphere damage and autism. Brain and Language 1999;70:29–69. [PubMed: 10534371]

Seaton BE, Goldstein G, Allen DN. Sources of heterogeneity in schizophrenia: The role of neuropsychological functioning. Neuropsychology Review 2001;11:45–67. [PubMed: 11392562]

Shah A, Frith U. Why do autistic individuals show superior performance on the block design task? Journal of Child Psychology and Psychiatry 1993;34:1351–1364. [PubMed: 8294523]

Siegel DJ, Minshew NJ, Goldstein G. Wechsler IQ profiles in diagnosis of high-functioning autism. Journal of Autism and Developmental Disorders 1996;26:389–406. [PubMed: 8863091]

Volkmar, FR.; Klin, A. Diagnostic issues in Asperger syndrome. In: Klin, A.; Volkmar, FR.; Sparrow, SS., editors. Asperger syndrome. New York: Guilford Press; 2000. p. 25-71.

Wechsler, D. Wechsler intelligence scale for children-revised. New York: Psychological Corporation; 1974.

Wechsler, D. Wechsler adult intelligence scale-revised. New York: Psychological Corporation; 1981.

Wechsler, D. Wechsler intelligence scale for children. 3. San Antonio, TX: The Psychological Corporation; 1991.

Wechsler, D. Wechsler adult intelligence scale. 3. San Antonio, TX: Psychological Corporation; 1997.

Weintraub S, Mesulam MM. Developmental learning disabilities of the right hemisphere. Emotional, interpersonal, and cognitive components. Archives of Neurology 1983;40:463–168. [PubMed: 6870605]

Williams DL, Goldstein G, Minshew NJ. Neuropsychologic functioning in children with autism: Further evidence of disordered complex information processing. Child Neuropsychology 2006;12:279–298. [PubMed: 16911973]

World Health Organization. International classification of diseases: Tenth revision. Geneva: World Health Organization; 1993.

Worling DE, Humphries T, Tannock R. Spatial and emotional aspects of language inferencing in nonverbal learning disabilities. Brain and Language 1999;70:220–239. [PubMed: 10550228]

Table 1

Demographic and psychometric data

	Autism group (n = 69)		**Control group (n = 72)**		***T***	***P***
	Mean	**S.D.**	**Mean**	**S.D.**		
Children						
Age	11.08	2.95	11.76	2.99	1.37	.17
Education (years)	5.01	3.05	5.85	3.06	1.56	.12
Verbal IQ	103.65	14.77	103.75	8.90	0.05	.96
Performance IQ	101.43	12.92	102.69	8.21	0.69	.49
Full scale IQ	102.68	12.88	103.35	8.26	0.37	.71
	Autism group (n = 77)		Control group (n = 107)		*T*	*P*
	Mean	S.D.	Mean	S.D.		
Adults						
Age	28.12	9.99	26.92	9.41	0.83	.41
Education (years)	13.00	2.29	14.11	2.20	3.25	.001
Verbal IQ	104.65	17.06	104.47	12.51	0.08	.93
Performance IQ	96.27	13.18	104.10	13.36	3.95	.00
Full scale IQ	100.99	14.92	104.64	13.24	1.75	.08

Table 2

Numbers and percentages of cases demonstrating NLD rules

Rule	Autism children	Control children	Autism adults	Control adults
Arithmetic ≥ 3 points < vocabulary	*n* = 18, 26.1%	*n* = 10, 13.9%	*n* = 19, 24.7%	*n* = 10, 9.3%
Block design ≥ 3 points < vocabulary	*n* = 13, 18.8%	*n* = 11, 15.3%	*n* = 16, 20.8%	*n* = 18, 16.8%
Performance IQ ≥ 15 points < verbal IQ	*n* = 12, 17.4%	*n* = 1, 1.4%	*n* = 25, 32.5%	*n* = 3, 2.80%
All 3 rules	*n* = 4, 5.8%	*n* = 1, 1.4%	*n* = 4, 5.2%	*n* = 0, 0%

Table 3

χ^2 values for associations between autism or control group membership and presence of the NLD rules

	χ^2	**df**	***p***
Children			
Arithmetic ≥ 3 points < vocabulary	3.29	1	.070
Block design ≥ 3 points < vocabulary	.317	1	.574
Performance IQ ≥ 15 points < verbal IQ	10.78	1	.001
All 3	2.00	1	.157
Adults			
Arithmetic ≥ 3 points < vocabulary	7.93	1	.005
Block design ≥ 3 points < vocabulary	.47	1	.495
Performance IQ ≥ 15 points < verbal IQ	30.23	1	.000
All 3	5.63	1	.018

Table 4

Age, education, and IQ data for autism participants demonstrating the three NLD rules

	Arithmetic ≥ 3 points < vocabulary (*n* = 37)		Block design ≥ 3 points < vocabulary (*n* = 29)		Performance IQ ≥ 15 points < verbal IQ (*n* = 37)	
	Mean/range	**S.D.**	**Mean/range**	**S.D.**	**Mean/range**	**S.D.**
Age (years)	21.25/7–48	12.02	19.78/8–36	8.69	21.36/6–52	10.75
Education (years)	9.66/2–17	4.78	10.48/2–19	4.56	10.71/1–20	4.72
Full scale IQ	100.92/80–127	11.85	102.45/84–127	12.25	105.97/79–136	13.42