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Language Abilities are Associated with Both Verbal and Nonverbal Intelligence in Children on the Autism Spectrum

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Abstract

Intellectual abilities factor into levels of functioning used to characterize autism. Language difficulties are highly prevalent in autism and may impact performance on measures of intellectual abilities. As such, nonverbal tests are often prioritized in classifying intelligence in those with language difficulties and autism. However, the relationship between language abilities and intellectual performance is not well characterized, and the superiority of tests with nonverbal instructions is not well established. The current study evaluates verbal and nonverbal intellectual abilities in the context of language abilities in autism and the potential benefit of tests with nonverbal instructions. Participants were 55 children and adolescents on the autism spectrum who underwent a neuropsychological evaluation as part of a study examining language functioning in autism. Correlation analyses were performed to examine relations between expressive and receptive language abilities. Language abilities (CELF-4) were significantly correlated with all measures of both verbal (WISC-IV VCI) and nonverbal intelligence scores (WISC-IV PRI and Leiter-R). There were no significant differences between nonverbal intelligence measures with verbal or nonverbal instructions. We further discuss the role of assessment of language abilities in interpreting results of intelligence testing in populations with higher prevalence of language difficulties.

Keywords

autism; language abilities; verbal intelligence; nonverbal intelligence; IQ

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Introduction

A core feature of autism is substantial and pervasive deficits in communication. In particular, linguistic and intellectual disabilities in early childhood predict adaptative behavior in adults with autism (Gillespie-Lynch et al., 2012). However, the extent to which verbal and nonverbal intelligence are related to language abilities in autism remains poorly understood. Indeed, communicative difficulties in this population are often dissociable from other abilities, including intellectual functioning (Hofvander et al., 2009). This gap in our understanding is perhaps due to the fact that traditional intelligence assessments rely heavily on verbal confirmation and verbal instructions to administer the task. Assessments of intellectual functioning may also require the participant to comprehend verbal directions and produce verbal responses. This is even the case for many measures of nonverbal intelligence (Grondhuis & Mulick, 2013).

Indeed, many nonverbal intelligence tests still have high linguistic demands. For example, assessments such as the Wechsler family of tests (Wechsler, 2002, 2003, 2008, 2014), the Differential Abilities Scales (Elliot, 2007; Elliott, 1990), and the Stanford-Binet (SB; Roid, 2003; Terman & Merrill, 1937; Terman & Merrill, 1960; Thorndike et al., 1986) rely on the comprehension of verbal instructions and the production of verbal responses. It is interesting to note that tasks like Matrix Reasoning (MR) from the Wechsler family of tests (Wechsler, 2002, 2003, 2008, 2014) are considered a measure of nonverbal reasoning (Massa & Rivera, 2009) despite the fact that instructions are delivered verbally. In the case of individuals on the autism spectrum, it is likely that communication difficulties (a diagnostic criterion of autism) influence participant performance on linguistically demanding tasks. Specifically, language disability may limit one’s ability to employ the verbal mediation strategies that their typically developing peers have at their disposal to complete these tasks (Larson et al., 2020).

To mitigate these issues, the Leiter International Performance Scale (Roid & Miller, 1997) was designed as a nonverbal analog to the SB. Instructions for the Leiter do not require examinees to understand verbal instructions or respond using verbal signals. Rather, the Leiter is administered through pantomime, and the examinee responds by selecting response cards through pointing gestures (DeThorne & Schaefer, 2004; Roid et al., 2003; Roid & Koch, 2017). Given that the Leiter does not rely on verbal comprehension or production, some researchers propose that the Leiter may be a more appropriate estimate of intellectual functioning for individuals with known speech or language difficulties (Athanasiou, 2000). Indeed, Grondhuis and Mulick (2013) found that scores on the Leiter-R (Roid & Miller, 1997) were, on average, 20.91 points higher than SB5 scores (Roid, 2003) in children and adolescents on the autism spectrum. Further, when only the nonverbal composite score of the SB5 was compared to the Leiter-R, scores on the Leiter-R were still 16.72 points higher (Grondhuis & Mulick, 2013). The observed differences in performance on various measures of intellectual functioning (e.g., the Leiter-R, the SB, and the Wechsler family of tests) in individuals on the autism spectrum warrant further investigation.

Understanding the moderating effect of language abilities on measures of intellectual functioning is critical for evaluating autism and other conditions associated with language difficulties. To this end, we aimed to assess the relations between receptive and expressive language abilities and verbal and nonverbal intellectual performance on two separate measures of intelligence. Specifically, we examined associations between language, measured via the Comprehensive Evaluation of Language Fundamentals-4th Edition (CELF-IV; Semel et al., 2003), and verbal and nonverbal intellectual abilities, measured via the Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV; Wechsler 2003) and the Leiter-R (Roid & Miller, 1997), in children and adolescents on the autism spectrum. In line with previous findings (Bölte et al., 2009; Giofrè et al., 2019; Grondhuis & Mulick, 2013; Nader et al., 2016), we hypothesized that children and adolescents on the autism spectrum would score significantly higher on nonverbal than verbal measures of intellectual abilities. We also hypothesized that language abilities would be significantly associated with performance on verbal intelligence scores. Given that the WISC-IV has greater linguistic demands than the Leiter-R, we hypothesized that the association between nonverbal intelligence and receptive language skills would be significantly stronger for the WISC-IV than the Leiter-R in children and adolescents on the autism spectrum. With regards to intelligence measures and specific language abilities, we hypothesized that there would be significant positive correlations between nonverbal measures of intelligence (Leiter-R and PRI) and receptive but not expressive language skills.

Materials and Methods

Participants were 55 children and adolescents, ages six years to 16 years, who underwent a neuropsychological evaluation as part of a study examining language functioning in autism (R01 HD051747). Participants were recruited via community posting and referrals from hospital clinics at an academic research institute in the Southwestern United States and an academic medical center in the Midwestern United States. Participants younger than six or older than 16 and individuals diagnosed with Fragile-X, Tuberous Sclerosis, or any known comorbid neurological conditions were excluded. All participants met the criteria for a DSM-IV-TR diagnosis of Autistic Disorder ($n = 36$), Asperger's Syndrome ($n = 14$), or Pervasive Developmental Disorder—Not Otherwise Specified (PDD-NOS; $n = 5$) informed by the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1989) and the Autism Diagnostic Interview-Revised (ADI-R; Lord et al., 1994). Diagnostic group assignment and data collection were confirmed through consensus diagnosis by a neuropsychology team under the supervision of a licensed clinical neuropsychologist. Data were collected over 3-4 testing appointments. The study was approved by the *[masked; affiliation #5 on title page]* Human Research Review Committee.

Intelligence Testing

Intellectual abilities were assessed using the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV; Wechsler 2003). Age-corrected Verbal Comprehension Index (VCI) scores were used as a measure of verbal intelligence, and Perceptual Reasoning Index (PRI) scores were used as a measure of nonverbal intellectual abilities administered via verbal delivery of instructions. A Full-Scale Intelligence Quotient (FSIQ) on the Leiter International Performance Scale, Revised (Leiter-R; Roid & Miller, 1997), was added at a later point in the study to measure nonverbal intellectual abilities administered via nonverbal delivery of instructions. The Leiter-R tasks are administered via pantomimed instructions and require pointing or matching rather than verbal responses.

Language Abilities

The Clinical Evaluation of Language Fundamentals, Fourth Edition (CELF-4; Semel et al., 2003) is a comprehensive battery of tests designed to assess the core components of language abilities, including Receptive Language Index (RLI) and Expressive Language Index (ELI) scores. The RLI includes performances from tasks focused on the ability to categorize words and understand relations between words based on semantic meaning, follow verbal directions and comprehend spoken language. The ELI measures performance on structured tasks of sentence formation, word structure, and verbal repetition. The two indices are scored as age-corrected standard scores based on a normative sample.

Data Analysis

To test the hypothesis that nonverbal intelligence would significantly differ from verbal intelligence and, consequently, from general intelligence, paired-sample *t*-tests were performed. Bivariate Pearson correlation analyses were performed to test the hypotheses that in individuals on the autism spectrum, (1) expressive (ELI) and receptive language abilities (RLI) would be associated with performance on verbal intelligence measures (VCI); (2) receptive, but not expressive language abilities will associate with nonverbal measures of intellectual abilities (Leiter-R and PRI); and (3) scores on tests with verbal instructions (PRI) will correlate more strongly with receptive language abilities (RLI) than those with non-verbal instructions (Leiter-R). Correlation coefficients were transformed to Fisher's z and comparisons were made using *z*-test of independent proportions.

Results

Of the 55 participants, 51 completed both the CELF-4 and WISC-IV (i.e., Subsample 1) and 26 completed both the CELF-4 and the Leiter-R (i.e., Subsample 2). Participant characteristics are presented in Table 1 (by subsample). Twenty-two participants completed all measures. Compared to Wechsler FSIQ scores, Leiter-R FSIQ scores were significantly higher; however, neither PRI nor VCI scores significantly differed from Leiter-R FSIQ scores (Table 2).

Associations Between Language and General Intellectual Abilities

Table 3 includes the correlation matrix between CELF-IV, WISC-IV, and Leiter-R FSIQ. Scatterplots of these relationships are presented in Figure 1.

The correlation coefficient for the relation between CELF-4 RLI and the Leiter-R FSIQ was identical to that of CELF-4 RLI and WISC-IV PRI ($r = .78$, $p < .001$). Two-tailed *z*-test of independent proportions on Fisher's z-transformed correlation coefficients indicated no significant difference ($z = .181$, $p = .856$) between the relations of CELF-4 ELI with the Leiter-R FSIQ ($r = .71$, $p < .001$) or the WISC-IV PRI ($r = .73$, $p < .001$).

Discussion

Our results indicated that nonverbal IQ was significantly higher than verbal IQ in individuals on the autism spectrum, consistent with prior research demonstrating greater scores on non-nonverbal compared to verbal tests in this population (Bölte et al., 2009; Giofrè et al., 2019; Grondhuis & Mulick, 2013; Nader et al., 2016). However, expressive and receptive language abilities were associated with both verbal and nonverbal intelligence scores, with no significant difference in the strength of relations for verbally (WISC-IV) or nonverbally (Leiter-R) delivered instructions. These associations (see Table 3) likely stem from the strong correlation between expressive and receptive language abilities.

Alternative explanations may consider the utilization of verbal mediation strategies even when performing on nonverbal tasks, consistent with previous research reporting reduced use of verbal mediation for cognitive tasks in individuals on the autism spectrum with language disability (Larson et al., 2020). While it cannot be considered its direct measurement, expressive language abilities conceptually facilitate verbal mediation processes (whether vocally or internally expressed). Thus, difficulties with expressive language would theoretically make verbal mediation more difficult and subsequently less effective in approaching nonverbal tasks. This would suggest that individuals with difficulties with expressive language are selectively disadvantaged on nonverbal tasks, while language-intact peers potentially benefit from the use of verbal mediation.

As receptive language was significantly associated with all measures of intelligence, an understanding of its relationship with intelligence can be illustrated by focusing on the early developmental period. If one's receptive language is poor, their learning is limited by what they can understand, inhibiting the development of intellectual abilities. This could also explain why the measurement of intellectual abilities in very young children is relatively unstable compared to postlingual intellectual assessment in autism (Lord & Schopler, 1989).

These robust relations of language abilities with IQ raise the question of how much weight is appropriate to place on language in the assessment of "intelligence," particularly given the highly verbal world in which we live. Indeed, Duncan and Bishop (2015) found small significant correlations between adaptive functioning and FSIQ in autism and noted that the relations strengthen as FSIQ decreases. Further examination of associations between different measures of intelligence with varying language loadings and adaptive functioning could offer some guidance in increasing these tests' utility for clinical decision-making. For example, more robust associations between adaptive functioning and measures of intelligence with lower language loadings would highlight a need to minimize the impact of language abilities in the measurement of IQ or, at least, prioritize the use of tests with weaker associations with language. This is easily illustrated in the case of difficulties with expressive language abilities associated with motor speech disabilities (e.g., a motoric limitation to verbal expression in the absence of intellectual disability following a stroke). The same could be true for developmental motor speech disability, where VCI cannot capture overall intellectual abilities.

Nevertheless, our data suggest that language abilities are strongly linked to both verbal and nonverbal intelligence as they are currently defined by widely used measures. Examination of performance differences on the WISC-IV FSIQ compared to the Leiter-R FSIQ indicates that while there are significant FSIQ differences, WISC-IV PRI did not significantly differ from the Leiter-R FSIQ score. This could suggest that the WISC-IV provides a comparable characterization of non-verbal intelligence to that offered by the Leiter-R while also providing information about verbal intellectual abilities (via WISC-IV VCI), which may have functional impacts on independence and adaptive skills. Similar findings have been reported by Giofrè et al. (2019), who found that WISC-IV FSIQ was substantially lower compared to the Leiter-3 FSIQ (*Mean difference* = 17.8, $p < .001$), while PRI and Leiter-3 scores did not significantly differ (*Mean difference* = 2.2, $p = .131$; Giofrè et al., 2019). Notably, the difference we observed between the WISC-IV FSIQ and Leiter-R FSIQ was 7 points smaller than what Giofrè et al. (2019) observed with the Leiter-3 FSIQ, which may reflect dissimilarities between Leiter-R and the Leiter-3 or sample differences (e.g., 18% female in Giofrè et al. versus 25.4% in our sample). Interestingly, Grondhuis and Mulick (2013) observed an even greater difference in FSIQ between the Leiter-R and the SB5 in children and adolescents on the autism spectrum (*Mean difference* = 20.91, $p < .001$). However, they also found the Leiter-R scores to be significantly greater than the SB5 nonverbal domain (*Mean difference* = 16.72, $p < .001$). Rather than suggesting substantial differences between the SB5 nonverbal domain and the WISC-IV PRI, which might contradict previous findings (Baum et al., 2015), age differences likely account for this discrepancy; Grondhuis and Mulick (2013) used a sample of 3-12 years old children on the autism spectrum, while both our sample and that of Giofrè et al. included children 6-16 years of age. Although they did not report age effects on the difference between the SB5 nonverbal domain and the Leiter-r, they noted that the preschool-aged children had a much greater difference in FSIQ (*Mean difference* = 28.56 points) than the elementary school-aged children (*Mean difference*= 16.58). Similar contrasts have yet to be examined in the WISC-V and Leiter-3, as the WISC-V has restructured the measurement of non-verbal intelligence, now offering separate Visual Spatial and Fluid Reasoning indices. If intelligence tests with stronger associations to language correlate better with adaptive skills or other relevant clinical outcomes, language might prove an integral component of intelligence. In such a case, minimizing the impact of language abilities on the measurement of intelligence could be construed as overestimating IQ. The utility of IQ in making specific clinical recommendations is limited, without information about other cognitive abilities and adaptive functioning. In terms of informing best practice for assessing IQ in individuals on the autism spectrum, future research should examine relations between IQ, language, and adaptive functioning toward the aim of discerning whether these associations represent a measurement confound versus an intrinsic component of language or other prerequisite skill for the development of intelligence.

These findings highlight the importance of considering the impact of an individual's language ability on the interpretation of other standardized test results, including intelligence tests. The scatterplots indicate that the associations identified in this study are not driven by low IQ scores or other generalized disabilities in individuals with low language scores, but rather, these relationships are represented across a continuum of language and IQ scores.

While language difficulties and intellectual disability can certainly co-occur, treatment providers must also consider that individuals with challenges in language may not be able to fully demonstrate their abilities on traditional IQ tests, even when IQ measures are considered “nonverbal.” While the limitations that impact these test scores may also have practical implications in daily life, and thus, these scores may be necessary for documenting these limitations and accessing services, it is important for providers to be aware of the limits of their interpretation of a person’s ability, particularly with regard to the abilities of individuals with significant motor disabilities or other non-cognitive barriers to communication. Alongside the adverse consequences of not adequately documenting a disability, there is also the risk of underestimating a person’s potential when abilities are determined by approaches to testing that may not allow the examinee to fully demonstrate them.

Our study had several limitations. One of the hallmark symptoms of autism is difficulties with overall social communication, which can impact test performance (e.g., interfering with children’s ability to understand testing expectations) and result in lower IQ scores (e.g., Oliveras-Rentas et al., 2012). As language is a critical component of social communication skills in autism (Loucas et al., 2008; Mundy et al., 1987; Yoder et al., 2015), a broader communication disability might account for some of the observed effects of language on IQ in our sample. Future research would benefit from including direct measures of nonverbal communication to better characterize the role of overall communication factors on performance in testing. Furthermore, the observed relations in the current study may exist in other cognitive domains in individuals on the autism spectrum (Rommelse et al., 2015). Future research should evaluate the extent to which neuropsychological testing in autism is sensitive to language abilities to better contextualize and interpret overall results. Participants in this study were primarily white and male, and although consistent with the ethnic/racial demographics of the study’s location (U.S. Census Bureau, 2022), this presents a limitation in generalizing the findings to individuals on the autism spectrum who are female and/or are of different racial/ethnic backgrounds. Future studies targeting those groups who were not well represented in the present study will inform the applicability of these findings to other groups.

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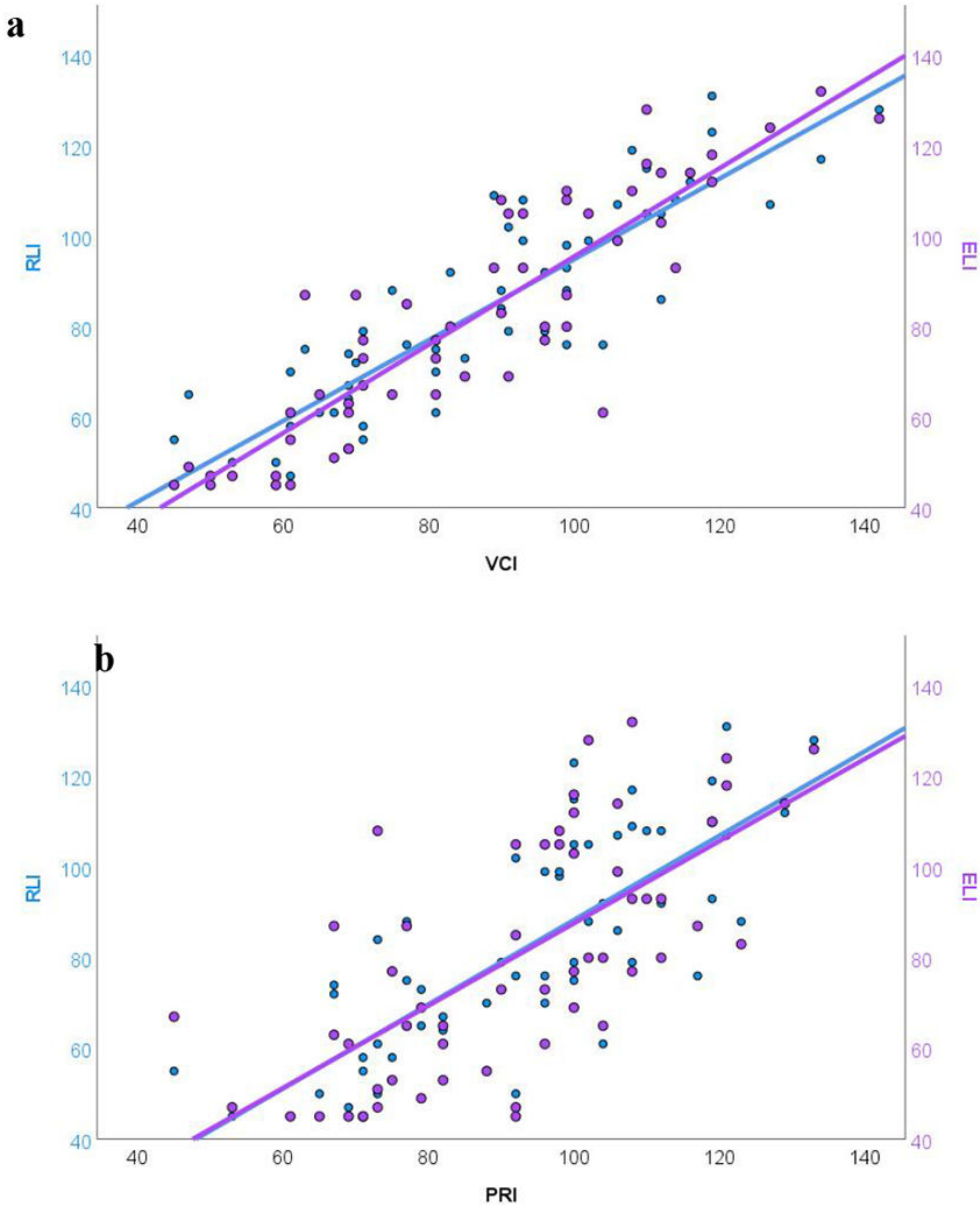
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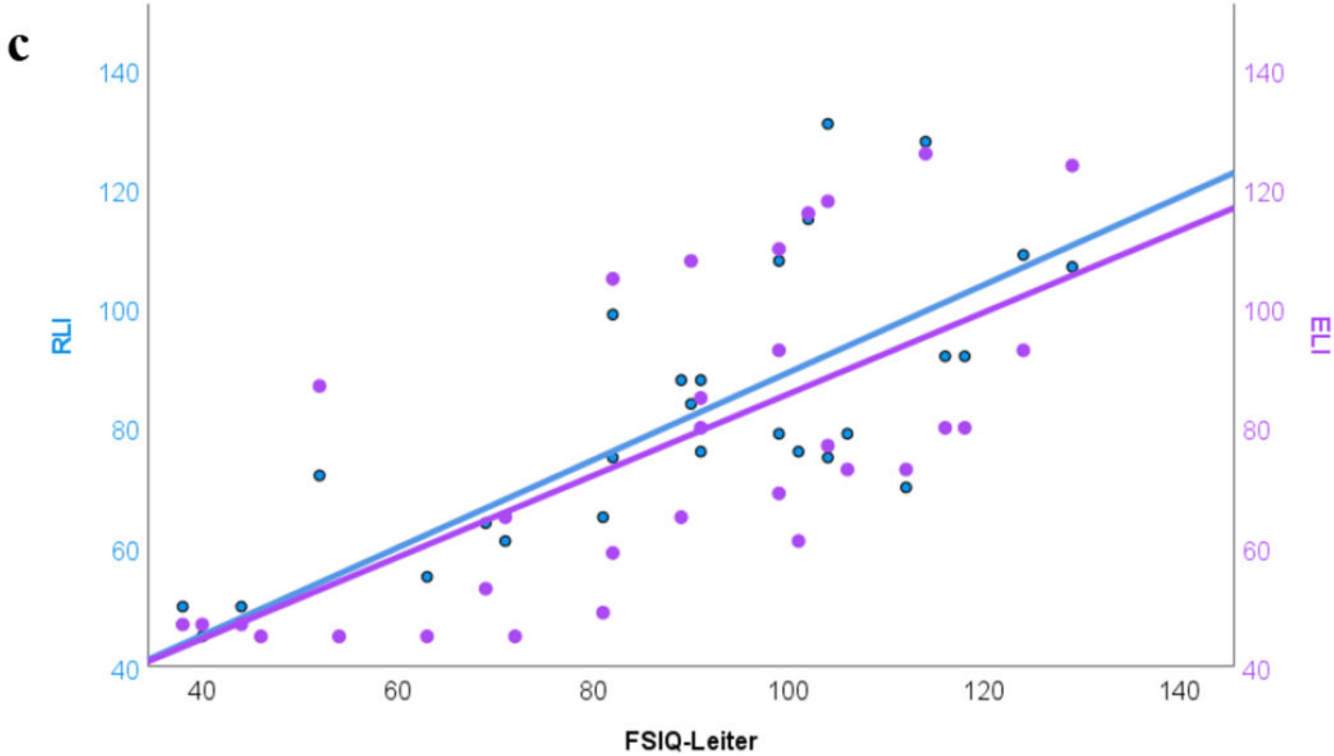

Figure 1:
Correlation scatterplots of Verbal Comprehension Index (VCI; a), Perceptual Reasoning Index (PRI; b), and Leiter-R Full Scale Intelligence Quotient (FSIQ; c) scores with Receptive Language Index (RLI) and Expressive Language Index (ELI) scores.

Table 1:

Participant characteristics

	Subsample 1 (*N* = 51)	**Subsample 2 (*N* = 26)**
Age	10.9 ± 3.0 [6.1-16.7]	10.4 ± 2.6 [6.7-16.7]
ADOS (*M* ± *SD* [range])		
Communication	3.71 ± 2.17 [0-8]	4.38 ± 2.37 [1-9]
Imagination Creativity	**1.02** ± .75 [0-2]	**1.0**4 ± .57 [0-2]
Reciprocal Social	7.53 ± 3.15 [1-14]	8.81 ± 2.97 [2-13]
Stereotyped & Restricted	2.08 ± 1.57 [0-6]	2.69 ± 1.32 [0-6]
ADI-R (*M* ± *SD* [range])		
Criterion A	22.17 ± 4.91 [4-28]	23.24 ± 5.46 [4-29]
Criterion B	16.90 ± 5.30 [3-26]	18.32 ± 5.84 [3-26]
Criterion C	6.23 ± 2.98 [1-12]	5.44 ± 2.79 [2-12]
Criterion D	3.73 ± 1.32 [0-6]	3.76 ± 1.30 [1-5]
CELF (*M* ± *SD* [range])		
CLS	79.3 ± 26.6 [40-130]	71.0 ± 26.0 [40-126]
ELI	79.8 ± 25.5 [45-132]	72.2 ± 26.0 [45-126]
RLI	81.4 ± 23.9 [45-131]	77.2 ± 25.0 [45-131]
WISC-IV (*M* ± *SD* [range])		
FSIQ	82.2 ± 21.8 [46-136]	–
VCI	85.0 ± 23.4 [45-142]	–
PRI	93.1 ± 18.8 [45-133]	–
Leiter-R (*M* ± *SD* [range])		
FSIQ	–	85.7 ± 25.9 [38-124]
Gender [n (%)]		
Male	36 (70.6%)	20 (76.9%)
Female	15 (29.4%)	6 (23.1%)
Race/Ethnicity [n (%)]		
Caucasian	36 (70.6%)	17 (65.4%)
African American	3 (5.9%)	1 (3.8%)
Asian	3 (5.9%)	1 (3.8%)
Hispanic	4 (7.8%)	4 (15.4%)
Multiracial	5 (9.8%)	2 (7.7%)
Other	0 (0%)	1 (3.8%)

Note. Subsample 1 completed the Wechsler intelligence scales; Subsample 2 completed the Leiter-R; in Subsample 1, ADI-R was available in 48 participants.

Abbreviations: ADI-R = Autism Diagnostic Interview, Revised; ADOS = Autism Diagnostic Observation Schedule; CELF = Clinical Evaluation of Language Fundamentals; CLS = Core Language Score; ELI = Expressive Language Index; FSIQ = Full-Scale Intelligence Quotient; PRI = Perceptual Reasoning Index; RLI = Receptive Language Index; VCI = Verbal Comprehension Index; WISC-IV = Wechsler Intelligence Scale for Children, 4^{th} Edition.

Table 2:

Comparisons of Scores Between Different Measures of Intelligence.

	Mean Difference ± Standard Deviation	*t*	*df*	*p*	*Cohen's d*
Leiter-R FSIQ – WISC-IV FSIQ	11.5 ± 16.3	3.304	21	.003	.70
Leiter-R FSIQ – WISC-IV VCI	8.5 ± 20.1	1.988	21	.060	.42
Leiter-R FSIQ – WISC-IV PRI	−2.2 ± 12.2	−.858	21	.400	.18
WISC-IV PRI – WISC-IV VCI	8.0 ± 14.4	4.016	50	<.001	.56

Abbreviations: FSIQ = Full Scale Intelligence Quotient; PRI = Perceptual Reasoning Index; VCI = Verbal Comprehension Index; WISC-IV = Wechsler Intelligence Scale for Children, 4th Edition.

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Table 3:

Correlations IQ scores with receptive and expressive language abilities

		1	2	3	4	5	6
1	CELF-4 ELI						
2	CELF-4 RLI	.91*					
3	WISC-IV FSIQ	.88*	.88*				
4	WISC-IV PRI	.73*	.78*	.89*			
5	WISC-IV VCI	.89*	.88*	.95*	.79*		
6	Leiter FSIQ	.71*	.78*	.73*	.84*	.61*	

* $p < .001$

Note. CELF-4 = Clinical Evaluation of Language Fundamentals-Fourth Edition; ELI = CELF-4 Expressive Language Index; FSIQ = Full-Scale Intelligence Quotient; PIQ = Performance Intelligence Quotient; PRI = Perceptual Reasoning Index; RLI = CELF-4 Receptive Language Index; VCI = Verbal Comprehension Index; VIQ = Verbal Intelligence Quotient; WISC-IV = Wechsler Intelligence Scale for Children, Fourth Edition