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Specific weaknesses of high-functioning autistic children on the Leiter-3 International Performance Scale

Carmen Belacchi[1], *Federico Ferrandes*[1], *Enrico Toffalini*[2] *& Cesare Cornoldi*[2]

Abstract

The assessments of non-verbal intelligence in individuals with Autism Spectrum Disorder (ASD) may be subject to biases. This study compared the scores obtained on the most recent version of the Leiter scale by 18 children with high-functioning ASD and 18 typically-developing controls, who were matched for age, sex, and IQ estimated using the Raven's Coloured Matrices. ASD children performed worse than controls on all virtually subtests and areas of the Leiter-3, including non-verbal IQ, attention-related, and working memory ability. It is suggested that the high degree of social interaction required by the Leiter-3 makes its use problematic for ASD children.

Keywords: Autism; Non-verbal intelligence assessment; Raven's Coloured Progressive Matrices; Leiter-3 scale.

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[1] Department of Communication Sciences, Humanities and International Sciences, University of Urbino Carlo Bo, Italy.
[2] Department of General Psychology, University of Padova, Italy.

Correspondence to: Carmen Belacchi, Department of Communication Sciences, Humanities and International Sciences, University of Urbino Carlo Bo, Via Saffi, 15 - 61029 Urbino (PU), Italy. Phone: 0722305813; Fax: 0722305812; E-mail: carmen.belacchi@uniurb.it.

1. Introduction

Assessing intelligence is crucial to understanding neurodevelopmental disorders. Indeed, a key diagnostic consideration is a disorder's degree of specificity, that is to say, whether it affects overall cognitive functioning, as in the case of intellectual disabilities (American Psychiatric Association, 2013), or if it only compromises certain cognitive abilities while preserving general intellectual functioning, as in specific learning disorders (see for example, Cornoldi, Giofrè, Orsini, & Pezzuti, 2014; Giofrè, Toffalini, Altoè, & Cornoldi, 2017; Toffalini, Giofré, & Cornoldi, 2017a, 2017b). Practitioners around the world draw on a range of intelligence tests to inform such diagnostic judgments.

In typical populations, different measures yield broadly similar outcomes. Indeed, normative scores on the most widely used intelligence tests are highly consistent with one another, as borne out by concurrent validity analyses conducted as part of the standardization procedures for these instruments, as in the case of WISC-IV (Wechsler, 2003).

The assessment of intelligence is also essential for children with Autistic Spectrum Disorder (ASD) in order to bring to light their potential and build the appropriate educational and life plans. Intelligence testing is typically required (DSM-5) to verify whether ASD is associated with intellectual disability (American Psychiatric Association, 2013), as appears to be for approximately 70% of persons with ASD (Fombonne, 2012). Nonetheless, the prevalence of intellectual impairment in ASD individuals has been the object of much debate and conflicting findings (Wignyosumarto, Mukhlas, & Shirataki, 1992; Baird, Simonoff, Pickles, Chandler, Loucas, & Meldrum, 2006; Fombonne, 2012; Williams, Siegel, & Mazefsky, 2018). Such contradictory outcomes may be accounted for by differences between populations, but also by differences between the tests used to evaluate intelligence in children with ASD (Nader, Courchesne, Dawson, & Soulières, 2016).

Indeed, there is growing evidence that, in the case of ASD, outcomes vary greatly as a function of measurement tool (see Charman, Pickles, Simonoff, Chandler, Loucas, & Baird, 2011; Soulières, Dawson, Gernsbacher, & Mottron, 2011; Barbeau, Soulières, Dawson, Zeffiro, & Mottron, 2013; Bodner, Williams, Engelhardt, & Minshew, 2014). This is due to the peculiar characteristics of individuals with ASD, who fail to meet the typical demands of many, though not all, intelligence tests. The key area of weakness emphasized in the relevant literature (Dawson, Munson, Webb, Nalty, Abbott, & Toth, 2007; Bodner *et al.*, 2014; Nader *et al.*, 2016) is verbal ability, given that the batteries mainly used to assess intelligence, such as the Wechsler and Stanford-Binet scales, rely primarily on language.

As a consequence, some authors have recommended the use of non-verbal measures of intelligence, and specifically the Raven's and Leiter tests, with ASD children, focusing on their non-verbal intellectual skills (see Mayes & Calhoun, 2003a, 2003b, for a discussion). The various versions of the Leiter test (see Tsatsanis, Dartnall, Cicchetti, Sparrow, Klin, & Volkmar, 2003) would appear to be particularly useful, because besides evaluating non-verbal intelligence, they allow draw information from multiple sources thanks to the batteries of different tasks included. The most recent edition of the Leiter test, namely the Leiter-3 (Roid, Miller, Pomplun, & Koch, 2013), and its standardized Italian version (Cornoldi, Giofré, & Belacchi, 2016) is of great interest in this context, because it is completely non-verbal (the subject receives instructions and responds by means of physical gestures only), relatively easy to administer, and includes no measures of verbal intelligence, verbal working memory or verbal processing speed, abilities that are frequently compromised in ASD.

The current evidence suggests that children with ASD may perform better on the Leiter tests than on classical intelligence batteries. For example, Grondhuis and Mulick (2013) reviewed the hospital records of 47 ASD children aged between 3 and 12 years. All participants had completed both the Leiter International Performance Scale Revised (Leiter-R) (Roid & Miller, 1997) and Stanford-Binet Intelligence Scales, 5th Edition (SB5) (Roid, 2003). Overall, the sample scored significantly higher on the Leiter-R than on the SB5 (with a mean discrepancy of 20.91 points), and this gap in performance was even more marked in the younger children.

Similarly, Giofrè, Provazza and Angione (2017) administered both the WISC-IV and the Leiter-3 (methodologically superior and easier to administer than earlier versions of the same instrument) to a sizable sample of children with ASD. They found that both overall IQ and domain scores for the two batteries were strongly correlated. However, global IQ scores based on the WISC-IV were on average 20 points lower than those yielded by the Leiter-3, suggesting that the former measure is at risk of underestimating the intellectual potential of children with ASD, particularly those presenting with low-functioning autism.

However, using the Leiter-3 battery with ASD children presents drawbacks of its own. First, to obtain an IQ estimation, four subtests must be administered (i.e., Figure Ground, Form Completion, Classifications and

Analogies, and Sequential Order): because these subtests are significantly different from one another in nature, they may represent different levels of difficulty for individuals with ASD; at the same time, they all require social interaction, observation of the examiners' non-verbal behaviors (including in some cases focusing on his/her face and eyes), and in some instances even imitation of these behaviors, all large demands for children with ASD. As is well known, a common symptom of ASD is difficulty in interacting with others face to face (on possible explanations for this phenomenon see: Dalton, Nacewicz, Johnstone, Schaefer, Gernsbacher, Goldsmith *et al.*, 2005; Dawson, Webb, & McPartland, 2005; Luna, Doll, Hegedus, Minshew, & Sweeney, 2007). Hence, it may be particularly challenging for young children with ASD to carefully observe an examiner with a view to interpreting his or her instructions, or to maintain their levels of attention throughout a string of subtests, especially during the varied and highly complex tasks making up the Classification Analogies subtest.

In the present study, we investigated whether the Leiter-3 battery poses particular difficulty for ASD individuals by administering the instrument to both a group of children who had been diagnosed with ASD and a control group of typically developing (TC) children matched for intelligence on Raven's CPM scale, another non-verbal instrument that requires significantly less interaction than the Leiter (Raven, Court, & Raven, 1990; Italian standardization by Belacchi, Scalisi, Cannoni, & Cornoldi, 2008). The Leiter-3 battery (Cornoldi *et al.*, 2016) includes other non-verbal subtests (Attention Sustained; Forward Memory; Attention Divided; Reverse Memory; Non-verbal Stroop), on the basis of which two additional non-verbal indexes are calculated, namely non-verbal Working Memory Index (WMI) and Processing Speed Index (PSI). Unlike in the WISC-IV, these indexes are not included in the estimate of global IQ. Again, the literature reports mixed findings in relation to the quality of ASD individuals' executive functions, including working memory and processing speed (assessed in the current study via the Leiter-3 WMI and PSI subtests). For example, Goldberg, Mostofsky, Cutting, Mahone, Astor, Denckla *et al.* (2005) did not find significant weaknesses in the executive functioning of a group of children (aged 8-12 years) diagnosed with high-functioning autism. Furthermore, children with ASD seem to be particularly good at the Stroop task (see also Hill, 2004), probably due to the fact that, having a preference for local processing (e.g., Cardillo, Mammarella, Garcia, & Cornoldi, 2017), they are less affected by global context. Nevertheless, procedural issues may also cause bias in research outcomes. For example, Adams and Jarrold

(2009) found that lower reading comprehension affects Stroop interference in children with ASD, potentially leading to inaccurate conclusions about inhibition in these children. However, the corresponding Leiter-3 subtest, similarly to the WMI and PSI subtests and the Leiter-3 battery in general, demands careful observation of the examiner, which we might also expect to cause particular difficulty for children with ASD.

2. Method

2.1. Participants

Participants were 18 Italian children who had received a diagnosis of high-functioning ASD from expert clinicians on the basis of CARS2-ST and ADOS criteria, and 18 control subjects matched for age ($t_{(34)}$ = -.75, p = .46; range: [56, 159] months in ASD, [65, 138] months in controls), Raven's IQ ($t_{(34)}$ = -.68, p = .50; range: [70, 128] points in ASD, [88, 126] points in controls), and gender (χ^2 = .18, p = .67). The diagnoses had been provided at one of two specialized centers in the Marche region (Central Italy), namely the Department of Child Neuropsychiatry in Fano and U.M.E.E in Cagli. The typically developing children were attending a primary school in the same geographic area. All children were Italian, with Italian parents. Parental informed consent was obtained for all participants. Table 1 summarizes the demographic characteristics and Raven IQs of the two groups of children.

Table 1 - *Demographic variables and Raven Non-Verbal IQ in the two groups*

	Autism (N = 18)		Control (N = 18)	
	M	*SD*	*M*	*SD*
Males/Females	14/4		15/3	
Age (months)	93.17	28.54	99.72	23.59
Raven CPM (Non-Verbal IQ)	102.39	19.05	105.83	10.12

2.2. Materials and procedure

The Leiter-3 (Cornoldi *et al.*, 2016) intelligence battery and the Raven's CPM scale (Raven *et al.*, 1990; Italian standardization by Belacchi *et al.*,

2008) were administered to all children. About the qualitative aspects of tests' administration, if a child showed some signs of fatigue or a decreasing in motivation, appropriate breaks were made. In the case of ASD children, taking into account their availability to collaborate and their span of attention, two administration sessions were carried out, within a maximum of one week.

The Leiter-3 battery includes both a series of subtests assessing fluid intelligence and a series of subtests evaluating specific cognitive processes (i.e., working memory, attention, and processing speed). The four subtests used to estimate non-verbal IQ are:

1. Figure Ground (FG): Identification of embedded figures, or designs, within a complex stimulus.
2. Form Completion (FC): Recognition of a "whole object" from a randomly displayed array of its fragmented parts.
3. Classification/Analogies (CA): Categorization of objects or geometric designs and analogical reasoning using geometric shapes, including 2 by 2, 4 by 2 and more complex matrices (this subtest is a combination of two subtests from the Leiter-R: Classification and Design Analogies).
4. Sequential Order (SO): Identification of the rule underlying a sequence of related stimuli that progress in a corresponding order on the basis of logical progressions of pictorial or figural objects (this subtest includes several of the classic, original Leiter items).

The cognitive subtests in the battery are: Attention Sustained (AS), Forward Memory (FM), Reverse Memory (RM), Non-verbal Stroop (NVS), and Attention Divided (AD).

Scores were standardized on the basis of age-relevant normative data. In the normative sample, M = 10 and SD = 3 for all subtests, and M = 100 and SD = 15 for the global indices.

3. Results

Table 2 reports descriptive statistics for all variables in the two groups, as well as the between-group comparisons. The dependent variables were Figure ground, Figure completion, Classification/analogies, Sequential order, Sustained attention, Forward memory, Backward memory, Non-verbal Stroop incongruent correct responses, Non-verbal Stroop congruent correct responses, Non-verbal Stroop effect, Sustained attention errors, Divided attention correct responses, Divided attention errors.

Table 2 - *Descriptive statistics for the Leiter-3 subtests and indices (standardized scores) in the two groups*

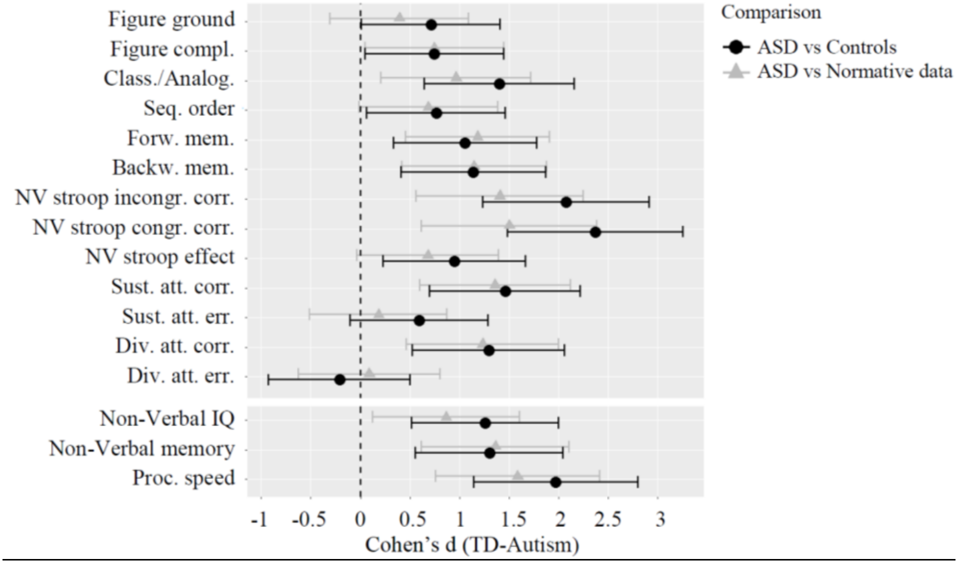
	Autism (N = 18)		Control (N = 18)	
	M	*SD*	*M*	*SD*
Leiter-3 subtests				
Figure ground	8.78	3.19	10.78	2.37
Figure compl.	7.89	2.63	9.78	2.41
Class./Analog.	7.33	2.50	10.78	2.41
Seq. order	7.89	3.14	10.11	2.65
Forw. mem.	6.78	2.41	9.06	1.86
Backw. mem.	6.78	2.60	9.50	2.15
NV stroop incong. corr.	6.00	2.68	11.28	2.40
NV stroop cong. corr.	6.00	2.28	11.22	2.13
NV stroop effect	7.61	3.94	10.72	2.44
Sust. att. corr.	6.06	2.80	9.50	1.82
Sust. att. error	9.50	2.41	10.78	1.86
Div. att. corr.	6.12	3.28	9.50	1.82
Div. att. err.	9.73	2.91	9.22	1.93
Leiter-3 indices				
Non-Verbal IQ	87.28	14.39	102.61	9.42
Non-Verbal memory	80.11	14.22	96.44	10.62
Processing speed	76.33	14.82	103.06	12.15

As shown in the last three lines in Table 2, the ASD group's standardized scores on the global measures of intelligence, memory, and processing speed fell far below the average standardized scores of 100 and below the scores of the TD control group. Specifically, the mean non-verbal IQ of the ASD group was 87.28 (*SD* = 14.39) compared to 102.61 (*SD* = 9.42) in the control group. Furthermore, among the four subtests, the difference in performance was especially large for the Classification/Analogies subtest.

The effects of Group and Raven's IQ were simultaneously examined at the multivariate level using a MANOVA model. There were three missing data observations for Divided attention (correct responses and errors) in the ASD group, so this variable was examined separately. At the multivariate level, the standardized Leiter-3 subtest scores were significantly predicted by Group, approximate $F_{(1,33)} = 9.77$, $p < .001$, Pillai's trace = .82, and Raven IQ scores, approximate $F_{(1,31)} = 7.77$, $p < .001$, Pillai's trace = .79. This shows that a between-group difference in the Leiter-3 scores remained after controlling for the effect of Raven's IQ scores (which were not significantly different between groups, however).

With regard to Divided attention correct responses and errors, we found a significant multivariate effect of Group, approximate $F_{(1,30)} = 6.32$, $p = .005$, Pillai's trace = .30, but not of Raven's IQ, approximate $F_{(1,30)} = 1.45$, $p = .25$, Pillai's trace = .09.

Figure 1 - *Standardized differences between children with ASD and matched controls (black points) or the normative data (gray triangles) in all Leiter-3 subtests and indices*



Note: Positive values indicate worse performance in children with ASD as compared to typically-developing children. Error bars represent the 95% confidence intervals of the standardized differences.

Figure 1 reports Cohen's d effect sizes for between-group comparisons of all variables. We compared the ASD group with both the TD group and the normative data. As shown, the ASD group performed worse than both control and standardization groups and Cohen's *d* was particularly high (close to 1.5) in the case of the Classification/Analogies subtest. Concerning the other tests in the battery, the ASD group generally obtained lower scores, with the exception of the error measures, where the ASD scores were only slightly lower than (Attention Sustained) or even equal to (Attention Divided) those of the control group.

4. Discussion

Assessing the intellectual functioning of children with ASD can help to design age-appropriate intervention procedures that take specific strengths and weaknesses into account. However, a crucial problem is that different tests can yield markedly different outcomes, leading to either overestimation or underestimation of these children’s potential cognitive functioning.

When it comes to assessing intelligence in ASD, non-verbal tests have frequently been recommended on the grounds that they do not rely on verbal communication, typically an area of weakness for children with ASD. This would make a purely non-verbal procedure yielding a measure of non-verbal IQ, such as the Leiter-3 test, seem appropriate. Indeed, it has been observed that subjects with ASD score higher on the Leiter-3 than on the classic IQ test, WISC-IV. However, the Leiter-3 may also pose challenges for children with ASD, given that completing it demands basic competencies that children with ASD may not have mastered. In particular, the test involves social interaction, requiring the examinee to continuously attend to the examiner’s behaviors and instructions, and this may penalize individuals with ASD.

Consistently with this line of argument, in the present study young children with high-functioning autism performed significantly more poorly than matched control subjects on almost all the Leiter-3 subtests, whether measuring fluid intelligence or executive function. However, this difference was particularly marked for some subtests. Concerning the intelligence battery in particular, the ASD group displayed a lesser deficit on the Figure ground, Figure completion, and Sequential order subtests. These subtests require a type of problem-solving that is focused on a specific object at hand, a characteristic that they share, to some extent, with the Raven CPM test (on which the ASD group was successful). On the contrary, the performance of the ASD group was markedly weaker on the Classification/Analogies subtest, in which careful observation of the examiner is very important.

Differently from other studies, the children with ASD also performed badly in a series of executive tasks, but it is possible that their performance here was affected by the same factors that undermined their intellectual performance. In fact, the ASD group performed relatively better on the Divided Attention test, where they obtained low scores for accuracy but also made few errors, an outcome that might be explained by the fact that this subtest is demanding but repetitive and involves analyzing a stimulus. It should be noted that, in contrast with this finding, high error scores on the AD subtest are often observed in atypical populations, as observed by Roid *et al.*, (2013, p. 57): “Even more than the AD correct score, the AD incorrect score is more evidence for a response pattern similar to atypical respondents (TBI, Autism, severe ADHD)”.

Clearly, this data requires further corroboration in the form of replication and convergent evidence in support of the tentative explanations put forward here. The limitations of the current study include the small size of the ASD group, its peculiar age range (it seems that older children may behave differently from younger ones, as suggested by the work of Giofrè *et al.*, 2017), and the fact that no other tests were administered. The limited sample size, in particular, makes it difficult to be establish whether and to what extent the ASD group performed more poorly in certain areas, especially when differences were modest. Despite these limitations, the study offers interesting preliminary data on the performance of individuals with ASD on non-verbal tests of intelligence and suggests that we should be cautious about drawing conclusions about the cognitive functioning of children with autism based on a limited set of test. Lastly, our results on high functioning ASD individuals do not allow generalizations to the entire population with ASD.

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