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The discrepancy between verbal and visuoperceptual IQ in children with a specific learning disorder: An analysis of 1624 cases

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ABSTRACT

Children with a specific learning disorder (SLD) are often characterized by marked intellectual strengths and weaknesses. In the last few years, research has focused on a common discrepancy between low working memory and processing speed on the one hand, and high verbal and visuoperceptual intelligence on the other. SLD profiles featuring a specific discrepancy between verbal and visuoperceptual abilities have been only marginally considered, however, and their systematic comparison vis-à-vis typically-developing (TD) populations has yet to be conducted. The present study examined a dataset of 1624 WISC-IV profiles of children with a diagnosis of SLD. It emerged that the proportion of children with a Verbal Comprehension Index (VCI) at least 1.5 SD (22 standardized points) lower than their scores on the Perceptual Reasoning Index (PRI) was larger than the proportion of SLD children with the opposite discrepant profile; it was also larger than the same proportion found among TD children. Comparing the two discrepant profiles revealed that the children also differed by type of learning difficulty, gender, and performance in the WISC-IV Symbol search task. Further examination suggested that children who were discrepant and also distinctly poor in visuoperceptual intelligence were particularly slow in general processing.

What this paper adds

This paper adds knowledge on the cognitive profiles of individuals with specific learning disorder (SLD). Recent research has suggested that children with SLD show greater heterogeneity within their intellectual profiles than the typically-developing (TD) population, as shown using the Wechsler scale, for example (WISC-IV; Wechsler, 2003). Previous research focusing on children with SLD as a group reported average intellectual profiles characterized by poor working memory and processing speed, but good general (i.e., verbal and nonverbal, or visuoperceptual) intellectual abilities. The issue of discrepancies between the latter two has not been considered in depth, however. In particular, a study on the frequency and the characteristics of children with these profiles within the SLD population has yet to be conducted. The present study takes advantage of a large dataset of intellectual profiles of children with a diagnosis of SLD who were also assessed with the WISC-IV as part of the AIRIPA project. The findings showed that children characterized by a marked verbal-visuoperceptual discrepancy were not only more common in the SLD than in the TD population, but also that they were associated with differences in male-to-female ratios and the frequency of types of SLD (e.g., verbal < nonverbal is more common in dyslexia, and vice versa in dyscalculia). Although a weakness in processing speed characterized most children with SLD, this was especially evident in children with a low perceptual reasoning index. These results contribute to our understanding of the cognitive functioning of children with SLD, and of their variability.

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1. Introduction

Children with a specific learning disorder (SLD) have been described as having more marked intellectual strengths and weaknesses than typically-developing (TD) children. In recent years, the intellectual profiles emerging from the Wechsler Intelligence Scale for Children (WISC-IV; Wechsler, 2003) applied to children with SLD have been analyzed in more depth, considering children with SLD as a single category, as suggested by the DSM-5 (Diagnostic and Statistical Manual of Mental Disorders, 5th edition; American Psychiatric Association, 2013). The WISC-IV scale is composed of 10 core subtests, and offers information on both the full-scale intelligence quotient (FSIQ) and four factorial indexes (Verbal Comprehension [VCI], Perceptual Reasoning [PRI], Working Memory [WMI], and Processing Speed [PSI]). There is debate on the reliability of these factorial indexes beyond what is explained by general intellectual level, as a general factor already accounts for 71.3% of the WISC-IV subtests' shared variance in the general population (Watkins, 2006). This figure drops to 47.9% in the SLD population, however (Styck & Watkins, 2016). In addition, some studies have argued that the four factorial indexes may well reflect the organization of intelligence (Flanagan & Kaufman, 2009) especially in the case of SLD (Giofrè & Cornoldi, 2015; Giofrè, Toffalini, Altoè, & Cornoldi, 2017; Prifitera, Saklofske, & Weiss, 2008).

Previous studies in this line of research reported that most cases of SLD feature a weakness in working memory and processing speed but high scores in both verbal and visuoperceptual reasoning (e.g., Cornoldi, Orsini, Cianci, Giofrè, & Pezzuti, 2013; De Clercq-Quaegebeur, Lemaitre, Bourgois, Getto, & Vallée, 2010; Poletti, Carretta, Bonvicini, & Giorgi-Rossi, 2018). In particular, many children with SLD seem to score high on the "general ability" index (GAI; Flanagan & Kaufman, 2009), which represents the combination of the measures of verbal (VCI) and visuoperceptual intelligence (PRI). Due partly to GAI being considered as a single measure of core intelligence in SLD, and partly to the two different aspects of intelligence (verbal and visuospatial) being examined, when children with SLD are analyzed as a single group (as also recommended by the DSM-5; APA, 2013), they may appear to share a common intellectual profile, with similar specificities, and thus need the same type of assessment and intervention. In our view, this approach may be misleading, prompting the suggestion that the same considerations are applicable to all children with SLD, both in research and intervention. The present paper aims to show that the SLD population often has different intellectual profiles, which may be impaired either in verbal or in visuoperceptual intelligence.

Previous research on SLD had identified specific strengths and weaknesses, not only with respect to a GAI generally and considerably higher than WMI and PSI, but also as concerns differences between the verbal and visuospatial domains. It had therefore been suggested that we need to identify children weak in verbal intelligence and strong in nonverbal intelligence, or vice versa (e.g., Rourke, 1985). The hypothesis that SLD is associated with weak verbal abilities and a history of early language difficulties has also been advanced by other authors. For example, in a review of published data obtained with previous versions of the Wechsler scales, Inglis and Lawson (1987) found that the severity of the deficits of children with SLD in the WISC subtests was related to the use of language and performance in verbal subtests, but largely unrelated to performance in nonverbal subtests. In the same vein, discrepancies involving a Verbal IQ < Performance IQ were found associated with SLD in a group of children at risk of cognitive deficits (Hyman, Shores, & North, 2006). Other aspects of language proficiency have been linked to SLD too, and to developmental dyslexia in particular, such as phonological and object-naming skills (Snowling, van Wagtendonk, & Stafford, 1988). Delayed language development at an early age has also been found associated with a risk of dyslexia (e.g., Brizzolara, Casalini, Sbrana, Chilosi, & Cipriani, 1999; Chen, Wijnen, Koster, & Schnack, 2017). In a study on the linguistic history of Italian children diagnosed with dyslexia, Chilosi et al. (2009) found that a sizable subgroup also scored low on verbal intelligence. Despite the fact that this evidence mainly concerned poor verbal abilities as an early predictor of SLD, it should be noted that the causal relationship between low verbal competence and SLD (and dyslexia specifically) may be at least partly bidirectional. According to the so-called "Matthew effect" in reading (e.g., Stanovich, 1986), there may be a rich-get-richer and poor-get-poorer mechanism at work such that, in the long run, children with dyslexia may further lag behind their TD peers in verbal competence as a result of their being less exposed to verbal material.

A less common profile encountered in children with SLD is reportedly characterized by a specific weakness in nonverbal (mainly visuoperceptual) intelligence and a superior verbal intelligence. This profile was first described by Johnson and Myklebust (1967) as a nonverbal learning disability (NLD) with schooling difficulties. It was soon further investigated by Rourke, Dietrich, and Young (1973), who studied this NLD profile systematically, referring explicitly to the intellectual discrepancy and to the children's performance on the WISC scales. There is a large body of evidence suggesting that an association between NLD and learning difficulties is very common, and that a discrepancy between verbal and visuoperceptual intelligence may be a defining characteristic of NLD (e.g., Drummond, Ahmad, & Rourke, 2005). As reviewed by Cornoldi, Fine, and Mammarella (2016), a diagnosis of NLD requires a series of symptoms that go beyond the intellectual profile, but a verbal-nonverbal discrepancy – first described on the grounds of the WISC-R Verbal vs Performance indexes, and subsequently by means of the WISC-IV VCI vs PRI indexes - has been a popular basis for the diagnosis of NLD.

The two subtypes of SLD, one characterized by a low verbal intelligence, the other by a low nonverbal intelligence, have also been associated with different academic and cognitive difficulties (Rourke & Finlayson, 1978). Loveland, Fletcher, and Bailey (1990) described two subtypes of SLD, one weak in reading, arithmetic, comprehension and the reproduction of verbally-presented events, the other only weak in arithmetic and the processing of nonverbally-presented events.

In short, the population with a diagnosis of SLD may include one profile with a specific linguistic weakness but a strong visuoperceptual intelligence, and another with a specific visuoperceptual weakness. A systematic investigation into the existence and frequency of these profiles, and a comparison with the corresponding profiles in the TD population is still lacking, however. In particular, it is still unclear whether such discrepant profiles represent a very frequent finding in the population with SLD. In fact, the standardizations of the WISC scales, and especially the WISC-IV (the most widely-used version in many countries, Evers et al., 2012), indicate that these discrepant profiles are in fact relatively common (Wechsler, 2003). To shed more light on these issues, the present study took advantage of a large dataset of intellectual profiles of children with a diagnosis of SLD who were also assessed with the WISC-IV scale. These profiles were examined to identify children with a "substantial" VCI-PRI discrepancy. A criterion of approximately 1.5 SD (at least 22 standardized points) was used to define a substantial discrepancy because it also seems a robust criterion for the diagnosis of NLD (for a review, Mammarella & Cornoldi, 2014). More in general, it is widely used to assess clinical groups (e.g., the DSM-5 suggests an achievement 1.5 SD below average for SLD), and it has been proposed for detecting discrepancies within the WISC-IV profile severe enough to make the overall IQ impossible to interpret (Flanagan & Kaufman, 2009). This cut-off also seemed to offer more robust evidence of the existence of different profiles than previously-used alternatives, such as 10 or 15 standardized points (e.g., Rourke, Dietrich, & Young, 1973; Cornoldi, Fine, & Mammarella, 2016). Our first aim was to see if there was a higher proportion of children weaker in verbal than visuoperceptual intelligence than vice versa, given the frequent association between verbal weaknesses and SLD. Second, we examined whether the proportion of such discrepant profiles is higher in the SLD population than in a corresponding population of TD children. According to a popular view, children with SLD have a heterogeneous intellectual profile, with more evident strengths and weaknesses than TD children (e.g., Masutto & Cornoldi, 1992).

Despite its popularity, the line of research devoted to identifying profiles of strengths and weaknesses within neurodevelopmental disorders has been criticized by those who argue that the informative power of these patterns may be too limited to orient effective decision-making for a given individual (e.g., Miciak, Taylor, Stuebing, & Fletcher, 2018; Youngstrom et al., 2017). It should be noted, however, that achieving such an informative power at the individual level (e.g., diagnostic power) would require effect sizes that would be considered uncommonly large for many fields of research in psychology. For example, even a respectable medium-sized between-group difference, such as Cohen's $d = .60$, has little diagnostic power at the individual level, $AUC = 0.66$. Interest in strengths and weaknesses in the clinical setting is largely on the grounds that psychometric elements are just one part of a much broader clinical assessment. Nonetheless, there is some evidence to suggest that even an approach relying on psychometric indices alone may have some informative power for the SLD population as a whole (Giofrè et al., 2017). The latter report did not consider possible discrepancies between verbal (VCI) and visuoperceptual (PRI) intelligence, however. Given that a poor verbal intelligence seems to be typical of SLD, and one criterion for the diagnosis of SLD is that other forms of intelligence must be spared, the 'low verbal intelligence and high nonverbal intelligence' profile may be genuinely common in the SLD population. There is no reason why the opposite might be true, however, since the NLD profile is generally assumed to be rare, and not all children diagnosed with NLD due to a poor visuoperceptual intelligence coinciding with a good verbal intelligence meet the criteria for a diagnosis of SLD as well (Cornoldi et al., 2016).

Another goal of the present study was to compare the two above-described discrepant profiles (with weaknesses in verbal or visuoperceptual intelligence) to see whether they differ in other aspects too. In particular, we focused on the type of learning difficulty and performance in the WISC-IV processing subtests that do not contribute to the calculation of verbal and visuoperceptual intelligence. An in-depth analysis was conducted on the cases that were not only discrepant, but also revealed a substantial weakness in one form of intelligence (i.e., either VCI or PRI below 85). Based on the available evidence (Loveland, Fletcher, & Bailey, 1990), we expected children with a poor verbal intelligence to have greater difficulties in reading than in arithmetic, and we expected children with a poor visuoperceptual intelligence to struggle more in arithmetic than in reading. We also examined whether the latter children were generally slower in processing than the former, as suggested by Rourke and coauthors (2001, 2005), but never thoroughly examined.

As for the characteristics of the TD population, we considered the WISC-IV Italian standardization sample of 2200 children and adolescents (aged 6–16 years) reported in the manual (Orsini, Pezzuti, & Picone, 2012). None of the children in the sample had been diagnosed with SLD, while 12.4% of the children reportedly presented a difference of at least 22 points between their VCI and PRI, with a minimal difference in the direction of the discrepancy: 5.8% of these children had a VCI < PRI, as opposed to 6.6% with a VCI > PRI.

2. Method

2.1. Participants

Under the auspices of the Italian Association for Learning Disabilities (AIRIPA), we analyzed the WISC-IV intellectual profiles of 1624 children, aged between 7 and 16 years (*M* age = 11.48 [*SD* = 2.44]; 60.8% males). The data included the children's weighted scores in the 10 basic subtests, administered by psychologists with expertise in SLD assessment and treatment, working at highly-reputed clinical centers in eight major regions of Italy.

Unlike previously-published analyses (Giofrè & Cornoldi, 2015; Giofrè et al., 2017; Toffalini, Giofrè, & Cornoldi, 2017a; Toffalini, Pezzuti, & Cornoldi, 2017) conducted on subsets of the AIRIPA data and focusing on different issues, the present study examined the issue of discrepancy between VCI and PRI, and considered a larger SLD sample that included more recently-assessed cases. All participants had a certified clinical diagnosis of learning disorder based on the ICD-10 International Coding System (World Health Organization, 1992), category F81 (specific developmental disorders of scholastic skills). They also met the Italian legal criteria concerning SLD (Italian legislation on learning disorder, 2010), and those of the National Italian Consensus Conference on Specific Learning Disorder (Istituto Superiore di Sanità, 2011), which are still being debated, however (Lorusso et al., 2014; Poletti et al., 2018). The main criteria currently used in clinical practice for the diagnosis of SLD are the following: (i) academic achievement in specific areas (reading, writing, arithmetic) below the 5th percentile, or more than 2 SD below average, when assessed using relevant standardized tests; and (ii) no better explanation for the impairment relating to socio-cultural, educational, emotional, intellectual, sensory or neurological problems. Children who had a diagnosis of SLD with any other comorbid neuropsychological disorder (e.g. attention-deficit hyperactivity disorder, developmental coordination disorder) were not included in this sample.

2.2. Instrument

The Italian adaptation of the WISC-IV was used (Orsini et al., 2012), and the weighted scores in the 10 WISC-IV basic subtests were computed (in the normal population, $M = 10$, $SD = 3$). The full-scale intelligence quotient (FSIQ) and the factorial indexes (i.e. VCI, PRI, WMI, and PSI) were calculated as indicated in the WISC-IV manuals (Orsini et al., 2012) (normal population: M = 100, $SD = 15$). The VCI was obtained from the following subtests: Similarities, Vocabulary and Comprehension. The PRI was obtained from the scores in: Block design, Picture concepts and Matrix reasoning. The WMI was obtained from the scores in: Digit Span and Letter-Number sequencing. The PSI was obtained from the scores in: Coding and Symbol search.

3. Results

The overall sample had an average FSIQ of 98.03 ($SD = 12.44$). As regards the four main indices, we found similar mean scores in verbal and visuoperceptual intelligence: $M_{\text{VCI}} = 103.15$ ($SD = 14.80$), $M_{\text{PRI}} = 104.28$ ($SD = 14.26$); and, as typically happens for the SLD population, lower $M_{\text{WMI}} = 90.19$ ($SD = 13.02$); $M_{\text{PSI}} = 93.11$ ($SD = 14.13$). Despite similar mean scores in verbal and visuoperceptual intelligence in the group as a whole, an examination of individual cases revealed some highly discrepant cases. A first analysis was conducted on the frequencies of children with SLD who had a difference of at least 22 points between the VCI and the PRI. We identified 118 children (7.3% of the SLD sample), who had a VCI > PRI. Using an exact binomial test, this proportion was not significantly higher than that of the TD population (6.6% [Orsini et al., 2012]), $p = .27$. On the other hand, a larger number of children (170, equating to 10.5% of the SLD sample) had a PRI > VCI, and this proportion was significantly higher than the 5.8% of the TD population ($p < .001$). The relative proportions of the children with the two types of discrepancy also differed significantly ($p < .001$): there were more children with SLD who had a VCI < PRI (10.5%) than those with a VCI > PRI (7.3%). It should be noted that alternative cut-off scores of 10, 15, and 30, for the differences between VCI and PRI generated similar results, but obviously with different frequencies. Concerning differences ≥ 10, the SLD cases with a discrepancy accounted for more than half of the whole sample (56.0%), and more than the proportion in the TD population (49.4%), $p < .001$, but these proportions were too high for any meaningful consideration on the "discrepant" cases. As for differences ≥ 15, 16.4% of the children with SLD had a VCI > PRI (not many more than the 14.7% of the TD population, $p = .05$); and 20.3% had a VCI < PRI (significantly more than the 14.3% of the TD population, $p < .001$). Finally, as regards differences ≥ 30, 2.5% of the children with SLD (42) had a VCI > PRI (not differing significantly from the 2.0% of the TD population, $p = .09$); and 3.5% (57) had a VCI < PRI (significantly more than the 2.2% of the TD population, $p < .001$). We therefore decided to maintain the predefined criterion of 22 standardized points.

Table 1 shows the characteristics of the two groups, including frequencies, gender, age, standardized scores on the main indexes of the WISC-IV, weighted scores in all core subtests, effect sizes of the comparisons between the two SLD groups, and between them and the TD population. As concerns the specific type of learning difficulty, the diagnoses based on the ICD-10 are reported: F81.0 in the case of a reading disability; F81.1 in the case of a spelling disability; F81.2 in the case of a calculation disability; and F81.3 in the case of a disability affecting more than one area of learning.

As shown in Table 1, the two groups were similar in age, $t(285) = -1.02$, $p = .31$, and FSIQ, $t(286) = -0.23$, $p = .81$, but differed in other respects. Significantly more than half of the group with a VCI > PRI were male ($p = .002$, exact binomial test), but this was not the case in the group with a VCI < PRI ($p = .63$). Concerning the specific ICD-10 diagnoses, the two groups showed a similar prevalence of the very common diagnosis of mixed learning difficulties (F 81.3), the rare diagnosis of a specific spelling difficulty (F81.1), and of the residuals (referring to diagnoses F81.8/.9). They revealed some differences in the patterns of their academic difficulties, however. The VCI < PRI group struggled especially with reading, as 29.4% of the children in this group had a diagnosis of F81.0, as opposed to 11.0% of those in the VCI > PRI group; this difference was significant, $\chi^2(1) = 12.74$, $p < .001$, using a chi-square test on the contingency table binning F81.0 vs. non-F81.0. The opposite pattern emerged in the case of the F81.2 diagnosis (calculation difficulties): 16.9% of the children in the VCI > PRI group had this diagnosis, as opposed to only 4.7% of the children in the VCI < PRI group.

These findings do not imply that a VCI-PRI discrepancy has a strong discriminant power between SLD subtypes at the individual level, however, even when effect sizes are medium-to-large. Conducting a ROC analysis, the discrepancy showed an AUC (area under the ROC curve) of .67, 95% CI [.61, .72] (Cohen's $d = .64$) in discriminating between reading (F81.0) and calculation (F81.2) difficulties; AUC = .62, 95% CI [.57, .67] (Cohen's $d = .46$), in discriminating calculation difficulties (F81.2) versus any other SLD subtype; and AUC = .58, 95% CI [.54, .61] (Cohen's $d = .28$), in discriminating reading difficulties (F81.0) versus any other SLD subtype.

When used to compare SLD against the TD population, the VCI-PRI discrepancy showed a limited discriminant power and small effect sizes. As intellectual profiles were not available for the TD population, they were simulated using a method that reproduced the covariance structure reported for the normative sample of the Italian validation of the WISC-IV (Orsini et al., 2012); a Monte Carlo method with 100,000 iterations was used to estimate uncertainty (see Giofrè et al., 2017, for details). For the SLD group as a whole against the TD population (using the absolute value of the VCI-PRI discrepancy), AUC = .53, 95% CI [.52, .54] (Cohen's $d = .12$). For F81.0, AUC = .58, 95% CI [.55, .61] (Cohen's $d = .31$); for F81.1, AUC = .52, 95% CI [.48, .56] (Cohen's $d = .07$); for F81.2, AUC = .59, 95% CI [.54, .64] (Cohen's $d = .35$); for F81.3, AUC = .53, 95% CI [.50, .55] (Cohen's $d = .12$).

We then examined the characteristics of the two groups in the subtests (Table 1), starting with those not considered for grouping

Table 1
Demographic data, descriptive statistics (means and standard deviations) for the two groups of SLD children with a discrepancy between their VCI and PRI, and effect size of the comparisons.

	VCI > PRI	VCI < PRI	Comparisons (Cohen's *d*)		
			VCI > PRI vs VCI < PRI	VCI > PRI vs TD population	VCI < PRI vs TD population
N (% in the SLD sample)	118 (7.3%)	170 (10.5%)	–	–	–
Age (in months)	134.79 (29.28)	138.23 (27.37)	–	–	–
% of males	75 (64.7%)	83 (52.2%)	–	–	–
General Ability Index (GAI)	103.65 (13.64)	100.31 (14.54)	.24	.25	.02 *
Full-Scale IQ	96.55 (12.30)	96.88 (11.44)	−.03 *	−.25	−.23
Factorial indexes					
Verbal Comprehension Index	117.31 (12.67)	87.26 (12.19)	2.43	1.25	−.93
Perceptual Reasoning Index	88.31 (12.76)	115.78 (11.90)	−2.24	−.84	1.17
Working Memory Index	88.99 (11.60)	91.14 (13.61)	−.17 *	−.82	−.62
Processing Speed Index	88.42 (13.43)	95.20 (12.42)	−.53	−.81	−.35
Subtests					
Similarities	12.47 (2.85)	8.13 (2.60)	1.60	.84	−.67
Vocabulary	12.63 (2.49)	7.89 (2.46)	1.92	.95	−.77
Comprehension	13.38 (2.65)	7.79 (2.69)	2.09	1.19	−.78
Block design	7.86 (2.76)	11.81 (2.50)	−1.51	−.74	.66
Picture Concepts	9.05 (3.00)	12.45 (2.80)	−1.18	−.32	.84
Matrix reasoning	7.83 (3.32)	12.77 (2.49)	−1.73	−.69	1.00
Digit span	8.14 (2.34)	8.24 (2.31)	−.04 *	−.69	−.66
Letter-number seq.	8.15 (2.29)	8.74 (2.86)	−.22 *	−.69	−.43
Coding	7.97 (2.73)	8.62 (2.67)	−.24	−.71	−.49
Symbol search	8.19 (3.06)	9.76 (2.47)	−.58	−.60	−.09 *
Diagnosis (raw number and % in subsample)					
F81.0	13 (11.0%)	50 (29.4%)	–	–	–
F81.1	12 (10.2%)	9 (5.3%)	–	–	–
F81.2	20 (16.9%)	8 (4.7%)	–	–	–
F81.3	45 (38.1%)	69 (40.6%)	–	–	–
Residual	28 (23.7%)	34 (20%)	–	–	–

Note. TD = typically-developing. For the TD population, in factorial indexes: $M = 100$, $SD = 15$; in subtests: $M = 10$, $SD = 3$. Pooled variance in the comparisons involving the TD population assumes equal number of SLD and TD cases.
All comparisons were significant at the t-test, $p < .05$, except those marked with an asterisk *.

the children, i.e., the working memory and the processing speed subtests. As the scores on different subtests were repeated measures on the same children, the analysis was conducted using mixed-effects linear models with participants as random effects. The fixed effects of interest were the subtests, the groups, and their interactions. The significance of the effects was assessed using the likelihood ratio test for nested models based on the chi-squared distribution (Pinheiro & Bates, 2000). We found a significant main effect of Group, $\chi^2(1) = 13.15$, $p < .001$, a significant main effect of Subtest, $\chi^2(3) = 25.55$, $p < .001$, and a significant Group by Subtest interaction, $\chi^2(3) = 14.68$, $p = .002$. The interaction can be better interpreted in the light of Fig. 1, which suggests that, although the VCI < PRI group had a better overall performance than the VCI > PRI group across the four subtests, the between-group difference seemed larger in the processing speed subtests, and particularly in the Symbol search subtest (with a medium effect size, whereas it was small in the Coding subtest, see Cohen's *ds* in Table 1). Concerning the six subtests comprising VCI and PRI, it should be noted that the between-group differences were relatively small for the two subtests that may, to some degree, involve verbal and visuospatial abilities simultaneously, namely Similarities (which, despite its verbal characteristics, also requires analogical reasoning), and Picture concepts (which, despite being visually presented, seems to involve semantic reasoning too).

It should be noted that, up to this point, the comparisons were drawn on the basis of a discrepancy which was relative, and it did not necessarily indicate an impairment in the form of intelligence that obtained the lower score. Within each of the two larger groups showing a VCI-PRI discrepancy, we therefore considered the subsamples of children who also showed a marked weakness in the lower of the two indexes. We first considered the cases that reflected a pattern seen in children with NLD, i.e., a marked VCI-PRI discrepancy associated with a PRI at least one standard deviation below average (below 85; i.e., poor visuoperceptual intelligence). We found that 47 of the 118 children had this pattern. The opposite pattern, i.e., a VCI-PRI discrepancy associated with a VCI < 85 (sometimes referable to a language disorder) emerged in 72 children. We repeated our analysis on the Subgroup by Subtest interaction involving the four processing subtests, and (as expected) it was significant, $\chi^2(3) = 32.34$, $p < .001$. Fig. 2 shows the pattern of scores for the two subgroups. As we can see, the pattern concerning the four processing subtests is clearer in this case: the subgroup with a marked VCI-PRI discrepancy and a poor visuoperceptual intelligence fared substantially worse than the other subgroup (with a normal visuoperceptual intelligence) in both the subtests on processing speed, whereas no difference emerged in the WM subtests.

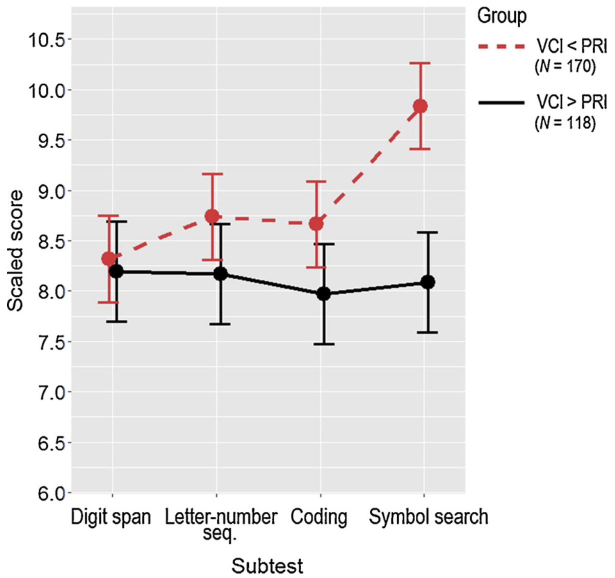

Fig. 1. Working Memory and Processing Speed subtests: Group x Subtest interaction effect on the scaled scores. Error bars represent 95% CIs of the estimated mean values. VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index.

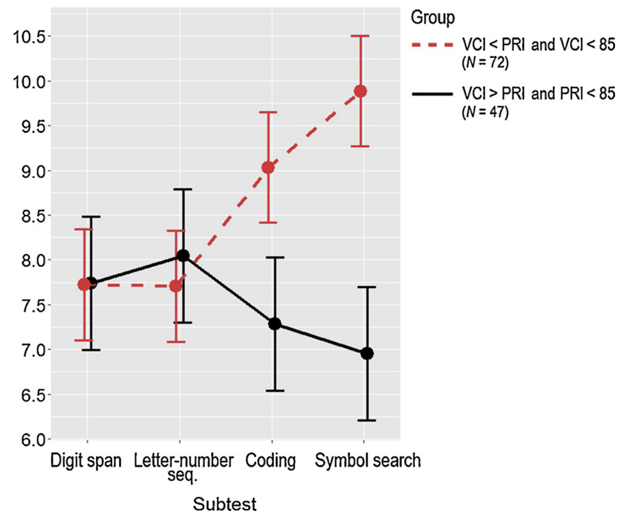

Fig. 2. Working Memory and Processing Speed subtests: Group x Subtest interaction effect on the scaled scores, including only participants whose standardized score in the lowest index (VCI or PRI) is below 85. Error bars represent 95% CIs of the estimated mean values. VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index.

4. Discussion

Children with SLD have often been described as having more marked intellectual strengths and weaknesses than TD children (Masutto & Cornoldi, 1992), but reports of their uneven intellectual profiles have mainly focused on the case of average or above-average levels of general abilities (both verbal and visuoperceptual) associated with poor processing abilities, especially in terms of WM and speed. These profiles have recently been studied on the basis of the WISC-IV battery, often revealing a profile in which both VCI and PRI are higher than WMI and PSI (e.g., De Clercq-Quaegebeur et al., 2010; Poletti, 2016). This particular profile (which appears to be behind the results described in the present study too) has become so common in SLD that it has come to be considered as a potential contributor to its diagnosis (Giofrè et al., 2017). This evidence was collected considering SLD as one group as a whole, as suggested by recent claims that not enough evidence is available to support any distinction between clinical subgroups within the SLD diagnostic category (DSM-5, APA 2013). But considering samples of children with SLD as a single group gives rise to a potential artefact in that their mean levels of verbal and visuoperceptual intelligence may conceal marked differences between individual children. In other words, if some children with SLD have a good verbal intelligence and a poor visuoperceptual intelligence, and others vice versa, considering their average scores will give the erroneous impression that all children with SLD have similar levels of verbal and visuoperceptual intelligence. The present study produced evidence against this assumption, further supporting the literature on children with SLD whose profiles show a discrepancy between their verbal and visuoperceptual intelligence. Our study also generated robust information on the absolute and relative frequencies of these SLD profiles, their characteristics, and how they compare with the corresponding profiles in the TD population, all aspects that had never been systematically investigated until now.

In fact, the present study was conducted on data concerning the intellectual profiles obtained with the WISC-IV scale of a very large sample of 1624 children with a diagnosis of SLD. This group was examined in terms of discrepancies in individual children's profiles, characterized by either a markedly higher verbal than visuoperceptual intelligence (judging from the VCI of the WISC-IV) or a markedly higher visuoperceptual than verbal intelligence (based on the PRI of the WISC-IV). It emerged that the SLD group contained more children with a VCI at least approximately 1.5 SD (22 standardized points) lower than their PRI than those with the opposite profile, thus seeming to confirm that a weakness in verbal abilities characterizes SLD as a group (Chilosi et al., 2009). We also found more children with this profile in the SLD group as a whole than in the TD population, but it is worth emphasizing that, although the difference was statistically significant, it was not very large. This means that a poor verbal intelligence coinciding with an average general intelligence should not be taken as a marker of SLD, as once suggested (Inglis & Lawson, 1987), and that the SLD category includes different cognitive profiles that are the result of distinct cognitive trajectories. One of the most common profiles is associated with language weakness, while some probably relate to executive deficits, and others to visuospatial/nonverbal impairments. It may be, as suggested by Pennington (2006), that multiple patterns of deficits exist in some cases, giving rise to different subgroups of SLD. This conclusion is supported by the fact that our SLD population also included a sizable group with a good verbal and a poor visuoperceptual intelligence (and the proportion of these cases was much the same as in the TD population): their presence confirms reports of such a profile within the SLD group from several other researchers (e.g., Rourke, 1985), often associated with a diagnosis of NLD. As also supported by their ICD-10 diagnosis, these children often have difficulty with calculation. Intriguingly, there is also a subgroup with a diagnosis of dyslexia whose visuospatial IQ is markedly lower than their verbal IQ, suggesting a relationship between dyslexia and a visual weakness (Franceschini, Bertoni, Gianesini, Gori, & Facoetti, 2017). In short, due to the presence of cases with a poor verbal intelligence, profiles with a substantial discrepancy between their verbal and visuoperceptual intelligence were more common in the SLD than in the TD population, and this is consistent with the finding that the correlation between these two forms of intelligence is stronger in the TD than in the SLD population (Giofrè & Cornoldi, 2015).

Comparing the SLD cases with a VCI > PRI versus those a VCI < PRI also gave us the opportunity to identify a number of important associated elements. In particular, we found that the VCI > PRI group frequently revealed weaknesses in processing speed and arithmetic, whereas the VCI < PRI group often had a reading difficulty. This extends previous evidence concerning the relationship between learning and intellectual abilities (Toffalini, Giofrè, et al., 2017a) to groups of children specifically identified as having weaknesses in verbal either or visuoperceptual intelligence. It should be noted that, although the diagnosis of a reading or arithmetic disorder (and the other SLD subtypes) in the sample we considered was based on the use of standardized achievement tests, no further information was made available to us on the children's specific scores (in agreement with the definition of the research project). Future research could therefore use more directly comparable measures of academic proficiency to better elucidate the relationship between WISC-IV profile discrepancies and specific areas of achievement. This should be done particularly with regard to cases of mixed disorder, collecting more information on their specific profiles and thus distinguishing between cases with calculation or reading difficulties (the most common cases in our sample) from other cases in the mixed disorder category. Future research should also examine whether and how similar discrepancies also characterize children referred for developmental disorders in general, and particularly children diagnosed with neurodevelopmental disorders other than SLD, and children with SLD coming from cultures/languages other than Italian.

The comparison drawn in the present study also showed that the gender ratio differed in the two groups we identified: there were more males than females in the VCI < PRI group, as often reported in populations of children with language disorders or SLD. For example, the DSM-5 states that male-to-female ratios range from about 2:1 to 3:1, and the analysis conducted on SLD by Toffalini, Giofrè, et al. (2017a) on a previous subset of the present data again found a higher proportion of males (74%) than females. On the other hand, the proportion of males with the opposite profile, i.e. the VCI > PRI group in the present study, was much the same as that of females. This result that may relate to the males being poor in visuoperceptual intelligence too, as suggested by the fact that a nonverbal neurodevelopmental weakness like motor coordination disorder is more common in males than females (Giofrè, Cornoldi, & Schoemaker, 2015).

Comparing the two SLD profiles with one another, and with the TD population generated some important information. The results suggested that the two SLD groups shared particular weaknesses in the working memory and processing subtests, but they also revealed substantial differences. The comparison between the two SLD groups, VCI > PRI and VCI < PRI, in the four WISC-IV processing subtests (not used to allocate them to one or other group) revealed that the former was weaker than the latter on processing speed. The difference was particularly evident in the Symbol search task (which is mainly visual), but it emerged clearly in the Coding subtest too (which involves processing visual, but also symbolic material). The difference was also especially clear when we considered the cases that were not only discrepant, but also had low scores (below 85) in the weaker of the two indexes comprising the GAI. These results suggest that poor visuoperceptual intelligence is more strongly associated with slower processing than poor verbal intelligence - in children with SLD at least. From this perspective, the absence of a special weakness in working memory measures in the former group vis-à-vis the latter might be due to the bias of the WISC-IV, which only includes verbal measures of working memory. Further research is therefore needed to support the conclusions deriving from the present results, also using other cognitive tasks and other indexes, such as the latest version of the Wechsler Intelligence Scale for Children (WISC-V).

In conclusion, the present study sheds light on the discrepant profiles seen in a sizable subsample of the SLD population, but it also has several limitations that need to be overcome by future research. Some of these limitations are due to the nature of the study, which was based on the participation of different Italian centers that only shared the use of the WISC-IV battery, while they adopted different measures to examine the children's other characteristics, or they did not make them available. Other limitations relate to the fact that the groups were formed on the basis of the factorial model of the WISC-IV, which has been widely supported (e.g., Giofrè & Cornoldi, 2015; Watkins, Wilson, Kotz, Carbone, & Babula, 2006), but also criticized on the grounds that the unique reliability of the indices is not very high after accounting for the general factor (see Watkins, 2006; though this may be different in SLD, Giofrè & Cornoldi, 2015; Styck & Watkins, 2016), and that its appropriateness for the purposes of clinical interpretation and diagnosis may be limited (e.g., Beaujean et al., 2017; Glutting, Watkins, & Youngstrom, 2003; Miciak et al., 2018; but see also Toffalini, Giofrè, & Cornoldi, 2017b). Despite these limitations, the present study seems to offer some useful novel information on the presence and characteristics of two substantially different profiles in the SLD population, each with a particular weakness, one in verbal intelligence, and the other in visuoperceptual intelligence. Unlike the GAI-FSIQ discrepancy previously examined by Giofrè et al. (2017), the discrepancies discussed here should not be attributed any strong diagnostic power for the purposes of identifying cases of SLD. Nonetheless, the presence of such a discrepancy in a number of children with SLD (and, in the case of VCI $<$ PRI, significantly more than in the TD population) should be borne in mind by researchers and clinicians. Simply put, considering and treating all children with a diagnosis of SLD in the same way (as often happens) should be avoided. For example, a child with SLD based on a verbal weakness should be taught to use compensatory strategies based on visualization, whereas a child with the opposite discrepancy (an underlying visuospatial weakness) may benefit from verbally-based compensatory strategies. Decisions affecting the future employment of children with SLD, e.g., their vocational choices, may also be improved by taking their cognitive functioning profiles into careful consideration.

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