



## Intelligence measures as diagnostic tools for children with specific learning disabilities



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### ABSTRACT

The assessment of intelligence has always been an essential part of the diagnostic process of children with specific learning disabilities (SLD). Recently, emphasis has been placed on the profile of intellectual strengths (e.g. in reasoning) and weaknesses (e.g., in working memory and processing speed). In this study, we compared the WISC-IV intellectual profile of 1383 children with SLD to the normative data for typically developing children; in particular, we analyzed the predictive power of WISC-IV indexes and their discrepancies—especially the general ability index (GAI) vs. the cognitive proficiency index (CPI) or vs. the full-scale (FSIQ)—as markers of the SLD condition. Results showed that the intellectual profile in general, and the GAI-CPI or GAI-FSIQ discrepancy in particular, represents an effective criterion for differentiating between groups. Examining the underlying cognitive profile might be useful when dealing with children who have SLD, as discrepancies could be effectively used to support a diagnosis.

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### 1. Intelligence measures as diagnostic tools for children with specific learning disabilities

Specific learning disabilities (SLD) are neurodevelopmental disorders with a biological origin that lead to persistent difficulties in the acquisition of specific academic skills. Different criteria have been proposed for the clinical diagnosis of SLD, but all include the consideration of children's intelligence. The discrepancy between a normal or high intellectual functioning and unexpectedly low academic achievement (i.e., the so-called intelligence-achievement discrepancy) has long been considered as the hallmark of SLD (U.S. Office of Education, 1977). Recently, the intelligence-achievement discrepancy has been sharply criticized primarily because cutoff-points are somewhat arbitrary (Tannock, 2013). Further, the dimensional nature of the distribution of intelligence and achievement scores—and thus of their discrepancy—has been stressed in recent scholarship, raising doubts about the usefulness of imposing any cutoff-point (Francis et al., 2005).

Another problem with the intelligence-achievement discrepancy hypothesis is that it regards intellectual functioning as a single global index (i.e. the intelligence quotient [IQ]). Recent formulations of intelligence describe this construct as composed of different factors (Horn & Cattell, 1966). These criticisms have led the recently published Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5;

American Psychiatric Association [APA], 2013) to prudently state that in children with SLD difficulties should be apparent “*in individuals who otherwise demonstrate normal levels of intellectual functioning*” (p. 69). Apart from giving exclusion criterion of intellectual disability and recommending cautious interpretation of borderline cases, the DSM-5 adds that “*assessment of cognitive processing deficits is not required for diagnostic assessment*” (p. 70; APA, 2013).

Many researchers believe that the examination of the different factors composing intelligence and their discrepancies can be especially relevant in the case of SLD. Research has shown that the average intellectual profile of children with this diagnosis differs from that of typically developing (TD) children, as it is characterized by highly heterogeneous scores (e.g., Cornoldi, Giofrè, Orsini, & Pezzuti, 2014; Poletti, 2016). This is consistent with the *specificity* hypothesis, which posits that SLD is defined by a specific pattern of strengths and weaknesses (PSW) within the neuropsychological functioning and in academic outcomes, rather than by generalized cognitive problems (Compton, Fuchs, Fuchs, Lambert, & Hamlett, 2012). According to this view, the identification of a particular PSW within an individual's cognitive functioning can provide vital information for the diagnosis of SLD (Flanagan, Ortiz, & Alfonso, 2007).

The PSW approach, however, has been criticized by many authors. Critics point out that while it is well established that specific cognitive processes are related to academic achievement, this does not necessarily imply that cognitive patterns can provide reliable information for the diagnosis of SLD (Watkins, 2000). In fact, the problem of studies using PSW as a detector of SLD is that they often show poor discriminant power; i.e. they may have good specificity, but generally low sensitivity

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(Stuebing, Fletcher, Branum-Martin, & Francis, 2012). As a consequence, using clinically significant scores or differences as cutoff-points leads to a low rate of false positives, but also to a moderate or low rate of true positives (Kranzler, Floyd, Benson, Zaboski, & Thibodaux, 2016; Stuebing, Fletcher, Branum-Martin, & Francis, 2012). However, the utility of cutoff-points has never been systematically studied on sufficiently large samples of children with SLD.

In this study, we examined to what extent the consideration of an individual's specific intellectual profile can assist in the diagnosis of SLD. To this aim, we used the *Wechsler Intelligence Scale for Children, 4th edition* (WISC-IV; Wechsler, 2003), which stands beside its recently updated 5th edition as the most widely used tool for assessing intelligence in children in many countries (Evers et al., 2012). Previous attempts, conducted using former versions of the WISC battery, led to unsatisfactory results (e.g., Kavale & Forness, 1984; Watkins, Kush, & Glutting, 1997). However, the WISC-IV seems promising as it differentiates between measures of general ability and other aspects—such as working memory and processing speed—that are often impaired in children with SLD (Cornoldi, Giofrè, Orsini, & Pezzuti, 2014). In fact, the consideration of the intellectual profile as it is measured by the WISC-IV battery can be particularly useful for the assessment of children with SLD (Fiorello et al., 2007). In the present study, we examined how indexes derived from the WISC-IV battery could predict the probability that an individual would have an SLD diagnosis.

The WISC-IV intellectual profile of children with SLD differs from the profile of TD children. Children with SLD are characterized by higher scores in verbal comprehension (VCI) and perceptual reasoning (PRI), and markedly lower scores in working memory (WMI) and processing speed (PSI) indexes (Cornoldi et al., 2014; Poletti, 2016). This implies that the general ability index (Prifitera, Saklofske, & Weiss, 2008), which includes only the verbal and perceptual indexes (VCI and PRI), is on average higher than the full-scale intelligence quotient (FSIQ), which includes all indexes, and in particular it is higher than the cognitive proficiency index (CPI; Saklofske, Coalson, Raiford, & Weiss, 2010), which includes only WMI and PSI. This index is particularly important for children with SLD, as the abilities that comprise GAI (VCI and PRI) are more strongly related to the *g*-factor in such children, compared to typically developing children (Giofrè & Cornoldi, 2015). In fact, it has been suggested that the GAI may be a valid alternative way of summarizing the overall intellectual functioning of children with SLD (Saklofske, Prifitera, Weiss, Rolfhus, & Zhu, 2005). Therefore, the discrepancy between the two broad indexes, i.e. GAI and CPI, may be of particular relevance in the case of children with SLD.

In the present study, we analyzed data from a large dataset of 1383 SLD children. All children in the set had a clinical diagnosis of SLD, obtained using the ICD-10 International Coding System. The children's intelligence was assessed using the 10 basic subtests of the WISC-IV scale. We chose to treat SLD as a single category—as it is also suggested by the DSM-5—but we are aware that different SLD subtypes may present systematic differences in their average intellectual profiles (Toffalini, Giofrè, & Cornoldi, 2017). Normative data, simulated from the Italian WISC-IV manual, was compared to the data of SLD children. We examined whether we could discriminate between the two groups (i.e., SLD and TD) using any of the following measures: a linear combination of the four main indexes of the WISC-IV (i.e. VCI, PRI, WMI, and PSI), the GAI-CPI discrepancies, or the GAI-FSIQ discrepancies.

## 2. Method

### 2.1. Participants

Data on 1383 children with SLD was collected under the sponsorship of the Italian Association for Learning Disabilities (AIRIPA). Data were provided by a group of 27 licensed psychologists, experts in the diagnosis and treatment of SLD, located in 8 major Italian regions. A subset of this data had been included in previously published articles (Cornoldi

et al., 2014; Giofrè & Cornoldi, 2015; Giofrè, Stoppa, Ferioli, Pezzuti, & Cornoldi, 2016; Toffalini, Giofrè, & Cornoldi, 2017); however, these articles did not address the issue examined in the present study. All children received a diagnosis within the F81 category (i.e., specific developmental disorders of scholastic skills) of the ICD-10 International Coding System (World Health Organization, 1992), which is the classification system generally consulted in Italy for SLD. Following the guidelines indicated by the National Italian Consensus Conference on SLD published by the Italian Ministry of Health (Istituto superiore di sanità, 2011), all diagnosed children met the following criteria: 1) academic achievement in at least one specific area below the 5th percentile or 2 SDs below average, as assessed using relevant standardized tests, 2) any major influence of known socio-cultural, educational, emotional, intellectual, sensory and neurological problems was eliminated as the cause of the low academic achievement.

Children with SLD were in a range between 7 and 16 years of age ( $M_{\text{age}} = 11.46$  [ $SD = 2.44$ ]; 39% females). According to the ICD-10 coding system, cases were categorized as follows: 346 children with reading disorder (F81.0); 147 children with spelling disorder (F81.1); 93 children with specific disorder of arithmetical skills (F81.2); 501 children with mixed disorder of scholastic skills (F81.3); 75 children with other developmental disorders of scholastic skills (F81.8); 19 children with developmental disorder of scholastic skills, unspecified (F81.9); the remaining 295 children, who received more than one diagnosis within the F81 category. Cases with other comorbid neuropsychological disorders (e.g., attention-deficit hyperactivity disorders, developmental coordination disorder) were excluded in a preliminary screening.

### 2.2. Instrument

The Italian adaptation of the WISC-IV (Orsini, Pezzuti, & Picone, 2012) with the four main indexes (VCI, PRI, WMI, and PSI), the GAI, the CPI and the FSIQ was used.

### 2.3. Data analysis

All analyses were conducted using the *R* software (R Core Team, 2014). Logistic regression models were used to establish the predictive (i.e., discriminating) power of the intellectual profile on the SLD vs. TD condition as a binomial response variable. Analyses were conducted in two phases. First, the predictive power of the entire WISC-IV profile was tested by entering the four main indexes as independent predictors. Further, the simple GAI-CPI difference was entered as a single predictor in the model. The GAI-FSIQ difference (a conceptually equivalent alternative) was also tested.

The coefficients of the model as well as a receiver operating characteristic (ROC) curve and its related area under the curve (AUC, which is a measure of a classifier performance; Fawcett, 2006), were estimated using a Monte Carlo method on simulated data. AUC was calculated using the “pROC” *R* package (Robin et al., 2011). In particular, the analysis was repeated 100,000 times on intellectual profiles simulated on the basis of the correlation matrix and the vectors of means and standard deviations of the 10 basic subtests available for both SLD and TD children. To produce simulated data on TD children, we used the correlation matrix and the descriptive statistics reported in the Italian version of the WISC-IV (Orsini, Pezzuti, & Picone, 2012). The Italian manual reports data from 2200 children between 6 and 16 years of age, and excludes any case with a diagnosis of SLD. The normality of the distributions of all 10 basic subtests was assumed, as it seems appropriate for intelligence measures. To obtain plausible confidence intervals for the coefficients and the AUCs, 1383 SLD profiles and 2200 TD profiles were generated for each iteration. As intellectual disability is an exclusion criterion for SLD, in order to simulate a realistically comparable TD population, we automatically and a priori excluded TD profiles with  $FSIQ < 70$ . After the 100,000 iterations, the median value was reported as the final estimate for coefficients and AUCs. We also calculated

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