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In emotion and reading motivation, children with a diagnosis of dyslexia are not just the end of a continuum

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Children with dyslexia (CwD) often report poor psychological well-being. We examined (i) whether anxiety, self-concept and reading motivation in CwD differed from those of typically developing children (TDC; case–control design, Study 1a) and (ii) whether these differences mirrored the linear relationships that these variables present with reading ability in the TDC group (dimensional approach, Study 1b). In Study 1a, 34 CwD were compared with 191 TDC in grades 4–8 on anxiety, self-concept, reading motivation and reading strategy using self-reports (controlling for sex, intelligence and math ability scores). In Study 1b, the differences that emerged in Study 1a were compared with the results obtained from a simulation procedure that generated dyslexia observations under the assumptions of a dimensional hypothesis. The CwD group presented small-to-moderate difficulties, which partially mirrored the predictions in the TDC group. However, violations of predictions based on the population without dyslexia were found for reading self-

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concept, social anxiety and reading competitiveness. In sum, children's diagnoses affect their self-perception as readers and social anxiety in a way that cannot be inferred from linear relationships. CwD need support to preserve an adequate image of themselves as readers and cope with social anxiety.

KEYWORDS
anxiety, self-concept, reading motivation, dyslexia, children

1 | INTRODUCTION

Dyslexia is a specific learning disorder that affects 4%–9% of school-aged children (Landerl & Moll, 2010; Lewis et al., 1994), persists into adulthood and challenges successful academic and working careers (APA, 2013). Children with dyslexia (CwD) present persistent and unexpected difficulties in developing age and experience-appropriate word reading skills (Parrila & Protopapas, 2017). However, available literature shows that dyslexia is less specific than thought, as it is often associated with mathematical difficulties (Joyner & Wagner, 2020). Evidence from recent studies shows that CwD also report poorer psychological well-being compared with their peers without such difficulties, even though only a few studies have so far systematically examined risk and protective psychological factors related to CwD mental health (Livingston et al., 2018).

CwD or whose reading performance is poor tend to report more anxiety (Francis et al., 2019; Mugnaini et al., 2009; see also Donolato et al., 2022), low self-concept (McArthur et al., 2020), weak reading motivation and inadequate use of reading strategies (Lau & Chan, 2003; Morgan et al., 2008; Vaknin-Nusbaum et al., 2018). Whether these challenges are specifically related to a clinical condition corresponding to a diagnosis of dyslexia or they are associated with reading ability on a continuum in the general population, however, is unclear. Indeed, under the so-called dimensional framework, dyslexia could be conceptualised as the lower end of a developmental continuum of individual differences in reading ability (e.g., Peters & Ansari, 2019; Snowling & Hulme, 2012; see also Carretti et al., 2022). According to this view, the emotional and motivational characteristics of CwD might simply reflect the relationships between these areas and reading ability along a continuum in the general developing population regardless of the dyslexia status. This view has already been suggested for reading-related cognitive abilities (e.g., Carretti et al., 2022). Unlike cognitive aspects, however, anxiety, self-concept, reading motivation and reading strategy use might be non-linearly related to reading ability, as marked reading difficulties or a diagnosis of dyslexia might trigger unique and complex patterns of functioning. Testing the dimensional framework on these aspects is important to disentangle whether there is anything 'special' in having dyslexia or, in other words, whether dyslexia differs only quantitatively or also qualitatively from the rest of the population. To date, no studies have tested this framework by adopting a dimensional approach to examining emotion and reading motivation in CwD.

The main goal of this study was to investigate whether anxiety, self-concept, reading motivation and reading strategy use reported by Italian CwD may be linearly inferred from the characteristics of the developing population without any neurodevelopmental disorders. This was based on a dimensional approach that considers a specific learning disorder as the lower end of the continuous distribution of reading ability in the developing population without dyslexia (Peters & Ansari, 2019; see also Carretti et al., 2022 and Mammarella et al., 2021 for an application of this approach to cognitive domains in reading and mathematical disorders, respectively). Notably, insights into the nature of these problems may be derived from an approach that compares traditional case–control-derived results with those resulting from a purely dimensional approach that examines the case–control differences as mirroring only the (linear) associations observed between reading decoding and the variables of interest in the developing

population without dyslexia. In two studies, we examined discrepancies between the results obtained from a traditional case–control design and those derived from a purely dimensional approach to identify weaknesses in anxiety, self-concept and reading motivation in CwD that cannot be predicted by the linear associations observed between these variables and reading in the developing population without reading problems.

An increasing interest in assessing anxiety (a set of cognitive and behavioural reactions in response to a source of threat; APA, 2013) and general self-concept (personal beliefs about oneself; Bracken, 1996; Harter et al., 1998) in CwD stems from the need to examine factors that foster their socio-emotional resilience and psychological well-being (Haft et al., 2016; Livingston et al., 2018). Although the findings vary based on the definition of dyslexia and comorbidity with attentional difficulties, anxiety seems, on average, more common in poor readers than in the controls ($d = 0.41$) (Francis et al., 2019; see also Donolato et al., 2022). CwD may show higher anxiety as a consequence of their experiences of repeated failures at school and fear of performing poorly in reading activities due to elevated frustration and avoidance of school-related activities (Livingston et al., 2018). However, it is still unclear to what extent CwD report anxiety problems, since the available research has often examined the combination between anxiety and depression in this population, with only a few studies evaluating specific aspects of anxiety or social anxiety (Mammarella et al., 2016). When it comes to self-concept in CwD, the available literature is scattered and inconsistent. A meta-analysis has pointed out that poor readers are likely to show lower general self-concept than their peers ($d = -0.57$) (McArthur et al., 2020). However, the available evidence is scarce, as the authors found only 13 eligible studies, among which some show that poor readers report lower self-concept than controls (e.g., Boetsch et al., 1996; McArthur et al., 2016) and others fail to lend support for any differences in this outcome (Frederickson & Jacobs, 2001; Taylor et al., 2010; see also Martínez & Semrud-Clikeman, 2004). Research on the developing population without dyslexia or reading difficulties has shown that severe anxiety and a weak general self-concept are associated with poor academic performance (Huang, 2011; Valentine et al., 2004) and that poor reading fluency is only weakly related to anxiety (Grills-Taquechel et al., 2012).

Two other important aspects associated with reading performance are motivation and the use of reading strategies. Reading motivation (defined as 'the individual's personal goals, values and beliefs with regard to the topics, processes and outcomes of reading'; Guthrie & Wigfield, 2000, p. 405) is particularly relevant when we look at the motivational-emotional factors underlying reading acquisition and dyslexia. A fundamental distinction between intrinsic and extrinsic motivation derives from self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000), which contrasts the former, defined as enjoyment and interest in reading activities, to the latter, described as reading competitiveness or the desire to exceed others in reading activities, on the two sides of a continuum (Möller & Bonerad, 2007). Instead, reading self-concept (i.e., the individual's expectations or self-assessment in reading activities) may be viewed as the result of inner motivational processes related to the self-concept of ability and task values that are defined by previous achievement experiences, evaluations and attributions (Eccles et al., 1998; Wigfield & Eccles, 2000). Finally, reading motivation is related to reading strategy use, described as the ability to identify the main ideas in a text, summarise its content and use monitoring strategies, which all support reading comprehension (Donegan & Wanzek, 2021; Wanzek et al., 2010; see also Schiefele et al., 2012). As concerns reading motivation, CwD report low levels of intrinsic and extrinsic motivation already in primary school (McGeown et al., 2012; Morgan et al., 2008; Zentall & Lee, 2012), with further decline in the transition to secondary school when children are followed-up in longitudinal studies (Lee & Zentall, 2017). Research has found that reading self-concept is also an area of weakness in those with reading difficulties (Morgan et al., 2008; Vaknin-Nusbaum et al., 2018; see also McArthur et al., 2020). As for the population without dyslexia or reading difficulties, there is a large body of evidence indicating a moderate positive association between intrinsic reading motivation and reading ability, while findings on the correlations between extrinsic reading motivation and reading skills point out either no associations or negative-weak correlations between these two variables (Schiefele et al., 2012; Toste et al., 2020).

Notably, this body of evidence derives from case–control studies that have compared children with and without dyslexia on anxiety, self-concept, reading motivation and reading strategy use and has never referred to the dimensional approach that combines the analysis of clinical groups through case–control studies with the examination of

these aspects in the typically developing population. Existing research so far has implemented this approach only addressing cognitive variables. For example, two recent studies suggested that the mean differences between CwD or mathematical difficulties and developing peers without such problems in a set of cognitive variables could be inferred with good approximation from the linear correlations observed between these cognitive variables and reading and math scores in samples without reading or mathematical problems (Carretti et al., 2022; Mammarella et al., 2021). What is still unclear is whether the same occurs for challenges with regard to anxiety, self-concept and reading motivation, or whether in this case the context may have more specific effects, as suggested by the bioecological model of human development (Bronfenbrenner & Morris, 2006). In fact, the bioecological model posits that child development varies substantially as a function of the interaction between the qualities of the person and the environment conceptualised as immediate and more remote environmental contexts or systems. Notably, difficulties that CwD present in anxiety, self-concept, reading motivation and reading strategies may be the result of the interplay between the child and the environment, especially when the child shows marked reading difficulties or receives a diagnosis of dyslexia. For example, low reading ability might non-linearly trigger some emotional and motivational dynamics only when the ability is below a certain threshold, as this entails failing to meet minimum school requests. In addition, the very experience of receiving a diagnosis and the joint role of school and family factors related, for example, to teacher and parental support and understanding of dyslexia, could affect anxiety, self-concept and socio-emotional resilience (Haft et al., 2016). Similar results were found in prior research on language difficulties. Goh et al. (2021) found that a series of socio-emotional and behavioural outcomes were relatively unrelated to language in the normal range of ability, but the associations were moderately strong (between 0.25 and 0.31, standardised betas) at clinically low level of language ability.

The above reasoning is in line with the bioecological model of human development, which, in the context of reading difficulties and dyslexia, aims to account for the unique and complex patterns of functioning in the *microsystem* or the home environment, the *mesosystem*, related to the school and classroom, the *exosystem*, related to the settings that support parents and families, and the *macrosystem* level, where the development of reading skills can be influenced by the extent to which parents and teachers support reading learning as largely dependent upon the cultural context. In Western countries, children with specific learning disorders are generally protected. With reference to the Italian context, a specific Law (Law 170/2010) offers support to students with dyslexia and other learning disorders, which might alleviate some of the negative socio-emotional consequences of having very low reading abilities in those who have received a formal diagnosis (Lombardi et al., 2021). Nonetheless, receiving a diagnosis might still trigger changes in children's perception as readers, possibly giving rise to a poor reading self-concept (even without affecting their general self-concept; McArthur et al., 2020), also due to the support enforced by Law. In such cases, non-linear effects would emerge along the child's reading ability continuum, disrupting any dimensional predictions.

1.1 | The present study

Two studies were conducted. Study 1a consisted of a 'traditional' case–control study in which CwD were compared against a sample of typically developing children (TDC) on anxiety, self-concept, reading motivation and reading strategy use. Standardised Mean Differences (SMDs) were calculated using Cohen's *d*. To obtain estimates that were as specific as possible, we adjusted for covariates that may affect reading acquisition, such as sex (Torppa et al., 2020) and general intelligence (Kriegbaum et al., 2018). Additionally, performance in another major area of learning, that is mathematics (Harlaar et al., 2012), was controlled, due to its well-known substantial covariance with reading ability both in the general population and in learning disorders (e.g., De Smedt, 2022). Thus, we aimed to identify emotional aspects that were related as specifically as possible with reading. Based on previous studies, we expected that the CwD group would report elevated social anxiety (Mammarella et al., 2016), adequate self-concept regarding competence but poor reading self-concept (McArthur et al., 2020), little enjoyment, interest and

competitiveness in reading activities (McGeown et al., 2012; Morgan et al., 2008), but acceptable reading strategy use to foster reading comprehension compared with the TDC group.

In Study 1b, we estimated the same SMDs under a dimensional framework hypothesis, which assumes that dyslexia merely represents the lower end of the reading ability continuum. According to this hypothesis, the SMD between dyslexia and controls on variable *X* reflects how *X* is correlated with reading ability in the general population (plus the use of a specific diagnostic cut-off and the exclusion of low IQ). In other words, linear associations across variables observed in children without dyslexia can be used to predict features of dyslexia, assuming that the latter is just the lower end of the reading ability continuum. With appropriate adaptations, any characteristics of dyslexia can be predicted under this framework. Study 1b was inspired by previous work by Carretti et al. (2022) on dyslexia, and by Mammarella et al. (2021) on mathematical learning disabilities, in which cognitive variables and their role in specific learning disorders were the focus of interest. Eventually, the dimensional predictions are disconfirmed if the case–control SMDs fail to reflect the linear associations between reading decoding and the variables of interest in the typically developing population, suggesting that non-linear effects take place or that CwD represent a separate population (see Carretti et al., 2022, for more details about the interpretation). Regarding the reading ability continuum, we took decoding speed as the measure of the children's ability (Wimmer & Goswami, 1994; see also Carretti et al., 2020) because Italian is a language with a transparent writing system (i.e., words are written the way they sound).

2 | STUDY 1a

2.1 | Methods

2.1.1 | Participants

The CwD group consisted of 34 children in school grades 4–8 (see Table 1). Children were recruited from clinical services and centres specialising in learning disabilities, where they had been diagnosed based on national guidelines defined by the Italian Consensus Conference (2011) and the ICD-10 codes (World Health Organization, 1992). This means that children had received a diagnosis of dyslexia (F 81.0) and had a total IQ of at least 85 and no diagnosis of mixed disorder of scholastic skills (F 81.3) or dyscalculia (F 81.2), no sensory or neurological problems, or other neurodevelopmental disorders, and sociocultural, or linguistic disadvantages.

The TDC group consisted of 191 children in school grades 4–8 (see Table 1) recruited from public primary and secondary schools in north-east Italy. The controls did not have any diagnosed neurodevelopmental disorders, primary visual, hearing or neurological impairments. All children came from working-class and middle-class families and spoke Italian as their first language. The mean IQ was similar in the two groups (Cohen's $d = -0.16$, [−0.53, 0.21]); all reading decoding variables presented large mean differences (Cohen's *d*s varying between 1.67 and 2.69), while mathematical abilities were different on average, but to a much smaller degree (Cohen's *d*s varying between 0.64 and 1.49). Further information on the characteristics of the CwD and TDC groups is reported in Table S1.

TABLE 1 Distribution of age and sex (assigned at birth) in children with dyslexia (CwD) and typically developing children (TDC).

	CwD group	TDC group
Age (years)	$M = 11.26$ (SD = 1.80)	$M = 11.58$ (SD = 1.43)
Males/females	23/11	84/107

Note: Unbalance in sex distribution is representative of the CwD condition and was controlled covarying sex in all subsequent models.

The study was approved by the Ethics Committee on Psychology Research at the University of Padova. The parents gave their written informed consent prior to enrolment in the study.

2.1.2 | Materials

Reading decoding

The Developmental Dyslexia and Dysorthographia-2 battery (DDE-2; Sartori et al., 2007) was used to assess the children's reading decoding skills. Subtests 2 and 3 were administered, which, respectively, comprised a list of words and a list of non-words that the child was asked to read aloud as quickly and accurately as possible in 60 s. Both subtests were scored on speed (syllables per second) and accuracy (number of errors). All scores were then standardised (*z*-scores) by grade using manual norms.

Mathematical skills

The standardised arithmetic battery (AC-MT; Cornoldi & Cazzola, 2004; Cornoldi et al., 2012) was administrated to assess children's mathematical skills. One subtest involved performing mental calculations with multiple digits (six for primary school children and four for secondary school children), scored on speed (the total time to solve the calculations) and accuracy (the number of correct answers). Participants also completed a task that involved retrieving arithmetical facts (12 for primary school children and 24 for secondary school children), which generated an accuracy score (number of correct answers). Once again, the scores in both subtests were standardised by grade into *z*-scores.

Intelligence

For the TDC group, the block design and vocabulary subtests of the Wechsler Intelligence Scale for Children (WISC) were administered for a quick estimation of the children's general IQ.[1] Data simulation based on the normative data (covariance matrices) showed that a combination of VC + BD correlates at $r = 0.871$ with GAI and $r = 0.819$ with the Full-Scale IQ, suggesting good enough approximation for the purposes of this study.

General anxiety

The Revised Children's Manifest Anxiety Scale: Second Edition (RCMAS-2; Reynolds & Richmond, 2012) was used to assess the children's anxiety. The RCMAS-2 is a self-report tool comprising 49 items with a 'Yes' or 'No' response format scored as 1 or 0, respectively. The tool examines worries (16 items; i.e., 'I am worried that my classmates could make fun of me'), physiological reactions (12 items; i.e., 'I often have a stomach ache'), social anxiety (12 items; i.e., 'I feel nervous when things don't go as I want') and the child's tendency to give a positive image of themselves (nine items; i.e., 'I like all the people I know'). Scores were added for each subscale, with higher scores indicating higher anxiety. The questionnaire showed good internal consistency for the worries (Cronbach's $\alpha = 0.86$), physiological reactions (Cronbach's $\alpha = 0.75$), social anxiety (Cronbach's $\alpha = 0.80$) and defensiveness subscales (Cronbach's $\alpha = 0.79$), as reported in the manual.

Self-concept

The Self-Concept-Competence scale (SC-C) of the Multidimensional Self-Concept Scale (MSCS; Bracken, 2003) was used. The children read 25 items and rated them on a 4-point Likert scale from 1 = *absolutely false* to 4 = *absolutely true*. The items provided information on the children's ability to master their environment, solve problems and achieve their goals (i.e., 'I have faith in myself'). Scores were summed so that higher scores indicated a higher general self-concept or self-concept related to competence. The scale has good internal consistency (Cronbach's $\alpha = 0.87$), as reported in the manual.

Reading motivation

The Italian version of the Habitual Reading Motivation Questionnaire (HRMQ) was administered (Möller & Bonerad, 2007; Viola & Sturaro, 2015). This self-report includes 19 items that the children were asked to rate on a 4-point Likert scale from 1 = *a little* to 4 = *very much*. It generates scores on subscales for reading enjoyment (five items; i.e., 'I enjoy reading books'), reading for interest (six items; i.e., 'I read to learn about my topics of interest'), reading competitiveness (four items; i.e., 'I love being the best at reading') and reading self-concept (four items; i.e., 'I generally find it easy to understand texts'). Scores were summed for each subscale, with higher scores indicating higher reading motivation. The Italian adaptation of this questionnaire showed that the different subscales were positively correlated with reading achievement (Viola & Sturaro, 2015). In the TDC group, the questionnaire's internal consistency was good for the reading enjoyment (Cronbach's $\alpha = 0.88$), adequate for the reading for interest (Cronbach's $\alpha = 0.75$), reading competitiveness (Cronbach's $\alpha = 0.78$) and reading self-concept (Cronbach's $\alpha = 0.66$) subscales.

Reading strategy use

The Questionnaire about Reading Strategies (adapted from Carretti et al., 2012) involves completing a 16-item self-report. The children were asked to rate their reading strategy use on a 4-point Likert scale ranging from 1 = *never* to 4 = *often* (i.e., 'I highlight the most important information in the text'). Scores were added up, with higher scores indicating higher reading strategy use. In the TDC group, the internal consistency of the scale was adequate (Cronbach's $\alpha = 0.73$).

2.1.3 | Procedure

The participants were tested by a trained assistant researcher during two sessions lasting approximately 60 min. In the first session, the children completed the self-report questionnaires, which were presented in the following order: the SC-C, the Questionnaire about Reading Strategies, the RCMAS-2 and the HRMQ. In the second session, the children performed the reading decoding and mathematics tasks and completed the block design and vocabulary subtests of the WISC-IV. All tasks were administered individually, and the self-report items were read aloud by the experimenter.

2.1.4 | Data analysis

As we focused on comparing the CwD and TDC groups, SMDs, calculated as Cohen's *d*, were estimated for all measured variables. In the second step, to adjust for covariates, SMDs were re-computed using linear models, entering the variables of interest as the dependent variables (one at a time) and the group (dyslexic vs. control) as the predictor. Covariates, namely, sex, intelligence and math ability scores, were entered as other predictors in the model. From a linear model, SMD was computed as the ratio between the regression coefficient for the group and the estimated sigma (standard deviation of the residuals, representing the pooled standard deviation after accounting for all covariates).

To quantify evidence in favour of an effect of the group, a Bayes Factor (BF) index was calculated using the 'BayesFactor' package in R (Morey & Rouder, 2018). By default, a Cauchy prior with a 'medium' scale parameter (i.e., $\sqrt{2}/2$) was used. A $BF_{10} > 1$ supports the alternative hypothesis (H_1) over the null hypothesis (H_0), while a $BF_{10} < 1$ supports H_0 over H_1. However, following a common rule-of-thumb interpretation (e.g., Lee & Wagenmakers, 2013), we considered any BF_{10} between 1/3 and 3 as providing anecdotal or inconsistent evidence towards either H_0 or H_1.

2.2 | Results

Table 2 shows how the CwD and TDC groups scored on all variables of interest and the comparisons between the two groups with SMDs. Scatterplots are shown in supplemental materials.

While some variables showed marked similarities between the two groups (i.e., the observed SMD was near zero), others presented substantial differences (i.e., the observed SMD > 0.50 in absolute values, with Bayesian Credible Intervals (BCIs) excluding zero and BF_{10} > 3). Due to the reduced size of the CwD group, caution should be taken in considering these differences.[2] Social anxiety approached $d = 0.50$, with higher social anxiety levels in the CwD than in the TDC group. A similar but negative effect emerged in self-concept, with a slightly lower self-concept regarding competence in the CwD than in the TDC group. On the other hand, there were no differences between the two groups in terms of worries, physiological reactions or defensiveness. As for reading motivation, the main differences were observed in reading enjoyment, reading for interest and reading self-concept in particular. The CwD group scored considerably lower than the TDC group in all of these. However, the two groups did not differ in reading competitiveness or reading strategy use.

3 | STUDY 1b

3.1 | Methods

3.1.1 | Participants, materials and procedure

The sample consisted of the same children examined in Study 1a as well as the materials and procedure.

TABLE 2 Descriptive statistics and comparisons between the children with dyslexia (CwD) and the typically developing children (TDC) groups in general intelligence, reading decoding, mathematics and other variables of interest.

	CwD group *M* (SD)	TDC group *M* (SD)	Between-group comparisons controlling for sex		
			Cohen's *d*	95% BCI	BF_{10} (H_1/H_0)
RCMAS-2 -WO	48.38 (9.21)	49.89 (10.24)	−0.09	(−0.45, 0.26)	0.25
RCMAS-2 -PA	53.82 (10.31)	51.09 (9.69)	0.23	(−0.12, 0.59)	0.49
RCMAS-2 -SO	52.53 (8.53)	48.54 (9.46)	0.44	(0.08, 0.81)	3.99
RCMAS-2 -DEF	50.74 (11.32)	49.46 (10.30)	0.14	(−0.22, 0.49)	0.29
SC-C	44.44 (10.00)	49.57 (9.06)	−0.45	(−0.82, −0.09)	3.71
HRMQ-ENJ	9.03 (3.09)	12.84 (4.25)	−0.79	(−1.16, −0.42)	>1000
HRMQ-INT	13.26 (3.86)	15.86 (3.33)	−0.65	(−1.02, −0.28)	80.22
HRMQ-COMP	6.47 (2.46)	6.36 (2.47)	−0.02	(−0.39, 0.33)	0.21
HRMQ-SC	9.74 (2.47)	12.48 (2.41)	−1.11	(−1.48, −0.72)	>1000
READ-STR	42.15 (5.45)	41.36 (5.96)	0.19	(−0.16, 0.55)	0.37

Abbreviations: BCI, Bayesian Credible Intervals; BF, Bayes Factor: It reflects the ratio between the likelihood of H_1 and H_0 given the data; see the data analysis for further details; HRMQ, reading motivation scale; HRMQ-COMP, reading competitiveness subscale; HRMQ-ENJ, reading enjoyment subscale; HRMQ-INT, interest in reading subscale; HRMQ-SC, reading self-concept subscale; RCMAS-2, anxiety scale; RCMAS-2 -DEF, defensiveness subscale; RCMAS-2 -PA, physiological reactions subscale; RCMAS-2 -SO, social anxiety subscale; RCMAS-2 -WO, worries subscale; READ-STR, reading strategy use; SC-C, Self-Concept-Competence scale.

3.1.2 | Data analysis

Having calculated the SMD from real cases, as explained in Study 1a, we adopted the following simulation procedure to estimate the predicted effect sizes from a dimensional framework that takes into consideration only the correlational data from the typically developing population. This procedure has been described by Carretti et al. (2022) and Mammarella et al. (2021). The advantage of using simulation is that it allows us to obtain exact predictions when provided with information and a set of assumptions (e.g., about the diagnostic process with its specific cut-offs and exclusion criteria) that would otherwise be difficult to obtain analytically.

The procedure involves simulating a large multivariate distribution (i.e., a population) that reproduces the exact general characteristics of the TDC group (specifically, the correlations among all variables, skewness and kurtosis, which are fully reported in the supplemental materials for Study 1b). Simulations were run using the 'MASS' (Venables & Ripley, 2002) and the 'lavaan' (Rosseel, 2012) packages in R, assuming normal distributions (but reproducing observed skewness and kurtosis parameters). To ensure stable results, we simulated a population of 6,000,000 individuals. In fact, as we also wanted to control for sex, as in Study 1a, the simulation procedure was slightly complicated by simulating and merging two separate populations of boys and girls (each with 3,000,000 individuals), which featured the same-sex differences in variables observed in the CwD group.

Once the population was simulated, the traditional case–control design of Study 1a was applied to estimate the predicted SMDs. Briefly, this method enabled SMDs to be predicted based on (1) correlational data from a sample of TDC and (2) the diagnostic procedure with inclusion and exclusion criteria adopted in case–control studies. Note that the observed and estimated SMDs provide independent information, even if the simulation uses data from the TDC group, because it is based on correlations, not on mean values.

Concerning the simulated diagnostic procedure, we identified dyslexia cases as having an overall reading decoding ability (i.e., a latent factor score obtained from word and nonword reading speed scores) under the 5th percentile, a general intelligence index not under 1 SD below average (i.e., excluding not only intellectual disability or borderline functioning, which indeed is not represented in the CwD group), and a math test score above the 5th percentile (to simulate the exclusion of mixed disorder of scholastic skills). We simulated the selection of controls as cases that had no dyslexia, no dyscalculia and no intellectual disability (i.e., the former two scores above the 5th percentile for reading and mathematics, respectively and a general intelligence not under 2 SD below average).

Overall reading decoding and mathematics scores were obtained as follows: Latent factors were estimated with confirmatory factor analysis (CFA) using the 'lavaan' package in R (Rosseel, 2012). Word and nonword reading *z*-scores for speed (i.e., age-based *z* transformations for syllables per second scores; Sartori et al., 2007) were used as the observed variables. As there were only two manifest indicators, an equality constraint was imposed on their loadings. Only speed scores were used, as recommended in the literature (Wimmer & Goswami, 1994; see also Carretti et al., 2020), because Italian has a consistently transparent orthography; therefore, errors or accuracy scores are known to be poor indicators of underlying reading skills, and they are also strongly skewed. An overall *z*-score was likewise extracted for mathematics achievement based on the three observed variables (speed and accuracy of mental calculation and accuracy of arithmetical facts).

The evidence was quantified in two ways. First, we looked at which SMDs predicted via simulation fell outside the bounds of uncertainty (95% BCIs) of the observed SMDs. Values outside the intervals were taken as analogously significantly different to the traditional null-hypothesis significance testing. Second, as in Study 1a, we computed the BF_{10}. In this case, however, the null hypothesis H_0 states that the observed SMD is not zero but the same as the value predicted via simulation. In other words, H_0 reflects the purely dimensional framework described in the introduction, while H_1 reflects its violation. This BF_{10} for an other-than-zero null hypothesis could be calculated using the 'bayestestR' package of R (Makowski et al., 2019), where we set a normally distributed prior with M equal to the null point and SD = 1, in a way analogous to that implemented by the 'BayesFactor' package for computing Bayesian *t*-tests. As in Study 1a, we interpreted $BF_{10} < 1$ as supporting H_0, $BF > 1$ as supporting H_1, although, using the rule-of-thumb described earlier, we also interpreted any BF_{10} between 1/3 and 3 as providing weak evidence.

3.2 | Results

Figure 1 shows the observed SMDs (black solid points) and their 95% BCIs (error bars), estimated from the comparison between the CwD and the TDC groups, as calculated in Study 1a. Importantly, Figure 1 also shows the values predicted dimensionally (blue triangular points) via the simulation procedure described above. For most variables, the predicted values fell within the range of the uncertainty of the values estimated from the real observed data. Nonetheless, the BFs supported the null hypothesis (that the estimates from the predicted and observed values coincided) only weakly for most variables.

In three cases, the BFs > 3 brought strong enough evidence of non-zero discrepancy between SMDs estimated from predicted versus observed values. The most notable case concerned reading self-concept related to reading decoding. For this variable, there was a very large SMD between the CwD and the TDC groups, whereas the predictions suggested virtually no difference between them. This means that, while reading ability may be scarcely related to reading self-concept in the TDC group (Table S2 in the supplemental materials shows a correlation of only $r = -0.15$), the CwD group experience, on average, an unexpectedly large weakness in this factor.

A similar exception, but in the opposite direction and to a much smaller extent, concerned reading competitiveness. This factor seemed to relate only moderately to reading decoding (the predicted Cohen's *d* was around −0.50), although the CwD group did not differ, on average, from the TDC group (the Cohen's *d* observed on real data was virtually zero). This suggests that contrary to what might be expected from the positive correlation between reading ability and reading competitiveness observed in the TDC group (Study 1a), the CwD group was not lacking in reading competitiveness.

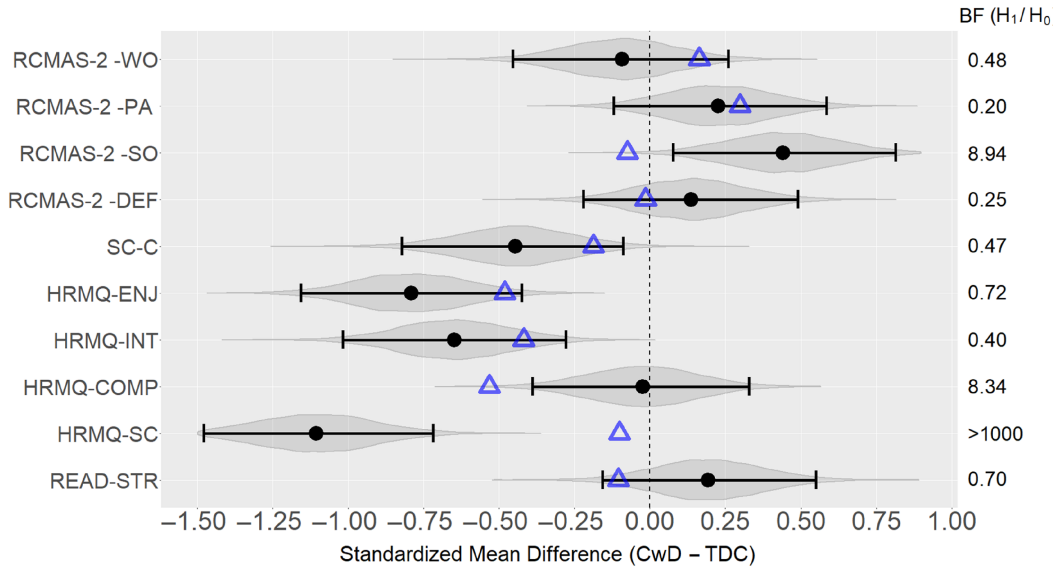

FIGURE 1 Observed (solid dots) versus predicted via simulation (triangles) standardised mean differences (Cohen's *d*s) between the dyslexia and control groups for all variables of interest. The Bayes factors (BFs) quantify the evidence against the dimensional hypothesis (i.e., evidence that an observed-predicted discrepancy in Cohen's *d* is non-zero). Error bars represent 95% Bayesian credible intervals calculated with the percentile method on the posterior distributions. Grey violins represent the posterior distributions of standardised differences. CwD, children with dyslexia; HRMQ, reading motivation scale; HRMQ-COMP, reading competitiveness subscale; HRMQ-ENJ, reading enjoyment subscale; HRMQ-INT, interest in reading subscale; HRMQ-SC, reading self-concept subscale; RCMAS-2, anxiety scale; RCMAS-2 -DEF, defensiveness subscale; RCMAS-2 -PA, physiological reactions subscale; RCMAS-2 -SO, social anxiety subscale; RCMAS-2 -WO, worries subscale; READ-STR, reading strategy use; SC-C, Self-Concept-Competence scale; TDC, typically developing children.

Another notable discrepancy concerned social anxiety, which was found to be unrelated to reading decoding (i.e., the predicted Cohen's *d* was zero), despite the CwD group reporting moderately more social anxiety issues on average than the TDC group (the Cohen's *d* observed in real data was nearly 0.50). In other words, CwD reported slightly more social anxiety than the TDC, despite a nearly null association between reading ability and social anxiety in the TDC group.

4 | DISCUSSION

We presented two studies to examine the extent to which CwD and TDC differed in anxiety, self-concept, reading motivation and strategy use. In Study 1a, we implemented a traditional case–control design in which CwD were compared with their peers without reading problems. In Study 1b, we estimated the differences between the two groups by implementing a dimensional approach to investigate whether weaknesses in anxiety, self-concept, reading motivation and strategy use reported by CwD could be inferred from the parameters seen in the TDC group. In doing so, we aimed to examine possible discrepancies between the results obtained using these two methods.

Study 1a showed that the CwD group reported higher scores for social anxiety than the TDC group, while no differences emerged for worries, physiological reactions or defensiveness scores. As for self-concept regarding competence, CwD showed slightly lower scores than the TDC. The CwD group also reported weaknesses, on average, in several areas of reading motivation, including lower reading enjoyment, reading for interest and especially reading self-concept, compared with the TDC group. However, no discrepancies between the two groups were detected in reading competitiveness or reading strategy use. Importantly, our findings emerged once all scores were adjusted for sex, intelligence and mathematical ability scores, indicating the robustness of these results, once accounting for these variables.

In Study 1b, we re-estimated the same differences between the two groups, but now implementing a dimensional approach, inspired by Carretti et al. (2022), Mammarella et al. (2021) and Peters and Ansari (2019), to predict the SMDs between the CwD and the TDC groups in our variables of interest. The results indicated that the CwD group reported slightly more social anxiety and a slightly lower general self-concept relating to competence than the TDC group did, while the two groups did not differ substantially in terms of worries, physiological reactions or defensiveness. There were larger differences between the two groups for most aspects of reading motivation (interest in reading, reading enjoyment and reading self-concept), whereas they were comparable with regard to reading competitiveness and reading strategy use. Overall, these results confirm that CwD experience, on average, a specific loss in several aspects of reading motivation (which were domain-specific in the clinical group examined) but retain a fairly adequate emotional adjustment.

As for anxiety, the results of Studies 1a and 1b align with evidence that CwD report higher levels of anxiety compared with their peers without dyslexia (Mammarella et al., 2016) and extend the available literature by indicating that struggling readers may show higher anxiety experience in social contexts rather than general anxiety symptoms. It is common for CwD to expect to perform poorly and worry about having to read aloud in class, which may trigger symptoms of social anxiety (Mammarella et al., 2016). Importantly, however, the results of Study 1b suggested that this effect may be specific to children who have received a diagnosis of dyslexia, rather than reflecting the way in which social anxiety is related to reading ability on a continuum. Our results also contribute to scattered research examining self-concept in CwD (McArthur et al., 2020) and evidence of their reading motivation and strategy use (McGeown et al., 2012; Morgan et al., 2008; Vaknin-Nusbaum et al., 2018). Interestingly, our findings show that CwD may perceive themselves as generally less competent than their peers without dyslexia, which is especially true when they evaluate themselves as readers. Once again, however, this does not reflect the relationship between reading ability and self-concept on a continuum. This might indicate that children who have received a diagnosis of dyslexia become more aware of their (poor) reading decoding abilities, whereas most other children cannot accurately assess their own competence in reading decoding. Another possibility is that reading performance in

CwD is not just below average but poor enough to become clearly apparent (perhaps regardless of a diagnosis). Finally, an interesting piece of evidence concerns reading competitiveness. On average, the latter was not different in the CwD than in the TDC group (Study 1a). Nevertheless, the dimensional framework suggested that a negative effect of dyslexia should be expected in this variable (Study 1b). That is, after controlling for sex, intelligence and math ability, we should expect a moderate dyslexia-control difference based on the set of linear relationships, but this difference is not actually observed. This may be because the dyslexic children in our study were likely to be involved in training programmes targeting reading decoding, which might have indirectly influenced their reading competitiveness but not their social anxiety.

As for the predictions made on the developing population without dyslexia, our results suggest that the average profile of the dyslexic children in Study 1b can be set in a dimensional framework with a good degree of accuracy for many of the variables of interest, but there is also a series of 'violations'. The main violation of the dimensional framework emerged for reading self-concept: The CwD group reported a much greater loss in this area than might have been expected from the association between reading self-concept and reading decoding (adjusted for sex, general intelligence and mathematical skills) in the TDC group. Thus, in our two studies, there were no other areas revealing major differences between the CwD and TDC groups (i.e., no other Cohen's *d* exceeded 0.80). In other words, the CwD group had only small to moderate problems in most aspects we examined. Future studies, therefore, need to replicate our findings with dyslexic children coming from other socio-economic backgrounds or less able to access psychological support after their diagnosis. The moderate size of the TDC group considered in Study 1a also means that further studies need to replicate our results in larger samples and with other measures to evaluate reading self-concept as the reliability of the subscale used to assess this variable in the present study was not optimal. Finally, during the recruitment of the CwD group, information reported in the last clinical certification was examined to evaluate participants for eligibility to the study and have updated data on their reading, spelling and mathematics performance. However, other relevant information, such as the age of the first certification or whether participants had received interventions for their reading problems, was unavailable and, therefore, not examined in this contribution.

To sum up, the present study showed that the levels of anxiety, self-concept, reading motivation and strategy use in CwD may only partially reflect their linear associations with reading decoding (having taken into account their sex, intelligence and math ability) on a continuum, which should be expected when a dimensional approach is adopted. This means that anxiety, self-concept, reading motivation and reading strategy use may not be accurately inferred from the set of relationships among variables observed in the developing population without dyslexia, as some discrepancies might emerge. Caution should be used in interpreting the results, however. As the sample size was limited, rather large bounds of uncertainty remained (see error bars in Figure 1). This means that, on the one hand, we might have lacked sensitivity to detect smaller discrepancies in other variables, while on the other hand, some discrepancies might have been exaggerated. Thus, it is recommended to put more emphasis on quantitative estimation with uncertainty rather than dichotomous statistical inference when interpreting our current results. Additionally, the limitation in sample size prevented us from conducting more fine-grained analyses, such as testing mediations via structural equation models and moderations via interactions. In fact, the variables investigated (e.g., motivation and self-concept) might be mediators in the relationship between reading decoding ability (or diagnosis) and distal outcomes such as anxiety, and/or they may moderate it. For instance, one may argue that higher levels of protective factors such as self-concept might soften the relationship between (low) reading ability and (high) mental health issues (see Boyes et al., 2018, for similar results concerning self-esteem as a moderator). These suggestions may inform future lines of research on reading difficulties within a dimensional framework, contingent upon the availability of larger samples.

The crucial advantage of testing a dimensional approach (as in Study 1b), is that it allows us to uncover the dimensions in which clinical groups behave. This is similar to the end of a (linear) continuum of individual differences and those that represent 'special' characteristics and modalities of functioning and are qualitatively different from the rest of the population. According to the bioecological model of human development (Bronfenbrenner &

Morris, 2006), these violations or discrepancies from the predictions in the typically developing population might vary according to the individual experience of having a diagnosis of dyslexia or other factors related to family and school to which a child with a diagnosis of dyslexia is exposed. That is, the social context might modulate CwD's response to their diagnosis, especially through the type of social support that these children can receive for their reading difficulties. Notably, our findings expand the available literature on anxiety and reading motivation in CwD by suggesting that challenges in reading self-concept and social anxiety may derive from different mechanisms than difficulties in reading motivation. However, the mechanisms underlying such differences are unclear and need to be investigated in future studies.

Back to our results, our findings are partly in contrast with what was observed in previous studies that examined cognitive characteristics, in which the dimensional frameworks were more consistently confirmed (Carretti et al., 2022; Mammarella et al., 2021). The major violation of predictions based on the developing population in our group of dyslexic children concerned reading self-concept and social anxiety, pointing out that CwD should receive support not only for their reading impairment but also to preserve a positive image of themselves as readers and cope with social apprehension.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy restrictions.

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ENDNOTES

[1] It is worth noting that the Wechsler full-scale IQ may be a biased indicator of general intellectual level in children with specific learning disorders. Previous research found that working memory and processing speed subtests are much weaker (due to specificities of the material involved) and only weakly related to the *g*-factor in children with learning disorders vis-à-vis the developing population without learning disorders (Giofrè et al., 2019; Giofrè & Cornoldi, 2015). We consequently used the General Ability Index (GAI) as a proxy for intellectual level in the dyslexic group (Saklofske et al., 2005; Italian standardization by Orsini & Pezzuti, 2014). Full intelligence assessments were conducted using the WISC–III (Orsini & Picone, 2006) or the WISC-IV (Orsini et al., 2012) battery obtained from the specialist centres where children had been diagnosed. For the few children in the CwD group assessed with the WISC-III, their Performance IQ was used as a proxy for intellectual level.

[2] A Monte Carlo simulation with 5000 iterations showed that in our conditions ($n_1 = 191$, $n_2 = 34$), and using the confidence interval bounds as a criterion for inference (i.e., simulated Cohen's *d* falling outside the bounds of the observed Cohen's *d* in order to reject H_0), a power of about 80% is reached for discrepancies of at least 0.50.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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