

Systematic Review

Academic Skills in Students with Autism Spectrum Disorder and Intellectual Disability: A Systematic Review and Meta-Analysis

Francesco Domenico Di Blasi ^{1,*} , Angela Antonia Costanzo ¹, Maria Finocchiaro ¹, Maria Agatina Stimoli ¹, Rosa Zuccarello ¹, Serafino Buono ¹, Raffaele Ferri ²  and Pierluigi Zoccolotti ^{3,4} 

¹ Unit of Psychology, Oasi Research Institute-IRCCS, 94018 Troina, Italy; acostanzo@oasi.en.it (A.A.C.); mfinocchiaro@oasi.en.it (M.F.); astimoli@oasi.en.it (M.A.S.); rzuccarello@oasi.en.it (R.Z.); fbuono@oasi.en.it (S.B.)

² Sleep Research Centre, Oasi Research Institute-IRCCS, 94018 Troina, Italy; rferri@oasi.en.it

³ Department of Psychology, Sapienza University of Rome, 00185 Roma, Italy; pierluigi.zoccolotti@uniroma1.it

⁴ Tuscany Rehabilitation Clinic, 52025 Montevarchi, Italy; pierluigi.zoccolotti@crtspa.it

* Correspondence: fdiblasi@oasi.en.it

Abstract: Background: A substantial proportion of children with autism spectrum disorder (ASD) also have an intellectual disability (ID). However, the academic achievement levels of students with ASD and ID (ASD-ID) are poorly documented and known. Method: We systematically reviewed studies on school skills (reading, spelling, and math) in children and adolescents with ASD-ID. The search was conducted in seven bibliographic databases: Embase, Pubmed/MEDLINE, PsycINFO, Cochrane Library, Ebscohost, Proquest, and Scopus until 28 May 2022. Results: We identified 33,750 reports, four of which met the inclusion criteria for the review. The studies, characterized by Level III evidence (non-randomized controlled trials), included 535 students, 266 in the ASD-ID group and 269 in the ASD-no ID group. A random-effects model meta-analysis revealed that students with ASD-ID had significantly lower reading, spelling, and math scores than students with ASD-no ID. The effect sizes associated with reading score differences were large, although with significant heterogeneity; similarly, the effect sizes associated with spelling and math score differences were also large, although to a lesser extent than for reading. Conclusions: The co-presence of ASD and ID is associated with significant deficits in reading, spelling, and math. However, the present meta-analytic results rest on a limited number of studies. This contrasts with the substantial proportion of children with ASD who have ID and highlights the need for further research to fill a significant gap regarding the profile of academic abilities of students with ASD-ID.

Keywords: autism spectrum disorder; intellectual disability; academic achievement; meta-analysis; systematic review



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1. Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental condition with difficulties in communication and social interaction associated with restricted and repetitive behaviors and interests [1]; ASD can be associated with varying degrees of intellectual disability (ID), language and motor delays, and sensory processing difficulties [2–4]. Before the year 2000, prevalence data for the ASD condition associated with ID (IQ < 70) ranged from 70% to 75%; more recent figures indicate 30% to 40% [5–12]. This revision in the percentage of ID is likely due to the renewed conceptualization of autism, the use of more accurate diagnostic protocols, and the increase in the proportion of ASD children without ID who are recognized even in milder forms [13,14]. About the ASD population with ID, only a few studies report the distribution among different levels of cognitive and adaptive functioning. So, the data are very variable and not easily comparable. The percentage of people with

severe ID varies between 7.4% and 38.8%, those with moderate ID vary between 8.4% and 81%, and those with mild ID between 6.6% and 39.4% [5,6,9,10,15–22].

The ability to read, write and calculate at a proficient level is crucial for intellectual and adaptive functioning for students with ASD, more specifically for students with ID. Children on this spectrum require life-long specific support and learning environments to achieve the best possible quality of life outcomes [23]. In past years, the academic achievement and inclusion of students with ASD have received particular attention. However, a recent review highlights that, concerning school skills and related environmental factors, students with ASD with ID are little studied and analyzed [24]. Indeed, most studies available in the literature focus on students with ASD without ID [24]. They typically show wide variability in profiles with mixed results regarding the level of academic skills. For example, decoding skills are often reported in the middle or upper range in students with ASD without ID, beyond general cognitive functioning and verbal skills [24,25]. By contrast, reading comprehension appears to be significantly impaired [25]. Another area of significantly weakened school skills is writing (sentence construction and handwriting) [26,27]. As in the case of reading, mathematical performance is reported as variable, and results depend upon the sub-skill examined [24,28]. Thus, compared to peers with typical development, students with ASD without ID show greater impairment in mathematical reasoning tasks, inferential processing, and problem-solving abilities than in computational skills [29–31].

It should be noted that the school environment can be very challenging for students with autism. The manifestation of problematic behaviour in the school context is the most relevant obstacle to achieving inclusion and interferes with learning and social adaptation. The lack of absence or recognition of the peculiarities of the autistic condition is the origin of problematic behaviour in most cases [32]. An environment not adapted to the atypical characteristics of the condition, such as the social-communicative and interaction deficit, anxiety for the lack of order and predictability in school [33], and the very intense sensory stimuli, such as high noise levels in the classroom [34] can have a highly negative impact on the acquisition of school skills and adaptation [35]. Furthermore, the different environments of learning, such as mainstream school settings or special education classrooms, may place a lesser or higher emphasis on cognitive, social, and academic skills with contrasting results, particularly for students with ASD with lower IQ [23,36–38].

The limitation in studies on academic achievement of ASD-ID may reflect difficulties in administering standardized measures to people with cognitive-behavioral profiles of varying severity (e.g., no language) and the lack of appropriate instruments for this population [24,39]. Therefore, the academic achievement levels of students with ASD and ID are poorly documented and known. Increasing knowledge and evidence about this subgroup of people on the autism spectrum can help improve assessment, rehabilitation, and support for learning and their participation/inclusion in social life and school activities.

This paper aims to systematically review studies on school skills (reading, spelling, and math) in children and adolescents with ASD and ID. We performed a meta-analysis for the scores obtained for reading, spelling, and math, comparing groups of students with ASD-ID with those of students with ASD-no ID. Data on the school skills of students with ID could help to extend knowledge about the autism spectrum with this impairment profile and, consequently, set up interventions to improve their school achievements.

2. Materials and Methods

2.1. Study Design

Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, we reviewed studies published up to 28 May 2022. We carried out a random-effects model meta-analysis for the scores obtained for reading, spelling, and math. The Cochran's Q test for heterogeneity was used to examine variation in effect size between selected studies.

2.2. Search Strategy

We searched the following databases: Embase, PubMed/MEDLINE, PsycINFO, Cochrane Library, Ebscohost, Proquest, and Scopus. The following term combination was used: (“academic achievement” OR “academic performance” OR “academic skills”) AND (“autism” OR “autism disorder” OR “autism syndrome”) AND (“intellectual disability” OR “intellectual disabilities” OR “intellectual impairment” OR “low-functioning” OR “developmental disorder” OR “mental retardation” OR “developmental disabilities” OR “neurodevelopmental disorder”).

2.3. Selection Criteria

We included studies that: (a) reported original research; (b) were conducted with groups of patients with autism and ID (IQ < 70, measured by standardized tests); (c) were published in English in peer-reviewed journals; (d) used standardized tests of academic achievement (emergent literacy and numeracy; reading decoding or comprehension, writing or spelling or handwriting, math or numeracy or problem-solving or arithmetic) compared to the performance of a control group; (e) examined students with and without ID, but it was possible to separate the data regarding participants with ID; (f) papers not consistent with the area of interest or with the selection criteria, such as, for example, reviews, comments, and editorials or letters, were not taken into consideration.

2.4. Selection, Procedures, Screening and Data Elaboration

The search and selection of papers was carried out by one of the authors (F.D.D.B.) and the eligibility of papers by two other independent authors (A.A.C. and M.A.S.). The research algorithm produced a total of 33,750 studies, 266 of which were considered potentially eligible (see Figure 1). Among these, the final papers were selected for review by carefully applying the criteria reported above. The level of evidence, modified from the recommendations by the Oxford Centre for Evidence-Based Medicine Guidelines Levels of Evidence Working Group [40], was also assessed for each paper included in the subsequent meta-analysis, as follows: Level III—non-randomized controlled trials.

2.5. Measures of Academic Achievement and ASD Diagnostic Tools

In the studies analyzed, reading skills were assessed only for the decoding parameter, while the assessment of text comprehension was only partially performed or absent. However, reading comprehension might be a weakness for students with ASD-ID. One of four studies [41] used an inclusive measure of reading (broad reading) that also comprised an assessment of text comprehension. However, using the overall result does not allow the analysis of the performance in individual subtests, including text comprehension. In another study [42], the results of the text comprehension test were expressed in grade-equivalents, a data format with which analysis is not possible. In the study by Mayes et al. [43], students with ASD-ID did not complete the comprehension test.

Several tools were used to diagnose autism. In one study, the DSM-IV criteria were used [43]. One study [38] used the Autism Diagnostic Interview-Revised (ADI-R) [44]. Another study [45] used, in combination with the DSM-IV criteria for autism disorder, the Autism Diagnostic Observation Schedule (ADOS) [46] and the ADI-R [44]. One study [41] used a questionnaire for parents and caregivers, the Social Communication Questionnaire (SCQ) [47], and a rating scale for teachers/caregivers, the Social Responsiveness Scale-Second Edition (SRS) [48]. No studies reported comorbidities with the diagnosis of ASD.

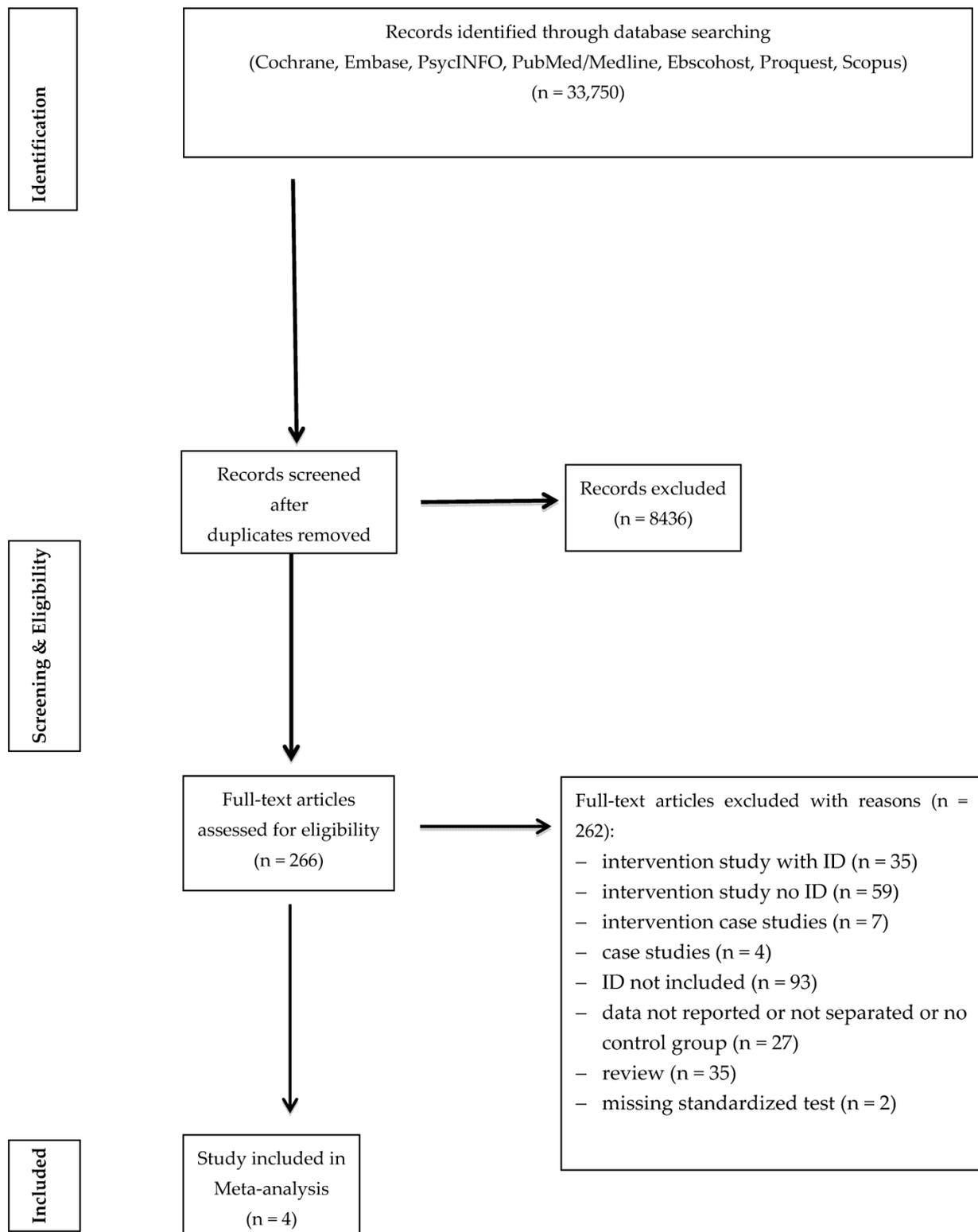


Figure 1. Flow diagram of the selection process of studies.

2.6. Data Extraction

We extracted details of the study design, participants, experimental and control groups, and measures from the selected papers. The measures to be analyzed were pre-specified before numerical data extraction. This review sought to examine the level of reading, writing, and math skills. For the reading items, we included only decoding ability. For

writing, we used the measure of spelling ability. For mathematics, we used the ability to solve arithmetic operations. Measures obtained by standardized tests were used. Two independent reviewers (M.F. and R.Z.) extracted results, with a third reviewer calling to resolve any discrepancies (S.B.). The data were extracted and expressed in tabular form.

2.7. Meta-Analysis (Random-Effects Model)

We carried out a random-effects model meta-analysis for the scores obtained for reading, spelling, and math. Means, standard deviations, and sample sizes were the input data for all meta-analyses. The DerSimonian–Laird estimator was used because it does not need normally distributed data [49–51]. The heterogeneity of parameters was assessed using Cochran’s Q test, with a $p < 0.10$ indicating evidence of heterogeneity [51]. Heterogeneity was also quantified by the I^2 statistics [50], expressed as a percentage: values greater than 50% indicate substantial heterogeneity [52].

3. Results

A total of four studies were selected for the meta-analysis. Table 1 reports a summary of the reading, spelling, and math results reported by these studies. A detailed description of the methodology and results of the single studies is presented in Table 2. Note that sample sizes were variable and ranged from 21 to 146 subjects. The total sample included 535 subjects, 266 in the patient group (ASD-ID) and 269 in the control group (ASD-no ID), ranging in age from 8.5 to 22 years. In the patient group, IQ ranged from 43.42 to 68.65, while in the control group, it ranged from 97.36 to 103.3. Participants were predominantly male, with their percentages ranging between 66.89% and 88%. The studies did not report separate male-female values concerning test results. Thus, statistical analyses on this issue were not possible. The four studies were characterized by Level III evidence (non-randomized controlled trials).

Table 1. Reading, spelling, and math scores in all groups of ASD-ID and ASD-no ID in the four studies included in this review.

Study	Sample Size	ASD-ID Group			ASD-No ID Group		
		Mean	S.D.	Sample Size	Mean	S.D.	
Reading							
Mayes and Calhoun [43]	21	81	18	42	102	15	
Kim et al. [42]	47	68.5	16.9	27	100.9	14.8	
McIntyre et al. [41]	111	14.07	5.1	146	91.7	8.1	
Zaidman-Zait et al. [45]	43	62.49	17.8	54	107.7	16.1	
	44	85.11	13.3				
Spelling							
Mayes and Calhoun [43]	21	78	23	42	102	17	
Kim et al. [42]	47	70.7	17.1	27	102.6	18.9	
Zaidman-Zait et al. [45]	43	64.49	18.3	54	110.6	17.3	
	44	85.44	16.3				
Math							
Mayes and Calhoun [43]	21	68	18	42	96	16	
Kim et al. [42]	47	53.3	22.1	27	101.3	17.1	
Zaidman-Zait et al. [45]	43	54.4	14.4	54	100.3	20.5	
	44	70.55	13.0				

Table 2. Selected studies comparing the academic skills (reading, spelling, and math) of students with ASD-ID and ASD-no ID.

Reference	N	Age at Assessment, Years Mean \pm SD, Range	IQ Mean \pm SD, Range (Tool)	Academic Skills Measures (Tool)	Findings	Study Design Level of Evidence
Mayes and Calhoun [43]	N = 21 ASD-ID ^o N = 42 ASD ^o 79% Males	8.5, 6–15	67 \pm 10, 48–79 103 \pm 16, 80–143 (WISC-III)	Reading Word reading Pseudoword decoding Spelling Math Numerical Operations (WIAT-II)	ASD-ID Reading decoding significantly exceeded IQ ASD-ID Spelling and Math scores did not differ significantly from IQ	Cross-sectional Level III
Kim et al. [42]	N = 47 ASD-ID ^o N = 27 ASD ^o N = 19 ID not ASD N = 18 not ASD not ID 67% Males	9	55 \pm 14.9 103.3 \pm 11.9 53.3 \pm 17.2 105.8 \pm 11.6 (WISC-III) (DAS)	Reading Letter identification Word recognition Spelling Math Arithmetic (WRAT-3)	Lower-IQ group showed consistently lower achievement for Reading, Spelling, and Math scores than the Higher-IQ group for both ASD and Non-Spectrum cases	Longitudinal Level III
Zaidman-Zait et al. [45]	N = 43 ASD-ID ^o N = 44 ASD-ID ^o N = 54 ASD ^o N = 37 ASD 88% Males	10.6 \pm 0.57	43.42 \pm 18.55 68.65 \pm 11.35 98.51 \pm 14.67 87.06 \pm 14.69 (WISC-IV) (M-P-R)	Reading Word reading (WIAT-II-A) Spelling (WIAT-II-A) Math Numerical Operations (WIAT-II-A)	ASD-ID had lowest academic achievement for Reading, Spelling, and Math scores	Longitudinal Level III
McIntyre et al. [41]	N = 111 ASD-ID ^o N = 148 ASD-low IQ N = 146 ASD-average IQ ^o N = 139 ASD-high IQ 86% Males	16.2 \pm 1.44, 13–22	49.94 \pm 20.86 * 77.38 \pm 20.80 * 97.36 \pm 19.57 * 104.53 \pm 18.86 * (Leiter-3)	Reading Passage Comprehension (WJ-III)	ASD-ID had very low academic achievement scores	Longitudinal Level III

ASD: autism spectrum disorder; ID: intellectual disability; SD: standard deviation; IQ: intelligence quotient; WISC-III: Wechsler Intelligence Scale for Children-III; WISC-IV: Wechsler Intelligence Scale for Children-IV; WJ-III: Woodcock-Johnson Tests of Achievement III; WIAT-II-A: Wechsler Individual Achievement Test-II Abbreviated; M-P-R: Merrill-Palmer-Revised Scales of Development; WRAT-3: Wide Range Achievement Test-3; Leiter-3: Leiter International Performance Scale-3; DAS: Differential Abilities Scale. ^o Samples included in the meta-analysis. * Derived from SE values in McIntyre et al. [41].

Figure 2 shows the results of the meta-analysis of reading, spelling, and math score differences between the ASD-ID and the ASD-no ID groups. The effect sizes associated with the reading score differences (decreased in the ASD-ID group) ranged from -1.29 to -20.3 , for a total of -5.35 (95% confidence interval: -2.52 , -8.17). However, heterogeneity was significantly high ($Q = 411.99$, $p < 0.001$, $I^2 = 99.03\%$). As it is apparent in Figure 2, results from one study [41] were quite deviant from all the others. Excluding these data, the total effect size associated with the reading score differences decreased to -1.85 (95% confidence interval: -1.25 , -2.45). Also, heterogeneity decreased, although it was still substantial and significant ($Q = 14.43$, $p < 0.002$, $I^2 = 79.21\%$). Similarly, the effect sizes associated with spelling and math score differences (both decreased in the ASD-ID group) ranged from -1.24 to -2.58 (total -1.77 ; 95% confidence interval: -1.21 , -2.32) and from -1.66 to -2.52 (total -2.04 ; 95% confidence interval: -1.60 , -2.48), respectively. Again, heterogeneity was significantly high in both cases ($Q = 13.52$, $p = 0.004$, $I^2 = 77.81\%$; $Q = 7.77$, $p = 0.051$, $I^2 = 61.37\%$), although to a lesser extent than for reading.

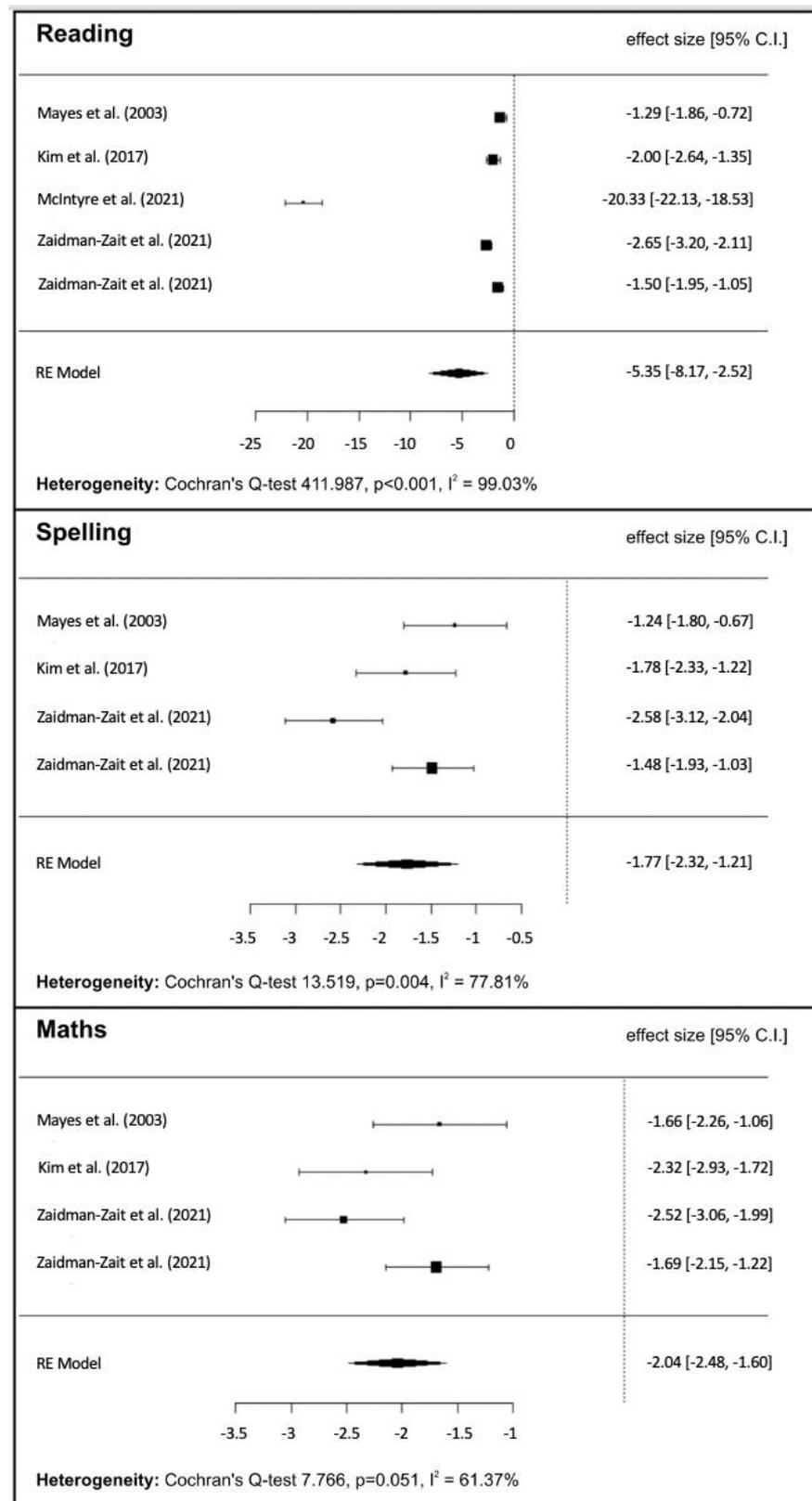


Figure 2. Meta-analysis of the selected studies [41–43,45] comparing the reading (top panel), spelling (middle panel), and math (bottom panel) scores of groups of students with ASD-ID and groups of students with ASD-no ID.

4. Discussion

This systematic review and meta-analysis revealed that students with ASD-ID have significant impairments in reading, spelling, and math compared to students with ASD-no ID. As for reading skills, the differences are more pronounced than in spelling and mathematics skills. However, this effect on reading seems greatly influenced by the data of a single investigation [41]. Notably, this study, which had a large sample size, used a broad reading measure which included an assessment of text comprehension. Thus, it is not easy to tease out the influence of these aspects on the overall evaluation concerning the reading effect in the meta-analysis. Of note, the results of this review rest on a limited number of studies. This observation contrasts with the substantial proportion of children with ASD who have ID and highlights the need for further research to fill a significant gap in our knowledge regarding the level/profile of academic abilities of students with ASD-ID.

An analysis of the participants in the four studies reviewed shows a wide range of ages at the time of the assessment. Younger children may have still been at a stage of learning the skill, while others may have already established and matured it. However, this should not generally affect the limited level of performance, compared to the control group. This finding dictates the need for longitudinal studies that can better represent the development of these skills over the school-age span, also studying any functional spillovers into daily life.

Studies do not report separate data for males and females. In a recent review, Saure et al. [53] pointed out that girls with ASD-ID show different symptom profiles than boys, suggesting that intellectual disability may influence sex differences within the autism spectrum. The same study indicates that when the ID condition is present, girls show more pronounced difficulties than boys in the areas of communication and social interaction, as well as language skills. Therefore, studies should also include a meaningful proportion of girls and report data separated by sex. This may help better define the differences in symptom and ability profiles that appear to differ between boys/men and girls/women with ID.

Text comprehension is a critical area for school learning. However, we could not separately evaluate this domain due to the absence or partial administration of tests in this area (apart from a study which used grade-equivalent scores [42], precluding the possibility of including it in the meta-analysis). However, there are indirect indications that text comprehension may be a critical area in children with ASD-ID. Thus, in Mayes et al.'s [43] study, children were unable to complete the comprehension test. Furthermore, as stated above, the study [41] using a broad measure of reading tapping both decoding and text comprehension [41], showed the worst level of performance in children with ASD-ID. Thus, despite direct evidence on this point, there are reasons to think that text comprehension is an area of weakness in the ASD population over and above the presence of ID (for a review, see [54]).

Overall, the meta-analysis indicates that in students with ASD, the presence of ID is an important negative prognostic factor for the acquisition of basic academic skills (reading, spelling, and math). However, the data also indicated the presence of considerable variability in performance among the groups analyzed in the selected studies. For example, in Mayes et al.'s [43] study, the students with ASD-ID obtained scores in mathematics and spelling, as expected based on IQ; by contrast, their decoding performance was significantly better than general cognitive functioning. This finding may have been affected by the limited numerosity of the group and the wide variability in the performance of its constituent individuals. The variability among academic skills, previously reported in some students [55], underscores the need to identify strengths and weaknesses in all areas of academic skills for each ASD-ID student. The longitudinal study by Kim et al. [42] reported discrepant abilities concerning IQ in reading and spelling or math in some students assessed at nine years of age and then at 18. This finding implies that early assessment and programming to enhance these skills may have long-term effects on school skill development in ASD, during adolescence and adulthood. Three out of four studies investigated

the effects of behavioral problems, language skills, and autistic symptomatology, as well as cognitive level, on the school skills of students with ASD-ID, trying to define profiles to set up necessary supports, as individualized as possible.

Although there is a large body of literature on school skills interventions predominantly based on individual cases [56–58], addressing these gaps in the assessment will give us more evidence to provide a more precise and more accurate database to support effective educational strategies and rehabilitation procedures for students with ASD-ID. In this vein, the findings of our meta-analysis stress the importance of early and comprehensive assessments in educational and clinical settings to identify learning difficulties within this population. Clinicians, educators, and parents should work collaboratively to develop customized intervention plans tailored to the unique needs of students with ASD-ID, focusing on strengthening their academic skills. Implementing evidence-based strategies and providing consistent support can be instrumental in mitigating the observed deficits in reading, spelling, and math, thus promoting more inclusive and positive educational experiences for these students.

The identification of psycho-educational profiles within the student population with ASD is fundamental to supporting their specific learning needs. Such considerations must encourage research to carry out studies that investigate cognitive functions and syndromic characteristics in relation to all aspects of learning. The importance of individualised assessments that indicate the strengths and weaknesses of children and adolescents with ASD-ID can help develop targeted educational programming. Therefore, further research is needed that targets longitudinal growth in academic achievement among subgroups of children with ASD and identifies factors related to individual characteristics and environment as predictors of academic achievement.

Furthermore, there is a need for multidisciplinary approaches integrating behavioral and educational interventions. Speech and language therapists, special educators, and psychologists can play pivotal roles in designing and delivering interventions that address the varying degrees of impairment in reading, spelling, and math. The emphasis should extend beyond academic achievement and encompass the development of communication and social skills, often intertwined with academic success. Early identification and intervention can significantly improve the outcomes for students with ASD-ID, potentially enhancing their quality of life and long-term prospects. A more stimulation-enriched educational environment could foster the learning of academic skills not only for students with ASD in general, but especially for those with associated ID and with the support of teachers and practitioners trained beyond the type of school-educational setting.

5. Limitations

With our review, we confirm a gap in studies dealing with ASD, particularly concerning the assessment by standardized tests of reading, spelling, and math skills of students with ID. The results are based on only a few studies, preventing us from drawing firm conclusions. Thus, our review has some limitations. First, given the different tests used and the difficulties in administering standardized tests to students with ASD-ID, future studies should include a greater variety of assessment types and instruments, including more individualized forms [24,39,59]. Second, there are absent or incomplete assessments of text comprehension, a crucial skill for academic success and adaptation; future studies should include such measures. Third, the performance of girls and boys with ASD-ID is not separately reported and, therefore, not studied in this review. So, to better define learning profiles, including samples with both males and females is needed. Another limitation is that none of the studies report the presence of comorbidities that could further affect assessment and learning levels.

6. Future Directions

The future holds promising perspectives for enhancing reading, spelling, and computation skills in individuals with ASD. One avenue of progress lies in developing personalized

and adaptive educational technologies. These tools will leverage artificial intelligence and machine learning algorithms to tailor instructional content to the unique needs and learning styles of each individual with ASD. By continuously adapting to the learner's progress and preferences, these systems can provide targeted support, making the learning experience more engaging and effective. Additionally, virtual reality and augmented reality applications may offer immersive and interactive learning environments, helping individuals with ASD develop these essential skills in a more natural and intuitive manner. These technologies can provide real-world simulations and multisensory experiences, facilitating comprehension and retention.

Moreover, ongoing research into the neurological underpinnings of ASD holds the promise of more effective interventions. Advances in neuroscience may uncover new insights into the cognitive processes associated with reading, spelling, and computation difficulties in ASD individuals. This knowledge can inform the development of innovative therapies and interventions that target the specific neural pathways implicated in these challenges. Furthermore, integrating behavioral therapy with educational interventions can help individuals with ASD develop the self-regulation and executive functioning skills necessary for academic success. As our understanding of ASD continues to evolve, these multidisciplinary approaches will play a pivotal role in improving the reading, spelling, and computation skills of individuals on the autism spectrum, ultimately empowering them to reach their full potential in the academic realm and beyond.

7. Conclusions

The few studies identified in this review unanimously point out that learning reading, spelling, and computation skills are complex for students with ASD-ID. This observation contrasts with the substantial proportion of children with ASD who have ID and highlights the need for further research to fill a significant gap regarding the profile of academic abilities of students with ASD-ID. Therefore, it would be relevant to investigate these skills and associated processes to establish functional profiles, and provide additional information to rehabilitators, families, and schools in designing targeted educational-didactic and rehabilitation interventions.

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