



Spelling and Autism: a Narrative Review of Recent Developments and Directions for New Research Priorities

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Abstract

Purpose of Review This review provides a critical overview of recent research on spelling and autism, highlighting developments and future research priorities.

Recent Findings It has long been known that some children with autism have difficulty learning to spell. Recent studies have explored the reasons why these children have difficulty learning to spell and how they are best supported to learn to spell.

Summary Spelling development has been linked to various factors in groups of autistic children, with language skills and intellectual functioning identified as key contributors to spelling achievement. Autistic and non-autistic children appear to draw on similar processes when spelling and may benefit from similar forms of instruction. Additional participatory research guided by autistic children, their parents and teachers is needed to further our understanding of spelling development and efficacious spelling instruction for autistic children. Potential avenues for future research are presented.

Keywords Spelling · Autism · Literacy

Introduction

Learning to spell is a key focus in the beginning years of formal education and has implications across the lifespan. Children who are proficient spellers are better able to navigate online information sources and communicate their learning across topic areas as compared to their less-literate peers [1–3]. Spelling development provides a foundation for growth in other aspects of writing, such as writing quality [4, 5], and is associated with improvements in other literacy and related skills, including reading and oral language [6, 7]. In these ways, spelling supports academic participation, achievement and satisfaction [8, 9] and contributes to occupational, financial and health outcomes over the longer term [10, 11].

Learning to spell is important for all children, including those with autism for whom spelling can play an additional role in supporting communication using Augmentative and

Alternative Communication (AAC) systems. AAC systems are used by people with communication disabilities to replace or clarify their speech in day-to-day interactions. Users select, write or type the words they want to say, often using a combination of spelling and pre-written messages, and present these messages using speech generating devices. It is estimated that around 30% of children with autism¹ do not develop speech and could benefit from AAC [14]. While it is not known how many minimally or non-speaking autistic children utilise text-based AAC, these systems have been shown to promote participation as well as early reading and writing skills for some users [15].

In this paper we provide a critical overview of the research on spelling and autism, aiming to highlight recent developments and future research priorities. We define spelling narrowly as the independent and intentional use of graphemes (e.g., letters in English and Spanish, characters in Chinese and Korean [16]) to represent the sounds and/or meanings of words in ways that are consistent with language-specific conventions. We consider spelling as requiring independence and intentionality on the part of the person who is spelling (i.e., the author of the written work).

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¹ We intentionally use both person- and identity-first language in this review to accommodate the full range of community preferences [12, 13].

Importantly, our definition encompasses all intentional *and* independent methods of grapheme production/selection including writing, typing and gestures (e.g., to select a letter using text-based AAC). This excludes any consideration of articles discussing spelling for individuals using the facilitator-dependent and invalidated technique of Facilitated Communication [17–19] or Rapid Prompting Method (which is comparable to Facilitated Communication on multiple dimensions and has no validation evidence [20, 21]).

In recent years, there has been increasing interest in the spelling skills and development of children with neurodevelopmental conditions in education journals and the news media as well as among advocates and parent groups [22]. Interest in spelling development and instruction for autistic children has been an area of substantial growth, driven at least in part by moves toward inclusive education and increasing recognition of children's support needs [23]. Spelling research to date involving children with autism has addressed three important questions. First, do children with autism have difficulty learning to spell? Second, why do some autistic children have difficulty learning to spell? Third, how are children with autism best supported when learning to spell? Each of these questions is discussed below with emphasis on recent findings.

Do Children with Autism Have Difficulty Learning to Spell?

There is long-standing research and clinical interest in whether children with autism have difficulty learning to spell. Early studies approached this question by comparing spelling accuracy in groups of autistic and non-autistic children with normal-range intellectual functioning, often as part of profiling children's broader learning strengths and weaknesses. In one such study, Minshew et al. [24] assessed word spelling accuracy and other academic skills in a group of autistic adolescent males ($n = 54$, mean age 16 years) and a group of non-autistic adolescent males ($n = 41$, mean age 15 years) matched on full-scale IQ, age, race and socioeconomic status. The authors described the group of autistic adolescents as "high functioning" (p.216) and excluded potential participants with verbal IQ scores below 70 but did not report on whether some participants were minimally or non-speaking or used AAC. Results showed no significant differences between groups in reading or spelling accuracy. However, autistic adolescents were found to have significantly lower reading comprehension skills, leading the authors to conclude that some autistic adolescents may have a psychoeducational profile that is unlike other disability groups and characterised by intact procedural skills, including spelling.

Subsequent studies have continued to measure spelling accuracy in groups of autistic children with normal-range IQ

but have not reached the same conclusions regarding children's broader psychoeducational profiles. Much of this research is represented in a meta-analysis by Finnegan and Accardo [25] which considered studies published between 2000 and 2015 on the written expression skills of autistic and non-autistic children and adults. In this review, five included studies compared spelling accuracy in autistic and non-autistic groups of children and adults using measures of word spelling accuracy in a dictation task, error rates in connected writing and word spelling accuracy as a proportion of spelling attempts in connected writing [26–30]. Summary effects calculated using data from all five studies showed that spelling accuracy scores were, on average, significantly lower for autistic children and adults as compared to non-autistic children and adults; however, this difference was associated with a small effect size ($g = 0.28$), and heterogeneity tests indicated that results were inconsistent. This is most likely related to the fact that the five studies differed with regard to participant age range, gender, language and socioeconomic status, among other potentially important factors. Based on these findings, it is difficult to make any broad conclusions regarding the spelling proficiency of autistic children, though it is clear that spelling accuracy varies widely in this group with some autistic children having significant spelling difficulties.

Research on spelling and autism published since the Finnegan and Accardo meta-analysis has continued to draw comparisons between small groups of autistic children and adults with normal range IQ and their non-autistic peers, providing further evidence that spelling accuracy is highly variable in these groups (e.g., [31, 32]). An exception to this is a longitudinal study by Solari et al. [33••] which did not exclude children with intellectual disabilities, though children who were minimally or non-speaking were excluded. The authors followed the academic development of a large group of autistic children ($n = 616$) across their first year of formal education. Results on a purpose-designed measure of word spelling accuracy showed that children with autism had significantly lower spelling accuracy skills than their non-autistic peers at the beginning of their initial year of formal education and that this gap closed by the end of that school year. Further analyses revealed that means for the autism group were heavily influenced by a small subgroup of children (approx. 10%) with persistent and often severe literacy learning difficulties. The authors stress that efforts are required to better understand why these children fail to progress, highlighting intellectual functioning and access to literacy instruction as potentially important factors.

Why Do Some Autistic Children Have Difficulty Learning to Spell?

The following studies have moved beyond comparing spelling accuracy in groups of autistic and non-autistic children

Table 1 Examples of CSSS scoring and spelling error types

Score	Spelling type and description	Target	Example
3 points	Correct: spelling is correct.	coat	coat
2 points	Legal: spelling is incorrect but comprises letters that could plausibly represent the target phonemes and/or morphemes.	coat (c-oa-t)	coet (c-oe-t)
1 point	Illegal: spelling is incorrect and does not represent the target phonemes and/or morphemes, though the phonemic structure of the target (number of phonemes) is preserved.	coat (c-oa-t)	cut (c-u-t)
0 points	Omission: spelling is incorrect, and phonemic/morphemic structure is not represented.	coat (c-oa-t)	ct (c- -t)

to consider why some children with autism have difficulty learning spell. This research has important implications for the early identification and remediation of spelling difficulties and may help inform the development of effective spelling supports [34]. The studies focus on whether spelling involves similar underlying processes for autistic and non-autistic children, and the factors associated with spelling achievement in these groups.

Processes Underlying Spelling for Autistic and Non-autistic Children

Theoretical models are used to describe the processes underlying spelling. Most contemporary models, including those cited in previous studies on spelling and autism, assert that spelling in English and some other alphabetic orthographies involve the coordination of three kinds of processing: phonological (i.e., spoken words and their phonemes), orthographic (i.e., written words and their letters) and morphological (i.e., word parts that signal meaning or grammar including base words and affixes [35, 36]). Evidence of these processes can be found in children's spelling attempts [37, 38].

Bailey and Arciuli [39] analysed spelling attempts produced by a relatively diverse group of school-age (5–12 years) children with autism ($n = 20$) and non-autistic children matched on age and word spelling accuracy ($n = 20$) for evidence of underlying linguistic knowledge using the Computerised Spelling Sensitivity System (CSSS [40]). All children in this study were able to communicate verbally using at least single words. The CSSS was used to award points based on whether spelling attempts encoded the phonological and morphological structures of their target words using plausible letter combinations and recorded the frequency of three error types: (i) omission, (ii) illegal and (iii) legal (see Table 1 for further description and examples). Results showed no significant differences in the overall level of linguistic information encoded in the spelling attempts of autistic and non-autistic children or in the types of errors produced by these groups. Consistent with earlier studies involving spelling analysis [41, 42], Bailey and Arciuli interpreted these findings as evidence of similarities in the

processes underlying spelling for autistic and non-autistic children but did not suggest that existing theoretical models can fully account for spelling development in autistic children. Rather, the authors acknowledged that findings were subject to important limitations including the use of a small sample which excluded children with very low spelling accuracy.

More recently, Peristeri and Tsimpli [43••] compared spelling errors produced by three age-, performance IQ- and socioeconomic-matched groups of bilingual Albanian-Greek children aged 9 to 12 years: a typically developing group ($n = 28$), a group of children with autism who had normal range verbal IQ and expressive vocabulary and no parent-reported history of language delay ($n = 28$) and a group of children with developmental language disorder who were not autistic ($n = 28$). Children's expository texts were evaluated in terms of percentage spelling errors on content words (i.e., nouns, verbs and adjectives) and frequency of spelling error types (phonological, morphological or orthographic). Descriptive statistics showed that children with autism produced more spelling errors (46%) as compared to the typically developing group (27%), but fewer spelling errors as compared to the children with developmental language disorder (69%). Across all three groups, morphological spelling errors were the most prevalent (i.e., misspelling of inflectional ending that does not distort the phonological identity of the word), followed by orthographic errors (i.e., misspelling of word stem that does not modify the pronunciation of the word) and phonological errors (i.e., misspelling that changes the phonemic composition of the word). Autistic children did not differ from the typically developing children in their frequency of phonological or morphological errors, though orthographic errors were significantly more prevalent in the writing of autistic children. The authors interpreted these findings as evidence that autistic and non-autistic children draw on similar sources of linguistic knowledge when spelling (i.e., phonological, orthographic, morphological awareness) and that other factors, including broader language skills, may influence autistic children's spelling performance.

Factors Associated With Spelling Achievement for Children With Autism

The following studies have considered the factors associated with academic achievement for autistic children, including and beyond those implicated in contemporary theoretical models of spelling. These tend to focus on two intrinsic child-related factors—intellectual functioning and oral language skills—while there has been relatively little research on environmental factors such as the quality and frequency of children’s literacy learning opportunities at home and school.

Intrinsic Child-Related Factors Research on the relationship between intellectual functioning and spelling has returned mixed results. An early study by Mayes and Calhoun [44] considered the potential links between general intellectual functioning and academic achievement in a relatively large, diverse group of children with autism aged 3 to 15 years ($n = 164$). The researchers noted that this group included children with low verbal IQ but did not report on whether children were minimally or non-speaking or used AAC. Children completed one of three intelligence tests and assessments of letter and word spelling accuracy among other tests of academic achievement. Spelling skills were generally commensurate with children’s expected level of achievement based on IQ, suggesting a link between general intelligence and spelling accuracy. Similar findings were reported by Venter et al. [45] and Kim et al. [46••], while contrary findings were reported by Estes et al. [47]. A more recent study by Kljajevic [31] found a significant, positive association between spelling accuracy and verbal IQ for 48 children with autism aged 7 to 12 years whose verbal IQ results centred near the normative mean (it was not reported whether children were minimally or non-speaking or used AAC). Taken together, these studies indicate that there may be an association between spelling accuracy and IQ for children with autism, though it is not clear whether this is the case for all autistic children and all IQ measures, or if intellectual functioning shares a unique association with spelling once other factors are taken into account.

Dockrell et al. [48] considered the relationships between word spelling accuracy and multiple other factors, including intellectual functioning and language skills, for 50 children with autism and 77 age-matched children with language impairment aged 6 to 12 years. It was not reported whether participants in either group were minimally or non-speaking or used AAC. For children with autism, spelling accuracy was most strongly associated with handwriting fluency ($r = .59$), followed by receptive vocabulary ($r = .50$), verbal working memory ($r = .48$), non-verbal intellectual functioning ($r = .40$) and receptive grammar ($r = .34$). Children

with autism who achieved scores more than 1.5SD below the mean on standardised language assessments were also found to have word spelling accuracy skills comparable to children with language impairment. These results suggest that multiple factors, including intellectual functioning and language skills, may contribute to spelling achievement for autistic children. However, this study did not consider the unique contributions of these factors, and approximately 20% of children recruited to take part in this study were excluded due to non-participation.

A more recent study by Åsberg Johnels et al. [49••] reported on the unique contributions of various factors to spelling accuracy for a group of 41 Swedish children with autism and normal-range intellectual functioning aged 12 years. The authors described this sample as a community-representative group but did not report whether it included participants who were minimally or non-speaking or used AAC. Children completed tests of word spelling accuracy, word reading accuracy, text reading fluency, reading comprehension, listening comprehension, rapid automatized naming (RAN), phonological awareness and nonverbal intelligence. Regression analyses showed that phonological awareness ($B = .64$) and listening comprehension scores ($B = .25$) predicted word spelling accuracy in this group. Notably, nonverbal intelligence and RAN did not predict unique variance in spelling accuracy. Secondary analyses showed that children with a history of moderate-severe language difficulties achieved significantly lower spelling accuracy scores as compared to those with either no history or a history of mild language difficulties. These results were taken as evidence that language skills contribute to spelling accuracy both concurrently and longitudinally for children with autism.

Environmental Factors There has been very little research on the environmental factors associated with spelling achievement for autistic children. Kim et al. [46••] considered the influence of school placement (i.e., general education or special education classes) on the spelling development of 74 children and adolescences with autism aged from 9 to 18 years. Children who remained in general education classes during this time were found to achieve significantly larger improvements in word spelling accuracy as compared to those in special education classes. However, this study excluded children and adolescences with very low intellectual functioning, and participants who attended general education classes tended to be those with higher baseline intellectual and academic functioning.

Another recent study by Asaro-Saddler et al. [50] considered whether writing instruction practices in two self-contained classrooms which included children with autism

aged 5 to 7 years were consistent with evidence-based approaches designed for the general population. While spelling received relatively little attention in the study, teachers were observed to use some evidence-based spelling strategies such as drawing students' attention to the phonemic features of target words, accepting the use of invented spelling, providing error correction and encouraging self-monitoring. Teachers were also observed to tailor their teaching practices to the individual needs of students. The impact of environmental factors such as these on children's spelling development was not directly assessed in this study and remains largely unexplored, though studies in the following section have reported on the effectiveness of specific spelling instruction protocols and strategies for children with autism under experimental conditions.

How Are Children With Autism Best Supported When Learning to Spell?

Previous reviews have considered autism and writing instruction more broadly and identified relatively few studies on spelling (e.g., in 2020, Accardo et al. [51] identified only three studies on spelling instruction involving children with autism). Most early studies on spelling instruction and autism have utilised single case designs to evaluate the effectiveness of tailored instruction targeting specific aspects of spelling for individuals with autism. These studies involved participants from a range of cultural and linguistic backgrounds, many of whom had limited spelling skills and were minimally or non-speaking or used AAC. Results provide support for various instruction protocols and strategies including cover, copy, compare [52], spell check [53], speech and visual feedback [54, 55], text to picture matching [56, 57], video modelling [58], fingerspelled self-cues [59], use of word boxes [60] and matrix training [61]. While it is outside the scope of this critique to explore these findings in detail, it is sufficient to note that instruction targeting specific aspects of spelling and carefully matched to the needs of individuals with autism has the potential to be effective in supporting spelling development and use of text-based AAC to participate in daily life.

Very few studies have considered the effects of comprehensive literacy instruction on the spelling outcomes of children with autism at the group level. In one such study, Bailey et al. [62••] evaluated the effects of ABRACADABRA, a comprehensive literacy program based on best-practice recommendations for the general population [63], on the spelling skills of children with autism aged 5 to 11 years. This study utilised a broad

recruitment strategy requiring that children had a confirmed autism diagnosis, were able to point to a specified image from a choice of three, use at least single spoken words to communicate, and sustain attention to any task for 15 min. Children completed oral language, reading and word spelling accuracy assessments before being assigned to matched instruction and control groups. Children assigned to the Instruction group received 26 h of literacy instruction targeting alphabets, reading comprehension, reading fluency and spelling skills using the ABRACADABRA program over a period of 13 weeks while children in the Control group continued their usual learning activities. All children then completed the same reading and spelling assessments administered at the outset of the study. There was no significant difference in the extent of word spelling accuracy gains achieved by children in the Instruction and Control groups. However, analysis of children's spelling attempts using the CSSS showed a significant improvement in the level of linguistic information encoded by children in the Instruction group relative to the Control group. The authors concluded that comprehensive literacy instruction designed for the general population may be effective in improving foundational spelling skills for children with autism but acknowledged important limitations in this small-scale study and a need for further research to determine the operational elements of comprehensive literacy instruction presented using ABRACADABRA.

While literacy instruction designed for the general population may be suitable for some children with autism, we agree with Asaro-Saddler et al. [50] that instruction content and delivery that is tailored to the needs of individuals will likely be most effective for children with autism. Koutsoftas [64] offers a case study which demonstrates the potential use of spelling analysis to help guide the tailoring of literacy instruction content for children with autism. This study followed a 6th Grade classroom which included two autistic children as they planned, wrote, and revised a written narrative. Spelling errors in these stories were categorised as either phonological, orthographic or morphological as defined by Bahr et al. [65]. One autistic child was found to produce a high number of phonological errors, suggesting difficulty in perceiving and/or representing the phonological structure of target words. The authors rationalised that this information could be used to justify a focus on phonological awareness instruction for this child to improve their spelling and broader literacy development. Consideration of other factors, especially those relating to instruction delivery (e.g., use of visual scaffolds, instruction dosage and frequency), is likely important though was not addressed explicitly in this study and has not been considered in depth elsewhere as far as we are aware.

Conclusions

This article offers a critical overview of the research on spelling and autism. While some children with autism have difficulty learning to spell, the reasons for this pattern of differing abilities are not yet fully understood. Recent studies provide some evidence that autistic and non-autistic children draw on similar processes when spelling and that factors associated with spelling development in the general population also contribute to spelling achievement for children with autism. An important implication is that assessment procedures shown to be effective in mapping and predicting spelling achievement in the general population may be well-suited to some autistic children. Similarly, literacy instruction approaches shown to be effective in promoting spelling development in the general population may be effective when tailored for and used by some autistic children. Indeed, research cited in this review supports the use of comprehensive literacy instruction programs—initially designed for non-autistic children—when teaching autistic children [62••].

Recent research provides some useful insights into the nature of spelling development and effective spelling instruction for children with autism, but a great deal of work remains to be done in each of these areas. Future studies must address key methodological limitations evident in much of the previous research to achieve meaningful progress. Chief among these is the underrepresentation of autistic children with higher support needs, including those who are younger, are minimally or non-speaking, have lower literacy skills and/or intellectual disability. Future studies should also ensure that participant groups are well-defined and report on key factors including children's spoken language skills, use of AAC, school placement and intellectual functioning to better communicate their findings and enable better comparison across study groups. We agree with Åsberg Johnels et al. [49••] that targeting of more homogeneous groups, such as children within a narrow age range, may also be advantageous. Other helpful recommendations for improving the planning, design and delivery of writing research are offered by De Smedt et al. [66] in relation to creating interventions, specifying outcomes, selecting appropriate research designs and data collection methods for both single-participant and group studies.

Beyond addressing methodological limitations, future research priorities should be established in partnership with autistic children, their parents and teachers and other supporters (see [67] for a discussion on this point and [68, 69] for practical guidance on inclusive research). One potential avenue for future research is the continued exploration of

factors associated with spelling development. Intrinsic child-related factors not yet considered in the research on autism and spelling, namely writing motivation and self-efficacy, have been identified as key contributors to literacy development in the general population [70]. These may prove helpful in identifying autistic children who are at-risk of spelling difficulties and in shaping the development of holistic spelling instruction that promotes writing participation, motivation, self-efficacy and spelling skills. Environmental factors, including the home literacy environment, parents' socio-economic status and community values, could also be usefully explored given the dearth of research in this area.

Future research on spelling instruction involving autistic children could extend beyond evaluation of the *effectiveness* of researcher-designed protocols targeting a narrow range of skills under tightly controlled experimental conditions to consider the *efficacy* of co-designed, comprehensive instruction approaches under real-world conditions. Participation of autistic children, their parents, teachers and other supporters both in the design and evaluation of these approaches is likely to lead to the development of more acceptable and impactful instructional materials [67–69]. Based on the research on autism and reading [71], it is anticipated that future approaches to spelling instruction will need to be highly customisable and able to accommodate a wide range of preferences and abilities to be optimally efficacious. Teacher and clinician education will also be an important factor in ensuring instruction fidelity [72].

A further potential avenue for future research is the role of spelling in supporting broader writing development and participation for children with autism. While most contemporary models include spelling as an important aspect of the writing process [73, 74], some questions remain regarding the contribution of spelling to writing development in the general population [75]. Future research on the role of spelling, alongside handwriting, in supporting writing development and participation for children with autism may have important implications for whether spelling development is seen as a priority for some or all autistic children moving forward.

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References

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

1. Graham S, Santangelo T. Does spelling instruction make students better spellers, readers, and writers? A meta-analytic review. *Read Writ.* 2010;27(9):1703–43. <https://doi.org/10.1007/s11145-014-9517-0>.
2. Varnhagen CK, McFall GP, Figueredo L, Takach BS, Daniels J, Cuthbertson H. Spelling and the web. *J Appl Dev Psychol.* 2009;30(4):454–62. <https://doi.org/10.1016/j.appdev.2008.12.022>.
3. Willson R, Given LM. The effect of spelling and retrieval system familiarity on search behavior in online public access catalogs: a mixed methods study. *J Am Soc Inf Sci.* 2010;61(12):2461–76. <https://doi.org/10.1002/asi.21433>.
4. Daffern T, Mackenzie NM, Hemmings B. Predictors of writing success: how important are spelling, grammar and punctuation? *Aust J Educ.* 2017;61(1):75–87. <https://doi.org/10.1177/0004944116685319>.
5. Limpo T, Alves RA, Connelly V. Examining the transcription-writing link: effects of handwriting fluency and spelling accuracy on writing performance via planning and translating in middle grades. *Learn Individ Differ.* 2017;53:26–36. <https://doi.org/10.1016/j.lindif.2016.11.004>.
6. Colenbrander D, Miles KP, Ricketts J. To see or not to see: how does seeing spellings support vocabulary learning? *Lang Speech Hear Serv Sch.* 2019;50(4):609–28. https://doi.org/10.1044/2019_LSHSS-VOIA-18-0135.
7. Moats LC. How spelling supports reading. *Am Educ.* 2005;29(4):12–43. Available from: <https://www.aft.org/sites/default/files/Moats.pdf>
8. Abbott RD, Berninger VW, Fayol M. Longitudinal relationships of levels of language in writing and between writing and reading in grades 1 to 7. *J Educ Psychol.* 2010;102(2):281–98. <https://doi.org/10.1037/a0019318>.
9. Cutler L, Graham S. Primary grade writing instruction: a national survey. *J Educ Psychol.* 2008;100(4):907–19. <https://doi.org/10.1037/a0012656>.
10. DeWalt DA, Berkman ND, Sheridan S, Lohr KN, Pignone MP. Literacy and health outcomes: a systematic review of the literature. *J Gen Intern Med.* 2004;19:1228–39. <https://doi.org/10.1111/j.1525-1497.2004.40153.x>.
11. Ritchie SJ, Bates TC. Enduring links from childhood mathematics and reading achievement to adult socioeconomic status. *Psychol Sci.* 2013;24(7):1301–8. <https://doi.org/10.1177/0956797612466268>.
12. Buijsman R, Begeer S, Scheeren AM. 'Autistic person' or 'person with autism'? Person-first language preference in Dutch adults with autism and parents. *Autism.* 2023;27(3):788–95. <https://doi.org/10.1177/13623613221117914>.
13. Monk R, Whitehouse AJ, Waddington H. The use of language in autism research. *Trends Neurosci.* 2022;45(11):791–3. <https://doi.org/10.1016/j.tins.2022.08.009>.
14. Rose V, Trembath D, Keen D, Paynter J. The proportion of minimally verbal children with autism spectrum disorder in a community-based early intervention programme. *J Intellect Disabil Res.* 2016;60(5):464–77. <https://doi.org/10.1111/jir.12284>.
15. Light J, McNaughton D, Caron J. New and emerging AAC technology supports for children with complex communication needs and their communication partners: State of the science and future research directions. *Augment Altern Commun.* 2019;35(1):26–41. <https://doi.org/10.1080/07434618.2018.1557251>.
16. Meletis D. The grapheme as a universal basic unit of writing. *Writ Syst Res.* 2019;11(1):26–49. <https://doi.org/10.1080/17586801.2019.1697412>.
17. Schlosser RW, Balandin S, Hemsley B, Iacono T, Probst P, von Tetzchner S. Facilitated communication and authorship: a systematic review. *Augment Altern Commun.* 2014;30(4):359–68. <https://doi.org/10.3109/07434618.2014.971490>.
18. Hemsley B, Bryant L, Schlosser RW, Shane HC, Lang R, Paul D, Banajee M, Ireland M. Systematic review of facilitated communication 2014–2018 finds no new evidence that messages delivered using facilitated communication are authored by the person with disability. *Autism Dev Lang Impair.* 2018;3:2396941518821570. <https://doi.org/10.1177/2396941518821570>.
19. American Speech-Language-Hearing Association. Facilitated communication [Internet]. American Speech-Language-Hearing Association. 2018 [cited 2024 Jan 10]. Available from: www.asha.org/policy/
20. American Speech-Language-Hearing Association. ASHA warns against rapid prompting method or spelling to communicate [Internet]. American Speech-Language-Hearing Association. [cited 2024 Jan 9]. Available from: <https://www.asha.org/slp/asha-warns-against-rapid-prompting-method-or-spelling-to-communicate/>
21. Schlosser RW, Hemsley B, Shane H, Todd J, Lang R, Lilienfeld SO, Trembath D, Mostert M, Fong S, Odom S. Rapid prompting method and autism spectrum disorder: systematic review exposes lack of evidence. *Rev J Autism Dev Disord.* 2019;6:403–12. <https://doi.org/10.1007/s40489-019-00175-w>.
22. Gentry R. Why spelling instruction should be hot in 2022/2023 [Internet]. *Psychology Today.* 2021; [posted Jan 5]. Available from: <https://www.psychologytoday.com/au/blog/raising-readers-writers-and-spellers/202101/why-spelling-instruction-should-be-hot-in-2022-2023>
23. De Bruin K. The impact of inclusive education reforms on students with disability: an international comparison. *Int J Incl Educ.* 2019;23(7-8):811–26. <https://doi.org/10.1080/13603116.2019.1623327>.
24. Minshew NJ, Goldstein G, Taylor HG, Siegel DJ. Academic achievement in high functioning autistic individuals. *J Clin Exp Neuropsychol.* 1994;16(2):261–70. <https://doi.org/10.1080/01688639408402637>.

25. Finnegan E, Accardo AL. Written expression in individuals with autism spectrum disorder: a meta-analysis. *J Autism Dev Disord.* 2018;48:868–82. <https://doi.org/10.1007/s10803-017-3385-9>.
26. Åsberg J, Kopp S, Berg-Kelly K, Gillberg C. Reading comprehension, word decoding and spelling in girls with autism spectrum disorders (ASD) or attention-deficit/hyperactivity disorder (AD/HD): performance and predictors. *Int J Lang Commun Disord.* 2010;45(1):61–71. <https://doi.org/10.3109/13682820902745438>.
27. Brown HM, Johnson AM, Smyth RE, Cardy JO. Exploring the persuasive writing skills of students with high-functioning autism spectrum disorder. *Res Autism Spectr Disord.* 2014;8(11):1482–99. <https://doi.org/10.1016/j.rasd.2014.07.017>.
28. Brown HM, Klein PD. Writing, Asperger syndrome and theory of mind. *J Autism Dev Disord.* 2011;41:1464–74. <https://doi.org/10.1007/s10803-010-1168-7>.
29. Cartmill L, Rodger S, Ziviani J. Handwriting of eight-year-old children with autistic spectrum disorder: an exploration. *J Occup Ther Sch Early Interv.* 2009;2(2):103–18. <https://doi.org/10.1080/19411240903146426>.
30. Myles BS, Huggins A, Rome-Lake M, Hagiwara T, Barnhill GP, Griswold DE. Written language profile of children and youth with Asperger syndrome: from research to practice. *Educ Train Autism Dev Disabil.* 2003;38(4):362–9. Retrieved from <https://eric.ed.gov/?id=EJ789134>
31. Kljajevic V. Literacy and numeracy in children on autism spectrum disorder. *Adv Neurodev Disord.* 2023;7(1):123–9. <https://doi.org/10.1007/s41252-022-00291-5>.
32. Gillespie-Lynch K, Hotez E, Zajic M, Riccio A, DeNigris D, Kofner B, Bublitz D, Gaggi N, Luca K. Comparing the writing skills of autistic and nonautistic university students: a collaboration with autistic university students. *Autism.* 2020;24(7):1898–912. <https://doi.org/10.1177/1362361320929453>.
33. ●● Solari EJ, Henry AR, Grimm RP, Zajic MC, McGinty A. Code-related literacy profiles of kindergarten students with autism. *Autism.* 2022;26(1):230–42. <https://doi.org/10.1177/13623613211025904>. **This study showed that variation in the spelling accuracy skills of a representative sample of autistic children was driven largely by a subgroup of children with severe, persistent spelling difficulties.**
34. Treiman R. Learning to spell words: findings, theories, and issues. *Sci Stud Read.* 2017;21(4):265–76. <https://doi.org/10.1080/10888438.2017.1296449>.
35. Berninger VW, Abbott RD, Swanson HL, Lovitt D, Trivedi P, Lin SJC, Gould L, Youngstrom M, Shimada S, Amtmann D. Relationship of word-and sentence-level working memory to reading and writing in second, fourth, and sixth grade. *Lang Speech Hear Serv Sch.* 2010;41(2):179–93. [https://doi.org/10.1044/0161-1461\(2009/08-0002\)](https://doi.org/10.1044/0161-1461(2009/08-0002)).
36. Treiman R, Kessler B. How children learn to write words. New York, NY: Oxford University Press; 2014.
37. Bahr RH, Leby S, Wilkinson LC. Spelling error analysis of written summaries in an academic register by students with specific learning disabilities: phonological, orthographic, and morphological influences. *Read Writ.* 2020;33:121–42. <https://doi.org/10.1007/s11145-019-09977-0>.
38. Zhao J, Joshi RM, Dixon LQ, Chen S. Contribution of phonological, morphological and orthographic awareness to English word spelling: a comparison of EL1 and EFL models. *Contemp Educ Psychol.* 2017;49:185–94. <https://doi.org/10.1016/j.cedpsych.2017.01.007>.
39. Bailey B, Arciuli J. Subskills associated with spelling ability in children with and without autism spectrum disorders. *Autism Dev Lang Impair.* 2018;3:2396941518803807. <https://doi.org/10.1177/2396941518803807>.
40. Masterson JJ, Hrbec B. Computerized spelling sensitivity system [Computer software]. 2011. Available from https://www.missouristate.edu/CSD/_Files/CSSS_Manual_2015.pdf
41. Wiggins KI. Spelling errors in children with autism. Master's thesis. Tampa: University of South Florida; 2010. Available from <https://digitalcommons.usf.edu/cgi/viewcontent.cgi?article=4670&context=etd>
42. Cardoso-Martins C, Gonçalves DT, de Magalhães CG, da Silva JR. Word reading and spelling ability in school-age children and adolescents with autism spectrum disorders: evidence from Brazilian Portuguese. *Psychol Neurosci.* 2015;8(4):479–87. <https://doi.org/10.1037/pne0000029>.
43. ●● Peristeri E, Tsimpli IM. Disentangling language disorder and bilingualism in children with developmental language disorder and autism spectrum disorder: evidence from writing. *J Autism Dev Disord.* 2022;53(12):1–24. <https://doi.org/10.1007/s10803-022-05727-4>. **Findings from this study suggest that autistic and non-autistic children draw on similar underlying processes when spelling.**
44. Mayes SD, Calhoun SL. Ability profiles in children with autism: influence of age and IQ. *Autism.* 2003;7(1):65–80. <https://doi.org/10.1177/1362361303007001006>.
45. Venter A, Lord C, Schopler E. A follow-up study of high-functioning autistic children. *J Child Psychol Psychiatry.* 1992;33(3):489–597. <https://doi.org/10.1111/j.1469-7610.1992.tb00887.x>.
46. ●● Kim SH, Bal VH, Lord C. Longitudinal follow-up of academic achievement in children with autism from age 2 to 18. *J Child Psychol Psychiatry.* 2018;59(3):258–67. <https://doi.org/10.1111/jcpp.12808>. **Findings from this study suggest that environmental factors, specifically school placement, can influence autistic children's spelling development.**
47. Estes A, Rivera V, Bryan M, Cali P, Dawson G. Discrepancies between academic achievement and intellectual ability in higher-functioning school-aged children with autism spectrum disorder. *J Autism Dev Disord.* 2011;41:1044–52. <https://doi.org/10.1007/s10803-010-1127-3>.
48. Dockrell JE, Ricketts J, Charman T, Lindsay G. Exploring writing products in students with language impairments and autism spectrum disorders. *Learn Instr.* 2014;32:81–90. <https://doi.org/10.1016/j.learninstruc.2014.01.008>.
49. ●● Åsberg Johnels J, Fernell E, Kjellmer L, Gillberg C, Norrelgen F. Language/cognitive predictors of literacy skills in 12-year-old children on the autism spectrum. *Logoped Phoniatr Vocol.* 2022;47(3):166–70. <https://doi.org/10.1080/14015439.2021.1884897>. **Findings from this study suggest that language skills contribute to spelling achievement for children with autism, even after other factors are taken into account.**
50. Asaro-Saddler K, Arcidiacono MB, Morris DM. Instructional practice for students with autism spectrum and related disorders: exploring the teaching of writing in two self-contained classrooms. *Read Writ Q.* 2017;33(2):171–86. <https://doi.org/10.1080/10573569.2016.1145561>.
51. Accardo AL, Finnegan EG, Kuder SJ, Bomgarner EM. Writing interventions for individuals with autism spectrum disorder: a research synthesis. *J Autism Dev Disord.* 2020;50:1988–2006. <https://doi.org/10.1007/s10803-019-03955-9>.
52. Barberio-Kitts C, McLaughlin TF, Neyman J, Worcester L, Cartmill H. The effects of a modified cover, copy, compare on spelling third grade core words for a student with autism. *Glob J Humanit Soc Sci.* 2014;14(2):1–5. Available from https://www.academia.edu/download/48022934/2014.Baberio-Kitts_CCC_and_Autism.pdf
53. Kagohara DM, Sigafos J, Achmadi D, O'Reilly M, Lancioni G. Teaching children with autism spectrum disorders to check the

- spelling of words. *Res Autism Spectr Disord*. 2012;6(1):304–10. <https://doi.org/10.1016/j.rasd.2011.05.012>.
54. Schlosser RW, Blischak DM, Belfiore PJ, Bartley C, Barnett N. Effects of synthetic speech output and orthographic feedback on spelling in a student with autism: a preliminary study. *J Autism Dev Disord*. 1998;28:309–19. <https://doi.org/10.1023/A:1026060619378>.
 55. Schlosser RW, Blischak DM. Effects of speech and print feedback on spelling by children with autism. *J Speech Lang Hear Res*. 2004;47(4):848–62. [https://doi.org/10.1044/1092-4388\(2004/063\)](https://doi.org/10.1044/1092-4388(2004/063)).
 56. Sugasawara H, Yamamoto J. Computer-based teaching of word construction and reading in two students with developmental disabilities. *Behav Interv*. 2007;22:263–77. <https://doi.org/10.1002/bin.248>.
 57. Tanji T, Takahashi K, Noro F. Teaching generalized reading and spelling to children with autism. *Res Autism Spectr Disord*. 2013;7(2):276–87. <https://doi.org/10.1016/j.rasd.2012.09.005>.
 58. Kinney EM, Vedora J, Stromer R. Computer presented video models to teach generative spelling to a child with an autism spectrum disorder. *J Posit Behav Interv*. 2003;2003(5):22–9. <https://doi.org/10.1177/10983007030050010301>.
 59. Angermeier K, Schooley K, Harasymowycz U, Schlosser RW. The role of fingerspelled self-cues during spelling with a speech generating device by a child with autism: a brief report. *J Dev Phys Disabil*. 2010;22:197–200. <https://doi.org/10.1007/s10882-010-9193-1>.
 60. Joseph LM. Effects of word boxes on phoneme segmentation, word identification, and spelling for a sample of children with autism. *Child Lang Teach Ther*. 2018;34(3):303–17. <https://doi.org/10.1177/0265659018805236>.
 61. Tanji T, Noro F. Matrix training for generative spelling in children with autism spectrum disorder. *Behav Interv*. 2011;26(4):326–39. <https://doi.org/10.1002/bin.340>.
 62. ●● Bailey B, Arciuli J, Stancliffe RJ. Effects of ABRACADABRA instruction on spelling in children with autism spectrum disorder. *Sci Stud Read*. 2017;21:146–64. <https://doi.org/10.1080/10888438.2016.1276183>. **Findings from this study suggest that evidence-based comprehensive literacy instruction may be effective in improving foundational spelling skills for some children with autism.**
 63. Centre for the Study of Learning and Performance. The Learning Toolkit [web application]. Montreal: Concordia University; 2009. Available from <http://www.concordia.ca/research/learning-performance/tools/learning-toolkit.html>
 64. Koutsoftas AD. (2017). Writing in two children with autism: a case study for assessment and goal development. *Perspect ASHA Spec Interest Groups*. 2017;2(16):20–33. <https://doi.org/10.1044/persp2.SIG16.20>.
 65. Bahr RH, Silliman ER, Berninger VW, Dow M. Linguistic pattern analysis of misspellings of typically developing writers in grades 1–9. *J Speech Lang Hear Res*. 2012;55(6):1587–99. [https://doi.org/10.1044/1092-4388\(2012/10-0335\)](https://doi.org/10.1044/1092-4388(2012/10-0335)).
 66. De Smedt F, Bouwer R, Limpo T, Graham S. Studies in writing: conceptualizing, designing, implementing, and evaluating writing interventions, vol. 40. The Netherlands: Koninklijke Brill NV; 2023.
 67. Zajic MC, Brown HM. Measuring autistic writing skills: combining perspectives from neurodiversity advocates, autism researchers, and writing theories. *Hum Dev*. 2022;66(2):128–48. <https://doi.org/10.1159/000524015>.
 68. Fletcher-Watson S, Brook K, Hallett S, Murray F, Crompton CJ. Inclusive practices for neurodevelopmental research. *Curr Dev Disord Rep*. 2021;8:88–97. <https://doi.org/10.1007/s40474-021-00227-z>.
 69. Mangan C, Clapham H, James B, Gatfield O, Malone S. Community insights and unheard perspectives: recommendations for inclusive community engagement in the National Autism Strategy. Final report [Internet]. 2023; Brisbane: Autism CRC [cited June 2023]. Available from https://www.autismcrc.com.au/sites/default/files/reports/NAS-CI_Final_Report_Community_insights_and_unheard_perspectives.pdf
 70. Limpo T, Filipe M, Magalhães S, Cordeiro C, Veloso A, Castro SL, Graham S. Development and validation of instruments to measure Portuguese third graders' reasons to write and self-efficacy. *Read Writ*. 2020;33:2173–204. <https://doi.org/10.1007/s11145-020-10039-z>.
 71. Arciuli J, Bailey B. The promise of comprehensive early reading instruction for children with autism and recommendations for future directions. *Lang Speech Hear Serv Sch*. 2021;52(1):225–38. https://doi.org/10.1044/2020_LSHSS-20-00019.
 72. Stahmer AC, Rieth S, Lee E, Reisinger EM, Mandell DS, Connell JE. Training teachers to use evidence-based practices for autism: examining procedural implementation fidelity. *Psychol Sch*. 2015;52(2):181–95. <https://doi.org/10.1002/pits.21815>.
 73. Berninger VW, Abbott RD, Abbott SP, Graham S, Richards T. Writing and reading: connections between language by hand and language by eye. *J Learn Disabil*. 2002;35(1):39–56. <https://doi.org/10.1177/002221940203500104>.
 74. Kim YS, Park SH. Unpacking pathways using the direct and indirect effects model of writing (DIEW) and the contributions of higher order cognitive skills to writing. *Read Writ*. 2019;32:1319–43. <https://doi.org/10.1007/s11145-018-9913-y>.
 75. Graham S. A walk through the landscape of writing: insights from a program of writing research. *Educ Psychol*. 2022;57(2):55–72. <https://doi.org/10.1080/00461520.2021.1951734>.

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