

Effectiveness of a Multicomponent Reading Intervention: A Longitudinal Study of Individuals with Autism and Intellectual Disabilities Using Augmentative and Alternative Communication

Line Britt Ulriksen

linebu@hiof.no

University of South-Eastern Norway - Campus Drammen: Universitetet i Sorost-Norge - Campus Drammen

<https://orcid.org/0009-0003-7289-0444>

Marthe Bilet-Mossige

University of South-Eastern Norway: Universitetet i Sorost-Norge

Kenneth Larsen

University of South-Eastern Norway: Universitetet i Sorost-Norge

Hugo Cogo Moreira

Østfold University College: Hogskolen i Ostfold

Anders Nordahl-Hansen

Østfold University College: Hogskolen i Ostfold

Research Article

Keywords: Autism spectrum disorder, intellectual disabilities, augmentative and alternative communication, longitudinal and multicomponent reading intervention

Posted Date: September 16th, 2025

DOI: <https://doi.org/10.21203/rs.3.rs-6628764/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Background

Research indicates a lack of competence, expectations, and evidence-based reading programs tailored for individuals with disabilities who utilize augmentative and alternative communication. This study investigated the effects of a longitudinal and multicomponent reading intervention on 40 students aged 6 to 14 with Autism Spectrum Disorder and/or Intellectual Disability requiring augmentative and alternative communication (AAC).

Methods

The reading intervention utilized multiple single-case designs with multiple randomized baselines to investigate the effect of an AAC-adapted reading material concerning phonological awareness, letter sound correspondence, decoding, shared reading, and sight words, and its effectiveness was measured using a generalized estimating equation.

Results

Evidence of the effects of the intervention phase compared to the control phase is lacking; however, within the intervention phase, scores showed an increase over time. Statistical analysis identified significant results only within sound blending. Moreover, an adapted standardized reading test was administered, confirming that 13 students developed phonological reading skills. Almost half of the participants also attained phonological awareness.

Conclusions

Most students demonstrated an increase in their early reading competence, irrespective of their speech abilities, age, and severity of diagnosis. Due to the heterogeneity of the sample, it is crucial to examine each student's outcomes. The present study contributes to the debate and the limited research base related to comprehensive and longitudinal reading instructions for students with autism and/or intellectual disabilities who require augmentative and alternative communication. Moreover, it provides important information to build upon, confirming previous findings that students many have low expectations of can achieve early reading skills. This study is registered with ClinicalTrials.gov (NCT05709405, registered on January 23, 2023). As the study involved educational, not health care, interventions, further registration was deemed unnecessary.

Background

Reading skills are essential in many areas of life, including education [1], access to information [2], independence, quality of life [3], lifelong learning [4], and self-determination [5]. Furthermore, reading and

literacy skills support language learning [6] and precise communication in augmentative and alternative communication (AAC) [7].

Students with Autism Spectrum Disorder (ASD) and Intellectual Disabilities (ID) may exhibit lower reading skills than expected based on their cognitive abilities [8], although the severity of ID is related to students' reading skills [9]. According to Arciuli and Bailey [10], the lack of reading competence among students with ASD and ID can be attributed to insufficient literacy experience, the quality of instruction, and low expectations [5]. Reading practices are often poorly organized and limited to instruction and recognition of sight words [11, 12], and teachers have not been equipped with the necessary skills to deliver effective and evidence-based reading instruction for this population [13]. This is one reason why approximately 90% of individuals with ID who require AAC enter adulthood without functional literacy skills [14], particularly those with moderate or severe ID [15]. Students with ASD and ID may have similar instructional needs as those with ID [16] and require specialized literacy instruction to achieve better school outcomes [17]. Challenges in producing speech and/or understanding language may further hinder literacy development and participation in reading and writing activities [18]. Shane et al. [19] estimate that 30–50% of students with ASD do not develop functional speech, and around one-third of individuals with ID struggle to communicate through verbal language [20].

Within reading interventions for students with ASD and ID requiring AAC, research has mainly emphasized a few reading components, such as letter-sound correspondence [21–23] and sight words [17, 24], while other studies emphasize more comprehensive evidence-based reading interventions which contain multiple components (e.g., Allor et al. [25]; Browder et al. [26]; Connor et al. [27]; Lemons et al. [28]), as it has shown improved reading outcomes. Furthermore, research has primarily focused on the development of reading skills for students who can express their language verbally [29]. El Zein et al. [30] note that such interventions often overlook students with average or above-average IQs and those with moderate to severe ID who have no or limited speech and require AAC. Additionally, high-quality single-case experimental studies are limited in this field [31, 32].

The National Reading Panel [33] has identified five essential literacy components that are effective for acquiring reading skills: a) phonemic awareness, b) phonics, c) fluency, d) vocabulary, and e) comprehension. Evidence indicates that multiple components identified by the NRP should be explicitly incorporated into early reading interventions [34], and students with ID benefit from evidence-based reading interventions that are comprehensive [25–28].

Several evidence-based strategies have been proposed for teaching students with ASD and ID. Evidence-based reading instruction provided with explicit strategies or adaptations (e.g., for those requiring AAC) is effective for students with ASD and ID [25, 26, 35, 36]. Research emphasizes that systematic, direct, and explicit phonics instruction is an evidence-based strategy for teaching reading skills to students with ASD or ID [32, 36–38]. Direct and explicit instruction is an essential strategy when using a reading instructional program that helps students interact with, comprehend, and understand written language [39]. In addition, students should receive scaffolding, corrective feedback, and cumulative reviews [26, 32, 36–38]. Yorke et

al. [36] also pointed out the need to adapt interventions for AAC users, allowing them to respond in ways other than verbally.

Literature review

Research on strategies related to reading instruction for mainstream and struggling students has provided evidence of the positive outcomes of multi-component interventions [40]. Afacan et al. [31] reviewed the quality and characteristics of studies focusing on multi-component reading interventions for students with ID. The seven studies included phonemic awareness, phonics, fluency, comprehension, and vocabulary. Multicomponent reading approaches were effective for students with ID. However, reading interventions specifically adapted for students requiring AAC are scarce. Furthermore, according to Michael Barker et al. [41], building a cumulative knowledge base is challenging because of the wide variety of information and assessments in these studies. Evidence bases for reading interventions for children requiring AAC consisted of small groups of single-case design (SCD) studies that used different measures and teaching strategies and demonstrated varying degrees of success. Although randomized controlled trials (RCTs) are considered the gold standard in research, studies using SCD can also offer a robust methodology crucial for developing evidence-based practices in special education [42]. SCD are frequently utilized and essential for gathering evidence in the field, with 83% of interventions for individuals with ASD employing SCD [43].

Some longitudinal and comprehensive studies have utilized a phonological approach [25, 26, 44]. In the intervention by Allor et al. [44], 28 children with moderate ID were randomly assigned to treatment or control groups, however, it did not specify their speech abilities or whether they required AAC. Statistically significant differences were identified in phonemic awareness, phonics, vocabulary, and comprehension, with all measures demonstrating moderate-to-strong effects. Allor et al. [25] investigated the outcomes of 141 students with IQs ranging from 40 to 80. Students in the treatment group received 19 to 134 weeks of instruction and made significant gains in phoneme segmentation ($ES = 0.66$), phonics ($ES = 0.58$), and phonemic decoding efficiencies ($ES = 0.49$).

The 93 students enrolled in the study by Browder et al. [26] had moderate or severe ID; however, the number of students requiring AAC was not stated. The students were only tested in one pre- and one post-test, and decoding was not part of the intervention. The effect size between groups on the posttest ranged from small (.15) to large (.95).

Two studies that have stated the AAC- population are Palmqvist et al. [45] and Ulriksen et al. [44], emphasizing a phonic-based approach. Palmqvist et al. [45] included 123 students with mild-to-severe ID who required AAC. The students were divided into four groups: one group received a phonics-based intervention; the second group received a comprehension-based strategy; the third group received both strategies; and the control group received typical teaching (TAU). They were assessed four times over the 12-week intervention, and it was found that the combination of comprehension-based and phonics-based reading instruction was the only approach that improved phonological awareness. In a study by Ulriksen et al. [46], seven students with moderate ID who required AAC participated in a phonological reading intervention using a multiple SCD with a pre-posttest and follow-up maintenance. There was a functional

relationship between the intervention and positive outcomes in the different components of letter-sound correspondence, sound blending, phoneme segmentation, and decoding; however, there was less evidence for decoding.

Methods

This study investigated 40 students with ASD and/or ID who required AAC and acquired early reading skills through a longitudinal multicomponent reading intervention. The students have worked systematically and explicitly with the reading program “Reading for all” for up to 18 months. “Reading for all” is based on the research of the evidence-based reading program ALL [2].

The research questions are:

- Is there a functional relationship between the use of “Reading for all” and improved acquisition of letter-sound correspondence?
- Is there a functional relationship between the use of “Reading for all” and increased accuracy of sound blending?
- Is there a functional relationship between the use of “Reading for all” and improved acquisition of phoneme segmentation?
- Is there a functional relationship between the use of “Reading for all” and improved acquisition of decoding by students aged 6–14 with ASD and/or ID who require AAC?

Our main hypothesis is that working systematically and explicitly with the multicomponent reading material “Reading for all” over 18 months will increase the student’s development in early reading skills.

The independent variable was the adapted reading material “Reading for all,” that is based on the research of ALL [2]. The dependent variable was the students’ accuracy in identifying the early reading components, such as letter-sound correspondence, sound blending, phoneme segmentation, recognition of sight words, and decoding.

The assessments in this study were developed by the researchers and focused on reading materials. The teachers conducted tests on letter-sound correspondence, sound blending, phoneme segmentation, recognition of sight words, and decoding. Additionally, teachers evaluated students’ communicative competence using the MacArthur-Bates Communicative Development Inventory (CDI) [47]. Furthermore, after the intervention concluded, the students who had achieved level two in the reading materials and those who demonstrated improvement in the final decoding test in month 18 were assessed using OL64, a standardized reading test [48].

The first and second authors conducted lessons and informed teachers and principals about the reading intervention at 12 schools from August to December 2022 to recruit students and teachers who could participate in the reading intervention. Teachers who had students meeting the inclusion criteria reached out to the students’ parents. Both the parents and teachers provided informed consent to participate in the study.

The inclusion criteria were:

- Diagnosis of ASD, ID, or other diagnoses confirmed by multidisciplinary assessments conducted by the Child Rehabilitation Service.
- Age 6–14
- They did not have functional speech and required AAC as their primary form of communication.
- Could not follow ordinary curricula but have an individual education plan (IEP).

The exclusion criteria were:

- Students with severe visual or hearing impairment
- Students who were able to decode syllables or single words
- Students with severe physical disabilities prevented themselves from answering or providing other reliable answers.

Of the 40 students, two moved abroad, and one could not continue for reasons unrelated to the school or intervention. One student could not be tested and was marked as having missing data throughout the study period. Additionally, one student underwent the first assessment before the onset of school refusal turned severe. Several students also experienced significant gaps during the intervention because of school refusal and health-related problems. It was impossible to obtain a map of communicative competence from all students because some teachers did not assess it despite several reminders. Three students had rare diagnoses that were not noted to ensure their anonymity.

As Table S1 illustrates, there is considerable variability in students' communicative competence, and their communication skills and assumptions vary widely. Both unaided (not requiring the use of any physical devices, such as manual hand signs, gestures, or facial expressions) and aided systems, including low-tech options (such as communication boards or picture exchange systems) and high-tech devices (such as speech-generating devices based on tablets), were utilized for expressive support and comprehension assistance, or both.

Setting, procedures, and design

The reading intervention took place between March 2023 and October 2024. Forty students from 12 schools participated, and their primary teachers implemented the interventions at their regular schools. All teachers were trained to conduct the assessments, perform daily reading instructions, and create video recordings. The first author was available throughout the intervention.

The instructions were delivered one-on-one, and daily guidance was recommended for about 20 to 30 minutes. Additionally, the teachers were encouraged to use flashcards featuring all symbols and words that the students encountered during the intervention. This approach aimed to enhance both students' vocabulary and comprehension. All teachers were asked to register for each work session on a registration form. Teachers should record correct and incorrect responses, the time spent, the folder used (e.g., whether

they worked at level two in folder 22), and the specific task (e.g., sound-blending). The students were assessed using the same test materials for early reading skills, with all tests administered by their primary teachers. All the testing situations were recorded.

The reading intervention employed a multiple SCD with several randomized baselines. The students were randomly assigned to four groups: A, B, C, and D, with each group starting at different times month. The students were randomized using PASS23 via *Weisurnalg* or *ithmdue* → *Weisurn* dynamically changing the group assignment probabilities based on the level of imbalance to establish longitudinal balance between groups [49] (See Table S2 in Additional file 1).

Ethical approval

was obtained from the Norwegian Agency for Shared Services in Education and Research (Sikt) on 10 October 2022, Sikt registration form: 988724. We submitted a preliminary application to the Regional Committee for Medical and Health Research Ethics. However, such approval was not necessary for studies involving human samples, in accordance with local legislation and institutional requirements; the REK deemed this research to be pedagogical and, therefore, outside its purview. Written informed consent for participation was secured from the parents or legal guardians of the participants. Rare conditions were not specified due to privacy concerns and the risk of identification. Additionally, when multiple students presented with three to four diagnoses, these were omitted since such combinations of diagnoses can lead to recognition.

The intervention and the primary and secondary outcomes

The material in use is called “Reading for all” and is based on the research and the evidence-based reading program ALL by Light and McNaughton [2]. ALL emphasizes a synthetic and analytic approach, which was developed by the recommendations of the National Reading Panel (NRP, 2000).

All instructional tasks were adapted for students without functional speech by using symbols, and oral or written responses were not required for any of the tasks. Internal speech (verbalizing phonemes silently in their minds) was also emphasized among students with speech limitations. The reading material included various strategies from evidence-based teaching, particularly for students with ASD and ID, such as direct and systematic instruction [33, 35], explicit instruction [33, 35, 50], scaffolding, immediate and corrective feedback, and cumulative review and practice [2].

The reading components emphasized in the reading material and intervention were as follows: 1) Letter-sound correspondence (the relationships between letters and sounds), 2) Sound blending (building words from individual sounds in spoken language), 3) Phoneme segmentation (initial sound isolation, detecting the first sound in words), 4) Sight words: the ability to recognize a word without decoding (both phonetically regular and irregular words and high-frequency words), 5) Word decoding (recognizing letters, associating letters with the correct sounds, and pull the sounds together into words), and 6) Shared reading: in these tasks, students are encouraged to decode target words that appear several times in the reading material.

The reading material consisted of several levels, with students required to master each task in each folder with at least 80% proficiency before proceeding to the next task and folder (see Appendix 1 in Additional file 1, for a description of the different levels). Additionally, the teachers received flashcards containing all the symbols and words (560 in total) that students encountered in the reading material. Teachers were encouraged to use these flashcards to develop concepts and vocabulary.

The primary outcomes were assessed 18 times at equal intervals each month, focusing on the student's skills in letter-sound correspondence, sound blending, and phoneme segmentation. Decoding and sight words were also evaluated at 1, 12, and 18 months. The first and second authors created all the early reading tests. To the best of our knowledge, no assessments in Norway demonstrating evidence of validity have been modified for students who require AAC. All tests were adapted from the reading material "Reading for All". In each test, the students must differentiate between the target word or target sound and the three other options. The students' primary teachers conducted all assessments. The tests incorporated Widgit symbols [51], and there was no requirement for verbal or written responses. Students could answer by pointing at symbols, making hand signs, or using speech.

1. In the first test, letter-sound correspondence [scores ranging from 0 to 25] measured students' ability to match sounds (phonemes) to correct letters (graphemes). The students had to discriminate between four letter sounds, that is, the target sound "a" and three others. The letters q, w, x, and z are excluded because they are rare in Norway.
2. The second test, sound blending [score ranging from 0 to 10], measured the student's ability to listen to extended phonemes (for example /s//s//s//u//u//u//n//n/), blend them, and respond by selecting the symbol that represented the word "sun."
3. In the third test, phoneme segmentation [scores ranging from 0 to 10] assessed students' ability to segment the first phoneme of the word (e.g., /c/ for cat).

Secondary outcomes were assessed at one time point during baseline and twice during the intervention (at months 1, 12, and 18).

1. The assessment of sight words [scores range from 0 to 10] measured each student's ability to recognize words learned by sight. The tasks contained, beside the target sight word, novel sight words, words with similar first sound as the target word and words with similar shape (for example in Norwegian "kan" and "kam"). The words also consisted of different consonant-vowel-consonant occurrences (CVC), such as VCVC, CCVC, VCCVC, and VCC.
2. Assessments in decoding [score ranging from 0 to 20] consisted of 20 tasks with CVC, VCC and CCV words, for example, "sol" (sun), "ost" (cheese) and "kne" (knee). Ten of the words were worked on explicitly in the material, but the last ten words were novel and were not included in the reading intervention. The decoding assessments tested the students' ability to recognize graphemes, associate letters with the corresponding sound, blend these sounds to determine the word, and finally identify the symbol representing the word.

The teachers registered all test situations in register forms. In addition, all assessments were videotaped

OL 64 is a reading test designed to map students' beginner word reading. Reading tests offer nuanced and systematic information about the skills necessary for further reading and writing development [48]. Students who achieved at least Level 2 in the reading material required for a standardized reading test were assessed after the intervention.

The teachers and parents worked together to assess students' communicative competence using the MacArthur-Bates Communicative Development Inventory (CDI) before implementing the reading intervention [47]. Nordahl-Hansen et al. [52] found that the CDI demonstrated good psychometric properties when administered to children with ASD, including interrater reliability and concurrent validity [53].

Data collection procedures

Since this was an open-label trial, it was not possible to blind the students to the interventions. Additionally, the first author could not be blinded to the intervention due to the coordination of all teacher training and fieldwork. However, the research assistant was blinded when the intervention was initiated for each student, and the two assessors independently coded the results while remaining unaware of each other's information.

All tests throughout the intervention were video-recorded monthly. To calculate interobserver agreement (IOA), Random.Org was used to randomly select 20% of the tests each month for the first seven months and 20% from the remaining recorded tests. In the first month, 27% of the test situations were selected based on the critical startup phase. Training was conducted whenever IOA fell below 80%, through written reminders and corrections emails. However, after the first assessment, we noticed that two tests (letter-sound correspondence and sound blending) were challenging to perform accurately. Therefore, a training video was recorded in which the first author provided the correct test instructions.

The agreements between the two assessors (the first and second authors of the manuscript) and the teachers were reviewed. The research assistant was blinded to each student's starting point (whether they were in groups A, B, C, or D), and the first and second authors conducted the IOA assessment in a blinded manner. Operationalized observation criteria and checklists were adhered to when controlling for agreement.

The same observers who collected the IOA also scored procedural fidelity by investigating the test videos using a procedural fidelity checklist created by the first and second authors. The first test session was scored with 27%, test sessions two-seven 20%, and the rest of the test sessions 20%. The checklist for the probes consisted of whether the teachers followed the instructions: a) *in sound blending*, extended the phonemes for one-two seconds, b) *in letter-sound correspondence*, said the letter sound and not the letter name; c) *in phoneme segmentation*: said the name of the symbol first, without any prompt, then gave the instruction; and d) *in sight words and decoding*: just pointing at the target word, not reading it.

In all tests, teachers were encouraged not to comment on whether answers were right or wrong, but to praise the effort. If a teacher gave incorrect instructions, the observers rejected the student's answer and marked it incorrect. The percentage of correct implementations was then calculated.

During the intervention, teachers provided monthly summaries detailing the students' progress: the number of sessions per week and the total minutes worked. Additionally, the summaries indicated whether students had engaged with the explicit assignment folder, which level they worked in (1, 2, or 3), and the specific folder and task they tackled. This ensures effective control over the intervention's implementation. When teachers failed to submit summaries, they received reminders via email. Furthermore, the first author was available for guidance throughout the intervention questioning.

Statistical analysis

A generalized estimating equation (GEE) was utilized to assess the effectiveness of the intervention concerning phonological awareness, sight words, and decoding. Due to the repeated measures from the same participant, the selected working matrix was an autoregressive first order. Thus, the primary model included the following covariates: a) the phase of the intervention or control over time and b) time (noted in the tables as a main effect). Additionally, two moderation models (also known as interaction models) were conducted: The first interaction model examined whether the time effect on the outcomes would be more pronounced during the intervention phase than in the control phase (as shown in Tables 1, 2, and 3, referred to as *Int 1*). Furthermore, we tested whether the effect of time on the outcome was conditioned by the severity of the disability (ranked from no severity to severe levels of disability), aiming to evaluate if overall language development over time is influenced by the severity of the disorder, where greater severity correlates with a diminished effect of time on the outcome scores (in Tables 1, 2, and 3 described as *Int 2*).

Table 1
Results for letter-sound correspondence and sound-blending

Outcome									
Model	Effects	LSC	95% WCI		p-value	SB	95% WCI		p-value
Main effects	Intervention	0.369	-0.488	1.277	0.398	0.662	0.094	1.229	0.022
Main effects	Time	0.378	0.248	0.508	< 0.001	0.196	0.139	0.254	< 0.001
Int 1	Intervention	-0.828	-2.616	0.961	0.364	0.908	-0.065	1.881	0.067
Int 1	Time	-0.107	-0.900	0.685	0.791	0.299	-0.098	0.696	0.140
Int 1	Intervention*time	0.522	-0.297	1.331	0.206	-0.109	-0.507	0.288	0.590
Int 2	Intervention	0.371	-0.487	1.228	0.397	0.665	0.098	1.232	0.021
Int 2	Time	0.363	0.237	0.488	< 0.001	0.192	0.137	0.246	< 0.001
Int 2	Severity	-0.574	-2.252	1.105	0.503	0.087	-0.546	0.720	0.788
Int 2	Time* severity	0.030	-0.048	0.109	0.452	0.010	-0.019	0.039	0.489
<i>Note.</i> NA = The interaction parameter was set to zero because it is redundant. Int 1 = results derived from an interaction model where the focus was on intervention*time effect's coefficient; Int 2 = results derived from an interaction model where the focus was on time*severity's effect coefficient.									

Table 2
Results for phoneme segmentation and sight words

Outcome									
Model	Effects	PS	95% WCI		p-value	SW	95% WCI		p-value
Main effects	Intervention	-0.084	-0.682	0.513	0.782	-1.851	-4.255	0.553	0.131
Main effects	Time	0.242	0.177	0.306	< 0.001	0.286	0.145	0.427	< 0.001
Int 1	Intervention	-0.033	-0.981	0.914	0.945	NA	NA	NA	NA
Int 1	Time	0.264	-0.129	0.656	0.188	NA	NA	NA	NA
Int 1	Intervention*time	-0.023	-0.424	0.374	0.909	NA	NA	NA	NA
Int 2	Intervention	-0.090	-0.687	0.508	0.769	-1.905	-4.270	0.461	0.114
Int 2	Time	0.260	0.195	0.324	< 0.001	0.294	0.154	0.433	< 0.001
Int 2	Severity	0.448	-0.079	0.975	0.095	-0.139	-0.481	0.203	0.426
Int 2	Time* severity	-0.037	-0.078	-0.005	-0.085	-0.010	-0.044	0.025	0.579
<i>Note.</i> NA = The interaction parameter was set to zero because it is redundant. PS = phoneme segmentation, SW = sight words. Severity refers to whether the students have different diagnoses as Down Syndrome/rare, ASD or ASD and a level of disability.									

Table 3
Results for decoding

Outcome					
Model	Effects	Decoding	95% WCI		p-value
Main effects	Intervention				
Main effects	Time	0.	0.	0.	< 0.001
Int 1	Intervention	NA	NA	NA	NA
Int 1	Time	NA	NA	NA	NA
Int 1	Intervention*time	NA	NA	NA	NA
Int 2	Intervention	-0.787	-4.659	3.985	0.690
Int 2	Time	0.462	0.216	0.708	< 0.001
Int 2	Severity	-0.143	-0.825	0.539	0.681
Int 2	Time* severity	-0.014	-0.090	0.062	0.718
<i>Note.</i> NA = The interaction parameter was set to zero because it is redundant.					

Bland-Altman plots and their derived estimates (mean difference, as well as lower and upper limits of agreement) [54, 55] were employed to assess the agreement between teachers and researchers regarding the continuous scores for all outcomes. A random subsample of 29 children was used for phonological awareness outcomes, while 15 were used for decoding outcomes. The NCSS software was utilized to calculate the Bland-Altman plots.

The significance level was set at $p < 0.05$. All analyses involving the intervention effect were performed using the SPSS 29.

Results

Evidence is missing regarding the effect of the intervention phase (vs. control) on the outcome modified by time (interaction 1) and the severity of the children's disabilities (interaction 2). This finding indicates that a) there is insufficient evidence that within the intervention phase, scores increase over time, and b) the overall development of the children across all outcomes over time is not dependent on severity.

[Tables 1–3 here]

The students completed letter-sound correspondence, sound blending, phoneme segmentation, sight words, and decoding at months 1, 12, and 18. Note that 18 measurements of letter sounds, sound blending, and phoneme segmentation were conducted, but only three of those are presented here. For individual outcomes in the different reading components, see Figures S1-S20 in Additional file 1.

Assessment of trial results in a standardized reading test (OL 64)

The test results described the students’ initial word reading abilities. Emphasis is placed on accurate reading and time management. Fast and confident readers exhibit a confidence level of 90% or more and can read 64 words in less than 7 minutes. Slow and confident readers also show a confidence level of 90% or more, taking between 7 and 10 minutes [48]. These students have gained alphabetic insights, recognize letter sounds, and have mastered basic phonological reading (see Figure S21 in Additional file 1).

Table 4 describes the effects of the intervention and control phases on the three models. As shown, there is a *time* effect over all the models, meaning that, on average, there is a positive increase in the scores for all the outcomes and their respective measures. For example, for the main effect model, for each repeated assessment of *letters* there is a 0.378 correct, meaning that in over ten assessments, the children are, on average, getting 3.78 correct points. Our main hypothesis for the main effect model was to see if the phase with the intervention had higher scores than the control phase, and only in the phonological awareness domain, *blending*, can one observe the intervention effect being 0.662 correct points compared to the control phase (p-value = 0.022). We lacked evidence of the difference between the two phases for all other domains.

Table 4
Severity features and time spent with each child over 18 months

	N	Mean	Minimum	Maximum
-1	16	29.4365	6.00	67.52
0	1	45.4000	45.40	45.40
1	13	46.0397	20.93	90.92
2	3	39.4222	16.90	64.88
3	4	51.3250	38.47	61.47
Total	37	38.8775	6.00	90.92
Note. Three students had missing data for hours/implemented time: ID 20, 24, and 30.				

[Table 4 here]

[Table 5 here]

Table 5
Interobserver agreement

Lower Limit of Agreement	Upper Limit of Agreement
-14,62665	9,086416
-18,93642	12,3732
-25,2267	18,15773
-27,97599	15,97599
-21,5325	9,389639

The Bland-Altman plot and its derived estimates (mean difference between a teacher and the researchers (also called *bias*) and lower and upper limits of agreements for the mean difference are reported in Table 5. The mean scores from the teachers were consistently lower than those from the researcher, with the largest difference noted in decoding and sight-word reading (about six points less on average). A perfect agreement would be reached if the teachers and researchers scored the same, yielding a mean difference of zero.

Overview of time used in hours for the participants (see Table S3 in Additional file 1). The result of the social validity assessment, along with Figures S22 and S23, are presented in Appendix 2.

Discussion

This study aimed to investigate the effect of the independent variable, the adapted reading material “Reading for all” based on the evidence-based reading program ALL [2] and evidence-based strategies for students with ASD and/or ID who require AAC. None of the students decoded syllables or words at the beginning of the intervention.

Blending, as a subdomain of phonological awareness, showed higher scores during the intervention phase than during the control phase. This finding, along with other non-significant effects observed across various domains of phonological awareness and outcomes, was not dependent on the time and severity of the disorder. Our tools are currently being evaluated for their psychometric properties and, as a result, may not be sensitive enough to capture monthly developments. As in previous research, this study provided mixed results independent of the different baseline groups or the use of intervention time. Due to great heterogeneity (students had great variability regarding their age, diagnosis, and baseline speech ability), our results are more generalizable to a broad audience rather than a specific sampling of children with a single diagnosis, for example autism. However, although statistical analyses stated significance only within sound blending, it is also crucial to investigate students' individual development in different reading components in such studies.

For students with limited or no speech ability (10 words or fewer, N = 11), internal speech was encouraged, allowing them to demonstrate competence by hearing and extending the sounds in their minds and using pointing as a response modality. The individual results in Table 4 show that some students acquired

phonological awareness, enhanced their letter-sound skills, and exhibited phonological reading abilities. However, a visual data inspection was not conducted using our statistical methods model.

Table S1 and Figures S1-S20 show that a few common denominators emerge for those demonstrating the best reading development. The baseline mapping of communicative competence reveals significant variety in both expressive and receptive languages. However, a common factor among most students acquiring phonological reading skills is that they had already learned many letter-sound correspondences at the beginning of the intervention. Letter-sound correspondence and phonological awareness are key components predicting later literacy development [56, 57]. Individuals with ID who require AAC exhibit lower phonological awareness and letter-sound skills compared to typically developing children [58], and they often need additional time to develop this knowledge [25]. This represents a distinct challenge for this population. By examining the individual test results from the final assessments, it was found that 33% of the sample successfully cracked the reading code, while 62% mastered more than 16 letter-sound correspondences in the first baseline assessment. In the final tests on phonological awareness, the specific results indicated that 19 out of 40 students achieved a high degree of phonological awareness. However, many students may require significantly more instructional time before developing phonological reading skills, as numerous students in this population might use 1.5 to 3.5 academic years to achieve functional reading skills [25].

Several students found it challenging to generalize their early reading skills to another adapted test, OL 64. Many students (N = 18) in Figure S21 were not assessed with this last test due to difficulties with a new format that differed from the researcher-made tests. Teachers reported that several students became frustrated and did not understand what to do, even though they provided similar instructions as in the 18 measurements during the intervention. According to Whitbread et al. [59], there is a significant issue for most individuals with ID in generalizing the skills they have achieved in controlled settings to everyday use. Since we conducted both the OL64 and included novel words in the reading test, it was possible to detect generalization skills, whether the students could read in another context, and whether they had automated words as pictures or read phonetically. However, the OL64 test indicated that only 13 students had achieved functional reading skills.

Using the standardized reading test OL 64 (adapted with Widgit symbols), the students could demonstrate whether they had mastered reading novel words, words with different vowel and consonant combinations, and words they had not encountered in the reading material, such as words with diphthongs (øy, au). Furthermore, the researcher conducted tests based on the student's placement within the materials. For instance, in March 2024, during the tests on decoding and sight words, students who were still at Level 1 had no expectations about mastering these tests because they had not received explicit instructions in phoneme segmentation and decoding prior to Level 2 in the reading material.

The aim was for the teachers to deliver the instruction for approximately 20–30 minutes each day. Calculating the time needed for each student showed that they received less instructional time than recommended, and the intensity of implementation was not optimal for many students. This is a common challenge observed in other studies [15, 45].

Owing to the large individual differences in the sample, it was not possible to determine the time used against the results. There are significant differences in the amount of time students spend reading instructions. During the monthly summaries, we noted that some students spent one minute on a task while others spent 20 minutes. Although the intervention lasted for 18 months, it is important to consider effective intervention time. For 18 months, at least 22 out of 82 weeks were holidays. Furthermore, several students took vacations during the school year, some experienced health issues and some refused to attend school. Allor et al. [60] noted that providing interventions with sufficient intensity is challenging, given that many students with ASD and ID develop slowly and need extensive practice to acquire their reading skills. In earlier research by Allor et al. [25], it was highlighted that even with 45 minutes of daily instruction using evidence-based methods, students made progress in oral reading fluency equivalent to 1.5 to 3.5 academic years, while the majority of typical students may accomplish similar progress in just half an academic year [25]. As detailed in Table S3, the instructional time indicates that most students received less instructional time than recommended. Additionally, maintaining motivation over such an extended period may be challenging, and a decrease in time was observed for some of the participating students. Overall, it appeared that students requiring the most intervention time received less due to various factors.

The reading material emphasizes concise instructions, enabling students to process them effectively. Students with ID may require additional processing time to receive, comprehend, and respond to information [61]. Furthermore, including all instructions—specifically what the teachers conveyed and how—at the back of each task ensured that all students received roughly the same guidance. This may have also contributed to a predictable teaching style, which is often preferred by this population. However, some students may have found it too rigid and therefore, they should have been allowed greater individual adaptation.

Limitations and future research

This study had some limitations. The number of baseline points varied among the groups: Group A had two before starting the intervention, Group B had three, Group C had four, and Group D had five data points. According to Ledford and Gast [62], it would be methodologically stronger if all four groups utilized five data points groups. However, the What Works Clearinghouse guidelines indicate that to meet design standards within single-case intervention, “the study should include at least three attempts to demonstrate an intervention effect at three different points in time” [63].

We aimed to measure student vocabulary before and after the intervention using the CDI, which the teachers and parents completed. However, it was impossible to obtain that many students after the intervention ended. Many students changed their teachers during the intervention, and the new teachers justified the lack of CDI by saying that they did not know the students well enough to map their communicative competence afterwards. Thus, assessing the impact of reading interventions on vocabulary development is impractical. According to the teacher survey, 88.9% of teachers reported that the students had improved their vocabulary.

It is optimal to use standardized tests when measuring skills in an intervention; however, Norway has no standardized tests to measure early reading skills in students who require AAC. The researcher developed all early reading tests in phonological awareness, letter sounds, sight words, and decoding and aligned with the reading material. According to Palmqvist et al. [45], measurement issues undermine the interpretation of results in most studies on similar topics. Sermier Dessemontet et al. [32] noted that standardized tests showed a smaller effect of phonics-based reading interventions in students with ID. This may be due to the researcher developing tests based on the reading programs used in the interventions, which were very similar to the material.

Another dilemma with these tests was that there was a 25% chance the students gave the correct answers. During the tests, it became clear that several students had not mastered the skills but guessed correctly. Therefore, in this case, with 18 measurements taken during the intervention, it was beneficial to stabilize the measurements over time. Another challenge was that some students developed rigid strategies by pointing to the square's bottom right.

Maintaining participation over such a long period was challenging because many students changed schools and teachers during the interventions. First, it is unclear whether teachers who take responsibility for students who have started an intervention are as motivated and engaged as the original teachers who agreed to participate. Second, changes in schools and teachers required new training sessions, which were time-consuming. Another challenge is that when students start at new schools with new teachers, it may take a long time to get to know the students and settle into a teaching routine. Several students who switched schools did not effectively engage with the intervention before October, three months after changing schools.

Future research should involve a larger randomized controlled trial (RCT) to examine all the components recommended by the Norwegian Research Council (NFR), also including comprehension. Additionally, it is vital to consider factors such as disability type, IQ, expressive and receptive language, and prior literacy experience. According to Allor et al. [60], a deeper understanding of these potential factors may enhance our ability to tailor instructions to meet individual differences. Furthermore, exploring a more tailored approach for each individual is crucial due to significant heterogeneity. According to Reichow et al. [64], future studies should focus on moderators to improve our understanding of how instruction and individual differences can be adapted to boost reading outcomes. However, it is important to note that moderation analysis (i.e., interaction analysis) requires larger samples compared to analyses that estimate only main effects.

Reading comprehension should also be measured as it is the ultimate goal of reading [65]. However, while understanding the meaning of words or connected text was considered through shared reading books, it was not assessed. Several studies [66–68] have shown that students with ID have less developed reading comprehension skills, which highlights the need to investigate methods for teaching reading comprehension and develop assessments that can measure reading comprehension for students with ID who require AAC.

Implications for practice

Research indicates a lack of high-quality reading instruction [10], expectations [5], and evidence-based reading programs [69] for students with autism and ID who require AAC. In Norway, as in many other countries, there are no clear guidelines for teaching functional reading and literacy skills to this population. It is crucial for both policymakers and teacher education institutions to help establish clearer standards and guidelines on how teachers should implement evidence-based reading instruction for this population. Additionally, developing adapted assessments is essential to ensure validity and reliability, with robust psychometrics that allow this population to demonstrate their skills.

Conclusions

The present study enhances the understanding of multicomponent phonics-based reading instruction for students with autism and ID who require AAC. The intervention highlighted evidence-based strategies, particularly those proven effective for students with ID who need AAC. While statistical analysis indicated significance for the reading component of sound blending, it is essential to examine all individual results and developments in this diverse population. Although it was challenging to identify many common factors, one aspect was particularly notable. Most students who developed phonological reading skills had already mastered numerous letter-sound correspondences before the intervention began. Additionally, it is important to note that students with limited expressive and receptive language progressed in reading components and acquired some functional early reading skills. To address the high levels of illiteracy in this population, literacy expectations and experiences must evolve, beginning with the fundamental belief that all students have the right to succeed as readers [22].

Further research is needed to establish reading standards for more homogeneous groups and deep dive into each individual characteristic to find what works and for whom. Identifying common denominators, in addition to implementing evidence-based strategies, may contribute to ensuring that individuals with autism and/or intellectual disability who require AAC have the opportunity to become functional readers.

Abbreviations

Augmentative and alternative communication (AAC)

Autism Spectrum Disorder (ASD)

Communicative Development Inventory (CDI)

Individual education plan (IEP)

Intellectual Disabilities (ID)

Interobserver agreement (IOA)

National Reading Panel (NRP)

Norwegian Research Council (NFR)

Randomized controlled trials (RCTs)

Single-case design (SCD)

Typical teaching (TAU)

Declarations

Ethics approval and consent to participate

This study was performed in line with principles of the Declaration of Helsinki. Ethical approval was granted via the Norwegian Agency for Shared Services in Education and Research (Sikt) on 10 October 2022, Sikt registration form: 988724. All the participants consented to participate through a written consent form.

Consent for publication

All participants consented to publication on the basis that none will be recognized in the publication.

Competing interests

The reading material “Reading for all” is based on the research of ALL (Light & McNaughton, 2011) and is developed by the first and second author of the manuscript. The reading material consisted of Widgit symbols from NorMedia and images from Tobii Dynavox, which were referred to in accordance with the guidelines. Neither NorMedia nor Tobii received any royalty for this study, and none of the researchers made any profit from using the reading material in the present study. The authors declare no conflict of interest.

Funding

Funding was provided through the Portfolio Plan for Education and Competence by the Research Council of Norway. Research funding: 1 900 000 NOK. Trial Sponsor details: The Research Council of Norway, Postboks 564, 1327 Lysaker, + 47 22037000.

Authors' contributions

Line Britt Ulriksen: Funding, Writing – original draft, Writing – review and editing, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, data curation, and conceptualization.

Marthe Bilet-Mossige: Writing – review and editing, references, Visualization, Resources **Kenneth Larsen:** Writing – review and editing, Validation, Supervision, Project administration, Methodology, Formal analysis, and conceptualization. **Hugo Cogo Moreira:** Writing – review and editing, Validation, Methodology, Formal analysis, Validation, Supervision, Software, Data curation, and conceptualization. **Anders Nordahl-Hansen:** Writing-review and editing, Validation, Supervision, Software, Project administration, Methodology, Formal analysis, conceptualization. All authors contributed to the article and approved the submitted version.

Acknowledgments

The authors deeply appreciate the engagement of all the students who have worked so hard over such a long period, their teachers who have been so dutiful and committed to the intervention, and the parents who consented on behalf of their children participating in the project. We are sincerely grateful for the support.

Availability of data and materials

The data supporting the findings of this study are available from the corresponding author upon request.

References

1. Baer J, Kutner M, Sabatini J, White S. Basic reading skills and the literacy of America's least literate adults: Results from the 2003 national assessment of adult literacy (NAAL) supplemental studies; 2009. NCES 2009-481. *National Center for Education Statistics*. Accessed Dec 12, 2024, <https://eric.ed.gov/?Id=Ed505187>
2. Light JC, McNaughton D. Accessible Literacy Learning (ALL) Reading program: Evidence-based reading instruction for learners with autism, cerebral palsy, down syndrome and Other Disabilities. Mayer-Johnson; 2011
3. Cihak DF, Smith CC. Teaching academic skills to elementary-age students with intellectual disability. In: Gargiolo RM, Bouck EC, editors. Instructional strategies for students with mild, moderate, and severe intellectual disability. Sage Publications; 2018 p. 231-65. <https://doi.org/10.4135/9781506369785.n13>
4. Lerner MD, Lonigan CJ. Bidirectional relations between phonological awareness and letter knowledge in preschool revisited: A growth curve analysis of the relation between two code-related skills. *J Exp Child Psychol*. 2016;144:166-83. <https://doi.org/10.1016/j.jecp.2015.09.023>
5. Ruppel AL, Dymond SK, Gaffney JS. Teachers' perspectives on literacy instruction for students with severe disabilities who use augmentative and alternative communication. *Res Pract Pers Severe Disabil*. 2011;36:100-11. <https://doi.org/10.2511/027494811800824435>
6. Clendon S, Paynter J, Walker S, Bowen R, Westerveld MF. Emergent literacy assessment in children with autism spectrum disorder who have limited Verbal Communication Skills: A Tutorial. *Lang Speech Hear Serv Sch*. 2021;52:165-80. https://doi.org/10.1044/2020_LSHSS-20-00030
7. Benson-Goldberg S, Erickson K. Reported and enacted emergent literacy instruction: Understanding young students with extensive support and complex communication needs, opportunity to learn. *Topics Early Child Spec Educ*. 2024;44:6-19. <https://doi.org/10.1177/02711214241235404>
8. Dessemontet RS, de Chambrier AF. The role of phonological awareness and letter-sound knowledge in the reading development of children with intellectual disabilities. *Res Dev Disabil*. 2015;41:1-12. <https://doi.org/10.1016/j.ridd.2015.04.001>
9. World Health Organization (2018). International Classification of Diseases 11th Revision. Retrieved from <https://icd.who.int/browse11>

10. 10. 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;52:225–38. https://pubs.asha.org/doi/pdf/10.1044/2020_LSHSS-20-0001. https://doi.org/10.1044/2020_LSHSS-20-00019
11. 11. Ahlgrim-Delzell L, Rivera C. A content comparison of literacy lessons from 2004 and 2010 for students with moderate and severe intellectual disability. *Exceptionality*. 2015;23:258–69. <https://doi.org/10.1080/09362835.2015.1064417>
12. 12. Ruppert AL. A preliminary study of the literacy experiences of adolescents with severe disabilities. *Remedial Spec Educ*. 2014;4:235–45. <https://doi.org/10.1177/0741932514558095>
13. 13. Ricci LA, Osipova A. Positives, potential, and preparation: Pre-service special educators' knowledge about teaching reading to children with Down syndrome. *Exceptionality Educ Int*. 2018;28:20–32. <https://doi.org/10.5206/eei.v28i2.7763>
14. 14. Mandak K, Light J, Boyle S. The effects of literacy interventions on single-word reading for individuals who use aided AAC: A systematic review. *Augment Altern Commun*. 2018;34:206–18. <https://doi.org/10.1080/07434618.2018.1470668>
15. 15. Sermier Dessemontet RS, de Chambrier AF, Martinet C, Meuli N, Linder AL. Effects of a phonics-based intervention on the reading skills of students with intellectual disability. *Res Dev Disabil*. 2021;111:103883. <https://doi.org/10.1016/j.ridd.2021.103883>
16. 16. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th ed. American Psychiatric Publishing. <https://doi.org/10.1176/appi.books.9780890425596>; 2013
17. 17. Caron J, Light J, Holyfield C, McNaughton D. Effects of dynamic text in an AAC app on sight word reading for individuals with autism spectrum disorder. *Augment Altern Commun*. 2018;34:143–54. <https://doi.org/10.1080/07434618.2018.1457715>
18. 18. Light J, McNaughton D. Literacy intervention for individuals with complex communication needs. In: Beukelman DR, Mirenda P, editors. *Augmentative and alternative communication: Supporting children and adults with complex communication needs*. Brookes Publishing Co; 2013 p. 309–51
19. 19. Shane H, Laubscher E, Schlosser R, Fadie H, Sorce J, Abramson J, et al. Enhancing communication for individuals with autism: Guide to the visual immersion system. *Paul H. Brookes Publishing* p. 1–19; 2015
20. 20. Beukelman D, Light J. *Augmentative and alternative communication: Supporting children and adults with complex communication needs*. Paul H. Brookes Publishing Company; 2020
21. 21. Benedek-Wood E, McNaughton D, Light J. Instruction in letter-sound correspondences for children with autism and limited speech. *Topics Early Child Spec Educ*. 2016;36:43–54. <https://doi.org/10.1177/0271121415593497>
22. 22. Caron J, Light J, McNaughton D. Effects of adapted Letter-Sound correspondence instruction with older learners with complex communication needs and autism spectrum disorder. *Augment Altern Commun*. 2023;39:45–59. <https://doi.org/10.1080/07434618.2022.2121226>
23. 23. Wright MHB, Flores MM, Dunn C, Shippen MM, Darch C. Teaching letter sound correspondence to preschool students with developmental and intellectual disabilities. *Educ Train Autism Dev Disabil*.

24. 24. Coleman MB, Cherry RA, Moore TC, Park Y, Cihak DF. Teaching sight words to elementary students with intellectual disability and autism: A comparison of teacher-directed versus computer-assisted simultaneous prompting. *Intellect Dev Disabil.* 2015;53:196–210. <https://doi.org/10.1352/1934-9556-53.3.196>
25. 25. Allor JH, Mathes PG, Roberts JK, Cheatham JP, Al Otaiba SA. Is scientifically based reading instruction effective for students with below average IQs? *Except Child.* 2014;80:287–306. <https://doi.org/10.1177/0014402914522208>
26. 26. Browder D, Ahlgrim-Delzell L, Flowers C, Baker J. An evaluation of a multicomponent early literacy program for students with severe developmental disabilities. *Remedial Spec Educ.* 2012;33:237–46. <https://doi.org/10.1177/0741932510387305>
27. 27. Connor CM, Alberto PA, Compton DL, O'Connor RE 2014. Improving reading outcomes for students with or at risk for reading disabilities: A synthesis of the contributions from the Institute of Education Sciences Research Centers. NCSE 2014–3000. *National Center for Special Education Research*
28. 28. Lemons CJ, King SA, Davidson KA, Puranik CS, Al Otaiba S, Fulmer D, et al. Developing an early reading intervention aligned with the Down syndrome behavioral phenotype. *Focus Autism Dev Disabil.* 2017;32:176–87. <https://doi.org/10.1177/1088357615618941>
29. 29. Westerveld MF, Paynter J, Trembath D. Reading instruction for children with ASD: Getting the story straight. *Journal of Clinical Practice in Speech-Language Pathology.* 2016;18:80–3
30. 30. El Zein F, Solis M, Lang R, Kim MK. Embedding the perseverative interest of a child with autism in text may Result in improved reading comprehension: A pilot study. *Dev Neurorehabil.* 2016;19:141–5. <https://doi.org/10.3109/17518423.2014.915893>
31. 31. Afacan K, Wilkerson KL, Ruppar AL. Multicomponent reading interventions for students with disabilities. *Remedial Spec Educ.* 2018;39:229–42. <https://doi.org/10.1177/0741932517702444>
32. 32. Sermier Dessemontet RS, Martinet C, de Chambrier AF, Martini-Willemin BM, Audrin C. A meta-analysis on the effectiveness of phonics instruction for teaching decoding skills to students with intellectual disability. *Educ Res Rev.* 2019;26:52–70. <https://doi.org/10.1016/j.edurev.2019.01.001>
33. 33. National Reading Panel (NRP). *Report of the national reading panel. Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction: Reports of the subgroups*; 2000. Accessed Dec 16, 2024, <https://www.nichd.nih.gov/sites/default/files/publications/pubs/nrp/Documents/report.pdf>
34. 34. Castles A, Rastle K, Nation K. Ending the reading wars: Reading acquisition from novice to expert. *Psychol Sci Public Interest.* 2018;19:5–51. <https://doi.org/10.1177/1529100618772271>
35. 35. Lemons CJ, King SA, Davidson KA, Puranik CS, Fulmer D, Mrachko AA, et al. Adapting phonological awareness interventions for children with Down syndrome based on the behavioral phenotype: A promising approach? *Intellect Dev Disabil.* 2015;53:271–88. <https://doi.org/10.1352/1934-9556-53.4.271>
36. 36. Yorke AM, Caron JG, Pukys N, Sternad E, Grecol C, Shermak C. Foundational reading interventions adapted for individuals who require augmentative and alternative communication (AAC): A systematic

- review of the research. *J Dev Phys Disabil.* 2021;33:537–82. <https://doi.org/10.1007/s10882-020-09767-5>
37. 37. Bradford S, Shippen ME, Alberto P, Houchins DE, Flores M. Using systematic instruction to teach decoding skills to middle school students with moderate intellectual disabilities. *Educ Train Dev Disabil.* 2006;41:333–43
38. 38. Fenlon AG, McNabb J, Pidlypchak H. So much potential in reading! *Teach Except Child.* 2010;43:42–8. <https://journals.sagepub.com/doi/pdf/10.1177/004005991004300105>.
<https://doi.org/10.1177/004005991004300105>
39. 39. Rupley WH, Blair TR, Nichols WD. Effective reading instruction for struggling readers: The role of direct/explicit teaching. *Reading Writing Q.* 2009;25:125–38.
<https://doi.org/10.1080/10573560802683523>
40. 40. Wanzek J, Wexler J, Vaughn S, Ciullo S. Reading interventions for struggling readers in the upper elementary grades: A synthesis of 20 years of research. *Read Writ.* 2010;23:889–912.
<https://doi.org/10.1007/s11145-009-9179-5>
41. 41. Michael Barker RM, Saunders KJ, Brady NC. Reading instruction for children who use AAC: Considerations in the pursuit of generalizable results. *Augment Altern Commun.* 2012;28:160–70.
<https://doi.org/10.3109/07434618.2012.704523>
42. 42. Horner RH, Carr EG, Halle J, Mcgee G, Odom S, Wolery M. The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children.* 2005;71:165–79.
<https://journals.sagepub.com/doi/pdf/10.1177/001440290507100203>.
<https://doi.org/10.1177/001440290507100203>
43. 43. Steinbrenner JR, Hume K, Odom SL, Morin KL, Nowell SW, Tomaszewski B, et al. Evidence-based practices for children, youth, and young adults with autism. The University of North Carolina at Chapel Hill, Frank Porter Graham Child Development Institute, national clearinghouse on autism evidence and practice review team; 2020
44. 44. Allor JH, Mathes PG, Roberts JK, Jones FG, Champlin TM. Teaching students with moderate intellectual disabilities to read: An experimental examination of a comprehensive reading intervention. *Educ Train Autism Dev Disabil.* 2010;45:3–22
45. 45. Palmqvist L, Holmer E, Samuelsson J, Thunberg G, Reichenberg M, Lundälv M, et al. Improved phonological awareness in children with intellectual disability: A large-scale controlled intervention study combining phonics-based and comprehension-based digital reading instructions [Internet]; 2024. OSF preprints
46. 46. Ulriksen LB, Bilet-Mossige M, Cogo-Moreira H, Øien R, Nordahl-Hansen A. Reading instruction for students with intellectual disabilities who require augmentative and alternative communication: A multiple single case study with baseline, posttest, follow-up, and maintenance. *Res Dev Disabil.* 2024;151:104790. <https://doi.org/10.1016/j.ridd.2024.104790>
47. 47. Kristoffersen KE, Simonsen HG 2012. Tidlig språkutvikling hos norske barn: Mac-Arthur-Bates foreldrerapport for kommunikatív utvikling. Novus

48. 48. Nielsen JC, Kreiner S, Poulsen A, Søgård A. Lærerveiledning til leseprøvene OL 64, OL 120, Mini SL 1 og Mini SL 2; 2008. [Teachers guide to the reading tests OL64, OL 120, Mini SL 1 and Mini SL 1] Cappelen Akademisk Forlag
49. 49. Wei LJ, Lachin JM. Properties of the urn randomization in clinical trials. *Control Clin Trials*. 1988;9:345–64. [https://doi.org/10.1016/0197-2456\(88\)90048-7](https://doi.org/10.1016/0197-2456(88)90048-7)
50. 50. Light J, McNaughton D, Weyer M, Karg L. Evidence-based literacy instruction for individuals who require augmentative and alternative communication: A case study of a student with multiple disabilities. *Semin Speech Lang*. 2008;29:120–32. <https://doi.org/10.1055/s-2008-1079126>
51. 51. Normedia. Inprint 3 (version 3.3.6). [Software]. NorMedia As. <https://normedia.no/inprint>
52. 52. Nordahl-Hansen A, Kaale A, Ulvund SE. Inter-rater reliability of parent and preschool teacher ratings of language in children with autism. *Res Autism Spec Disord*. 2013;7:1391–6. <https://doi.org/10.1016/j.rasd.2013.08.006>
53. 53. Nordahl-Hansen A, Kaale A, Ulvund SE. Language assessment in children with autism spectrum disorder: Concurrent validity between report-based assessments and direct tests. *Res Autism Spec Disord*. 2014;8:1100–6. <https://doi.org/10.1016/j.rasd.2014.05.017>
54. 54. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*. 1986;1:307–10. [https://doi.org/10.1016/S0140-6736\(86\)90837-8](https://doi.org/10.1016/S0140-6736(86)90837-8)
55. 55. Bland JM, Altman DG. Agreement between methods of measurement with multiple observations per individual. *J Biopharm Stat*. 2007;17:571–82. <https://doi.org/10.1080/10543400701329422>
56. 56. Melby-Lervåg M, Lyster S-AH, Hulme C. Phonological skills and their role in learning to read: A meta-analytic review. *Psychol Bull*. 2012;138:322–52. <https://doi.org/10.1037/a0026744>
57. 57. Tunmer WE, Hoover WA. The cognitive foundations of learning to read: A framework for preventing and remediating reading difficulties. *Aust J Learn Difficulties*. 2019;24:75–93. <https://doi.org/10.1080/19404158.2019.1614081>
58. 58. Ainsworth MK, Evmenova AS, Behrmann M, Jerome M. Teaching phonics to groups of middle school students with autism, intellectual disabilities, and complex communication needs. *Res Dev Disabil*. 2016;56:165–76. <https://doi.org/10.1016/j.ridd.2016.06.001>
59. 59. Whitbread KM, Knapp SL, Bengtson M. Teaching foundational reading skills to students with intellectual disabilities. *Teach Except Child*. 2021;53:424–32. <https://doi.org/10.1177/0040059920976674>
60. 60. Allor JH, Yovanoff P, Otaiba SA, Ortiz MB, Conner C. Evidence for a literacy intervention for students with intellectual and developmental disabilities. *Educ Train Autism Dev Disabil*. 2020;55:290–302
61. 61. Næss K-A, Engevik LI, Hokstad S, Mjøberg AG. Vokabularstimuleringstiltak for barn med Down Syndrom: Hva sier forskningen? [Vocabulary Stimulation Interventions for Children with Down syndrome: What does the Research Say?]. *Norsk Tidsskr Logoped*. 2017;1:6–21
62. 62. Ledford JR, Gast DL. Single case research methodology: Applications in special education and behavioral sciences. Routledge; 2014
63. 63. Kratochwill TR, Hitchcock J, Horner RH, Levin JR, Odom SL, Rindskopf DM, et al. Single-case designs technical documentation. What works clearinghouse; 2010. Accessed Febr 15, 2025,

<https://eric.ed.gov/?id=eD510743>

64. 64. Reichow B, Lemons CJ, Maggin DM, Hill DR. Beginning reading interventions for children and adolescents with intellectual disability. *Cochrane Database Syst Rev*. 2019;12:CD011359. <https://doi.org/10.1002/14651858.CD011359.pub2>
65. 65. Browder DM, Hudson ME, Wood AL. Teaching students with moderate intellectual disability who are emergent readers to comprehend passages of text. *Exceptionality*. 2013;21:191–206. <https://doi.org/10.1080/09362835.2013.802236>
66. 66. Schulte AC, Stevens JJ, Elliott SN, Tindal G, Nese JFT. Achievement gaps for students with disabilities: Stable, widening, or narrowing on a state-wide reading comprehension test? *J Educ Psychol*. 2016;108:925–42. <https://psycnet.apa.org/doi/10.1037/edu0000107>. <https://doi.org/10.1037/edu0000107>
67. 67. Trexler EL. Categorical differences in state-wide standardized testing scores of students with disabilities. Ann Arbor, MI: ProQuest; 2013
68. 68. Wei X, Blackorby J, Schiller E. Growth in reading achievement of students with disabilities, ages 7 to 17. *Except Child*. 2011;78:89–106. <https://doi.org/10.1177/001440291107800106>
69. 69. Accardo AL, Finnegan EG. Teaching reading comprehension to learners with autism spectrum disorder: Discrepancies between teacher and research- recommended practices. *Autism*. 2019;23:236–46. <https://doi.org/10.1177/1362361317730744>

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [AdditionalFile1.docx](#)
- [CONSORTChecklist.docx](#)