# Critical Review:
# Efficacy of phonics-based reading instruction for children with Down syndrome

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Children with Down syndrome (DS) are capable of developing literacy skills that help promote their independence. A systematic, phonics-based approach to reading is currently accepted as the best intervention for typically developing children, yet it is unknown whether this method is also effective for students with DS. This critical review examines the evidence regarding the efficacy of phonics-based reading instruction for school-aged children with DS. Studies included single-subject designs, non-experimental pre-post test designs, and a nonrandomized clinical trial. Overall, findings provided suggestive evidence that a phonics-based reading intervention may foster early literacy skills in children with DS.

## *Introduction*

Many children with Down syndrome (DS) receive literacy services from mainstream schools, yet it remains unclear how best to improve reading skills in this population. Obtaining a functional level of literacy can positively affect an individual's educational, vocational, and social outcomes, all of which contribute to independence and quality of life. Therefore, it is important to determine the optimal method of reading instruction in order for children with DS to attain the highest level of literacy.

Typically, reading interventions fall within two categories: sight-word reading or phonics instruction. The sight-word or whole-word approach to reading teaches students to associate whole printed words with their spoken forms. The phonics-based or word-analysis approach to reading teaches students letter-sound correspondences to help them decode and read words.

Several studies have documented the positive effects of sight-word reading approaches in children with DS, as this method capitalizes on their strong visual processing skills (Browder & Xin, 1998). It has also been suggested that children with DS have poor phonological awareness and auditory working memory (Cossu, Rossini & Marshall, 1993), which are both important prerequisite skills for phonics-based reading instruction.

A number of more current research studies have demonstrated that children with DS can learn to read using a phonics-based approach. A major advantage to teaching with this method is that students can apply learned decoding strategies to read untrained words. This ability not only fosters independent reading, but also improves fluency and comprehension (Browder, Ahlgrim-Delzell, Flowers & Baker, 2012). Furthermore, the National Reading Panel states that the best approaches to reading instruction for typically developing children incorporate a phonics component (National Reading Panel, 2000). It is worth investigating whether children with DS also benefit from this approach, as it could offer them a chance to attain a higher level of literacy.

## *Objective*

The primary objective of this paper is to critically evaluate existing literature regarding the efficacy of systematic, phonics-based reading instruction as a literacy intervention for school-aged children with DS.

## *Methods*

Search Strategy

Computerized databases including CINAHL, PubMed, Scopus, and Proquest were searched using the following terms:

> (Down syndrome) AND (children) AND (literacy) AND (intervention) AND (phonics) OR (word-analysis)

Reference lists of previously searched articles were also used to obtain relevant studies.

Selection Criteria

Selected studies were required to measure or describe the literacy outcomes of a phonics-based reading intervention in school-aged children with DS. Studies with a significant language intervention component were excluded from this review.

Data Collection

Results of this literature search yielded nine articles that met the selection criteria. Six articles employed a single-subject design, two papers utilized a non-experimental pre-post test design, and the final study conducted a nonrandomized clinical trial.

## *Results*

Single-Subject Designs

Single-subject design studies (SSDS) are ideal for establishing the feasibility of an intervention for small, heterogeneous populations like DS, and are common in the field of communication sciences and disorders. These designs permit the modification of the independent variable to suit the participant's needs without compromising the integrity of the experiment. However, these studies are susceptible to subject selection bias and often have low statistical power due to small sample size. Consistent evidence from multiple SSDS is required to confidently judge the effectiveness of an intervention, as this type of design also has low external validity and generalizability of treatment outcomes.

**Cupples and Iacono (2002)** conducted a SSDS to compare the effectiveness of computerized whole-word and word-analysis reading programs for children with DS. A total of seven children (ages 8-12) were recruited from La Trobe University and a DS parent association in Melbourne, Australia. Children were randomly assigned to receive a whole-word or word-analysis intervention. Participants attended weekly, individual 1-hour treatment sessions for six weeks. Appropriate tests measuring word reading, decoding and phonemic awareness were administered pre- and post-treatment, and weekly oral reading probes were used to monitor progress. Results indicated gains in word reading for 2/4 children in the word-analysis condition, and 3/4 children made gains in decoding. Word reading gains were found for 2/3 participants in the whole-word condition, but no decoding gains were made. No meaningful changes were made in phonemic awareness in either condition.

The study's strengths included appropriate recruitment and intervention procedures. Appropriate statistical analyses were completed, but a direct comparison of the two methods was not feasible given the study's design and small sample size. Other limitations included lack of fidelity measure and lack of maintenance data to observe if gains were preserved.

Overall, the study provided suggestive evidence that children with DS may be taught to read words using a word-analysis literacy intervention. Furthermore, it provided suggestive evidence that only reading approaches including an analytic component foster decoding skills.

**Al Otaiba and Hosp (2004)** led a SSDS to evaluate the effectiveness of a tutor delivered, phonics-based reading program for four children with DS (ages 7-12). No recruitment criteria were specified. In this ten-week study, four participants received individualized 1-hour lessons developed from Peer-Assisted Learning Strategies (PALS) reading materials. Frequency of treatment sessions was not reported. An appropriate standardized assessment battery measuring phonological processing, word reading, and decoding skills was delivered pre- and post-intervention. Weekly progress was monitored using curriculum-based measurements of letter-sound knowledge, word reading, and fluency. Results indicated that 2/4 children made word reading gains and 3/4 children made improvements in decoding. All children displayed growth of varying degrees on the weekly probes.

Strengths included appropriate statistical and visual analyses and the use of a tutor-training model to increase treatment fidelity. Limitations of the study included lack of detail outlining selection process and eligibility criteria and lack of follow-up data to assess skill maintenance.

Overall, the study provided suggestive evidence that individualized reading lessons incorporating phonics-based activities may foster word reading and decoding in children with DS.

**Baylis and Snowling (2011)** conducted a SSDS with group analyses to investigate the impact of an analogy-based phonics literacy program for children with DS. A total of 10 participants (ages 9-14) were invited from a cohort of children partaking in a longitudinal research study at the University of York. Participants received individual, twice-weekly 1-hour teaching sessions over a ten-week period. A ten-week waiting period was set for five children to create a control group for the group analysis. An appropriate assessment battery measuring sight word reading, letter-sound knowledge, and decoding was administered multiple times before and after treatment. Results indicated literacy gains for 9/10 participants, with larger effect sizes for word reading and letter-sound knowledge than decoding. Eight children maintained their reading gains three months post-treatment. Participants in the waiting group made no meaningful improvements during the control period.

The study's strengths included appropriate baselining and the repeated collection of skill maintenance data. Appropriate recruitment criteria and statistical analyses were reported. Limitations included lack of fidelity measure and delivery of assessments and interventions by the same individual.

Overall, the study presented highly suggestive evidence that a structured reading program emphasizing analogy-based phonics instruction may be an effective intervention for developing readers with DS.

**Cologon, Cupples, and Wyver (2011)** led a SSDS to determine whether children with DS could benefit from an analogy-based word-analysis reading program. A total of seven children (ages 2-10) were recruited through a DS association in Canberra, Australia. Over 10 weeks, participants received weekly, individual 1-hour literacy sessions in their homes. An appropriate test battery measuring word reading, decoding, phonemic awareness, letter-sound knowledge, and passage comprehension was administered twice pre- and post-intervention. Oral word reading probes were given at each treatment session to measure weekly progress. Results indicated that all children displayed growth in each literacy skill, although larger effect sizes existed for word reading than decoding. A six-month follow-up assessment revealed that all children maintained their literacy gains.

Statistical analyses were appropriate. Strengths of the study included well-specified recruitment and intervention procedures, strong inter-rater reliability, and well-established baseline and maintenance periods. Despite its inherent design limitations, the study was well executed.

Overall, the study provided highly suggestive evidence that a word-analysis reading approach may improve essential literacy skills in children with DS, including decoding and phonemic awareness. Furthermore, the success of the younger participants provided suggestive evidence that previous sight-word reading instruction may not be necessary to benefit from a word-analysis reading program.

**Lemons et al. (2012)** conducted a series of SSDS to evaluate the effectiveness of three commercial phonics-based reading programs in children with DS. A total of 15 children (ages 5-13) were recruited from local school districts and a university-affiliated DS clinic in Pittsburg, Pennsylvania. Children were allocated to one of the three programs based on their current reading skills: six received the Road to Reading (RTR) program; five received RTR plus phonological awareness instruction; and, four received the Road to the Code (RTC) program. Individual sessions were delivered four days a week for 12 weeks. Intervention-related measures of decoding, word reading, fluency, and phonological awareness were administered during each session. Results indicated that all children in the RTR made gains in decoding, word reading, and phonological awareness, although growth in decoding was reportedly more modest. All children in the RTR plus phonological awareness condition also made word reading gains, but children receiving the RTC program demonstrated no change. Gains were moderately retained across sessions.

Appropriate statistical analyses were completed. Acceptable recruitment criteria, treatment fidelity, and inter-rater reliability were reported. Word reading gains should be interpreted with caution, as nine participants reportedly received concurrent sight-word reading instruction during the intervention period. Results are also limited by lack of follow-up data to assess skill maintenance.

Overall, the study provided suggestive evidence that phonics-based reading programs may improve early literacy skills in children with DS. Although children made gains in word reading, it is unclear how much the phonics intervention contributed to these gains.

**Lemons et al. (2017)** expanded their research with another SSDS investigating the effectiveness of a phonics-based reading intervention incorporating modifications to suit the DS phenotype. A total of seven children (ages 6-8) participated; no geographical or recruitment details were reported. Participants received individual, 20-40 min. sessions four times per week for four months. The study adapted activities from the RTR and RTC programs and made appropriate modifications. Lesson mastery probes measuring word reading and letter-sound knowledge were used to monitor progress at each session. Results indicated that 3/7 children demonstrated gains in word reading and letter-sound identification, and progress was maintained across lessons for most children.

Statistical analyses were appropriate. Strengths of the study included acceptable treatment fidelity and inter-rater reliability as well as detailed eligibility criteria. Limitations included lack of recruitment methods and failure to address its primary research question, which was to specifically examine whether program adaptions aligning with the DS behavioural phenotype could be beneficial.

Overall, the study provided suggestive evidence that a modified phonics-based reading program may improve early literacy skills in children with DS.

Nonrandomized Clinical Trials

A nonrandomized clinical trial provides a high level of evidence because it uses a control condition to determine whether treatment outcomes are attributed to the intervention. Since the design is quasi-experimental, confounding variables may still exist. Nonetheless, this type of design can have strong external validity as long as a reasonably similar control group is selected.

**Goetz et al. (2008)** led a nonrandomized clinical trial evaluating the effectiveness of a phonics-based reading intervention for children with DS. A total of 15 children

(ages 8-14) with emerging reading skills were selected from a cohort of students that previously participated in a longitudinal research project conducted by the University of York. Eight children received a reading intervention that was designed using Jolly Phonics materials, and seven children received the same intervention eight weeks later. Participants received individual, 40 min. sessions five times per week for 16 weeks. An appropriate standardized assessment battery was administered before and after treatment to measure word reading, letter-sound knowledge, phonological awareness, and decoding. Results indicated that the intervention group made gains in letter-sound knowledge and early word recognition, and these gains were maintained five months post-treatment. The control group made no significant changes before or after receiving the intervention.

Strengths of the study included appropriate statistical analyses, recruitment criteria, and follow-up data to assess skill maintenance. Limitations included small sample size and lack of fidelity measure.

Overall, the study provided suggestive evidence that phonics instruction may produce improvements in word reading and letter-sound knowledge for children with DS.

Pre-Post Test Designs (non-experimental)

Non-experimental pre-post test designs have a simple structure and can be easily implemented and analyzed, but they are not ideal for determining the effectiveness of interventions. This design lacks a study control, which lowers internal validity. Post-treatment outcomes may be attributed to the intervention, but the inference is uncertain. Therefore, non-experimental pre-post test designs provide weaker levels of evidence and must be interpreted with caution.

**Lemons and Fuchs (2010)** led a non-experimental pre-post test design study examining the effectiveness of a novel phonics-based reading intervention for children with DS. They also investigated whether child characteristics were predictive of differential growth in reading skills, but this research question will not be discussed in this review. A total of 24 children (ages 7-16) participated; no geographical or recruitment details were reported. Participants received individual, 1-hour sessions for five days a week for six weeks. Intervention-related measures of word reading, decoding, and letter-sound knowledge were administered pre- and post-intervention and a control word list was included to create a pseudo-control condition. Results indicated that on average, children made growth in all literacy skills, although smaller effect sizes were found for decoding. No participants made gains on the control word reading measure.

Appropriate statistical analyses and eligibility criteria were reported. Strengths included acceptable treatment fidelity and inter-rater reliability, acceptable test-retest reliability, and well-described methods and intervention procedures. Limitations included lack of recruitment procedures and the inherent shortcomings of a pre-post test design.

Overall, the study provided suggestive evidence that children with DS may make early reading gains as a function of participating in a phonics-based reading intervention.

**Colozzo, McKeil, Petersen, and Szabo (2016)** conducted a non-experimental pre-post test design study to examine the efficacy of a one-year phonics-based reading program for children with DS. A total of 15 participants (ages 3-6) were recruited on a first come, first serve basis by the DS Research Foundation in British Columbia, Canada. The program integrated phonics-based reading strategies with a whole-word reading approach. Participants received weekly, individual 1-hour sessions for 45 weeks. Intervention-related measures of letter identification, sound identification, print concepts, and word reading were given before and after the intervention. Results indicated that all children made improvements on all of the early literacy measures.

Statistical analyses were appropriate. Strengths included its yearlong design and well-detailed intervention procedures. Limitations of the study included lack of fidelity measure and small sample size.

Overall, the study provided suggestive evidence that a hybrid reading program combining phonics and sight-word instruction may effectively improve early literacy skills in children with DS.

## *Discussion*

This review analyzed nine studies to determine the efficacy of using phonics-based reading instruction to improve early literacy skills in children with DS. Each intervention targeted appropriate phonics elements, including phonological awareness, letter-sound correspondences and text reading. Although the strength of reading success varied across participants, all studies reported positive word reading growth. Despite the varying levels of validity across designs, the overall findings provide suggestive evidence for the efficacy of phonics-based reading instruction for children with DS.

The studies that employed a single-subject A-B-A design provided the strongest evidence (Baylis et al., 2011; Cologon et al., 2011). They each established a baseline control period equal in length to the intervention period in order to collect appropriate participant control data. Baylis et al. (2011) also utilized a treatment waiting period for five subjects to further establish causality. Findings demonstrated that little to no reading progress was made prior to the interventions, suggesting that children with DS are unlikely to achieve considerable literacy gains without additional reading instruction. Both studies also included follow-up testing, which provided evidence that reading skills are likely to be maintained after treatment is withdrawn. The four remaining SSDS utilized a basic A-B design. Although this is a weaker design, the studies were appropriately conducted and the reported evidence supported the conclusions of the stronger studies. Taken together, these consistent findings increase the overall external validity of the evidence.

Five SSDS used a multi-probe across lessons design to measure reading gains (Al Otaiba et al., 2004; Cologon et al., 2011; Cupples et al., 2002; Lemons et al., 2012; Lemons et al., 2017). Criterion-referenced probes were administered across sessions to better capture small reading improvements. This design was useful as it provided additional information to compare to participants' pre-post assessment data. For example, Al Otaiba et al. (2004) suggested that standardized reading tests might lack sensitivity to detect meaningful change following a brief intervention period because their results were incongruent with the curriculum-based probe data.

All studies appropriately measured and reported positive gains in word reading, which is the primary expected outcome from a phonics reading intervention. Seven studies also measured decoding via non-word reading or generalized word reading tasks and reported consistent gains. This data provided suggestive evidence that phonics interventions may foster decoding skills, which is an essential skill for attaining a higher level of literacy. Studies that included additional measures of phonological awareness, letter-sound knowledge, and print-concepts provided even stronger evidence, as all of these skills align with the expected outcomes from a phonics intervention and highlight the full benefits of this approach. Only Cologon and colleagues (2011) measured and reported improvements in reading comprehension, which is also an important skill for independent reading.

Although many studies reported that participants improved in both word reading and decoding, smaller gains were consistently found for the latter. This trend suggests that children with DS may need more time and instruction to develop and apply decoding skills. Also, most participants demonstrated positive literacy growth even if gains were not deemed significant. It is possible that reading improvements were underestimated due to small sample size and limited power across studies. Goetz et al. (2008) calculated moderate to large effect sizes for their literacy measures, indicating that outcomes may have been significant if the sample size was increased. Lemons et al. (2017) noted that gains might not have been significant due to positive baseline measures. Still, reading growth across studies remained quite modest compared to typical literacy norms. This comparison suggests that children with DS may require more repetition and greater treatment intensity to make necessary gains for higher-level reading.

Three studies utilized an analogy-based phonics approach, which teaches students to identify word onsets and rimes in order to decode and read words (Baylis et al., 2011; Cologon et al., 2011; Cupples et al., 2002). These studies were well designed and reported some of the strongest outcomes, which provided suggestive evidence for the effectiveness of an analogy phonics approach for children with DS. The authors noted that teaching participants to segment a word into only two word parts reduced cognitive load, which may have increased reading success because children with DS typically have working memory deficits. However, the remaining studies selected a common synthetic phonics approach that teaches students to convert letters into sounds to form words, and the reported evidence was also positive. However, the degree of growth varied depending on each child's baseline literacy skills. Participants with greater letter-sound knowledge and sight-word reading skills prior to the intervention made the most reading gains. Thus, there is evidence to support the use of both phonics methods for children with DS, but pre-existing cognitive and literacy skills may need to be considered in order to select the most appropriate method for each individual student.

Overall, most children with DS responded positively to a phonics-based reading intervention. The studies provided highly suggestive evidence that phonics instruction may improve word-reading and letter-sound knowledge, and provided suggestive evidence that this approach may improve other literacy outcomes, such as phonological awareness and decoding. Only one study attempted to directly compare sight-word and phonics-based reading approaches (Cupples et al., 2002), but an appropriate statistical analysis was not possible. Nonetheless, the study observed that only children receiving phonics instruction learned to read untrained words, suggesting that only this type of reading approach fosters decoding. However, further

information is needed to make this conclusion, as this was a small-scale study and findings have yet to be reproduced. It is recommended that future research studies recruit a larger sample size and directly compare the sight-word and phonics-based reading methods to develop a best practice standard for children with DS. Literacy is highly correlated with an individual's quality of life, so it is imperative that research continues to examine which reading method is most effective for children with DS.

### *Clinical Implications*

Despite variable study outcomes, the overall evidence suggests that phonics-based reading instruction may be an appropriate method of reading instruction for school-age children with DS. It is unclear why some participants responded more favorably to treatment than others, so instructors will likely need to trial both sight-word and phonics-based approaches to determine the optimal method of reading instruction for each child. The success of the analogy-based and synthetic phonics programs suggests that both of these approaches should be taken into consideration when choosing or developing a phonics-reading program for children with DS. Finally, it is recommended that reading programs are intensive, provide lots of repetition, and are delivered on an individual basis to reduce distractions and potential behaviour challenges.

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