

A Brief Review of Current Research on Reading Difficulties and Approaches to Intervention

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Abstract

Even with good instruction, approximately 10% of people struggle to acquire adequate literacy skills, possibly due to deficits in key cognitive processes such as phonological awareness, attention, or sensory processing. In this paper, we describe current research on how students learn to read. Decoding skill (i.e., translating letters to sounds to access word meaning) is the foundation for learning to read; decoding difficulties form a bottleneck for developing adequate reading skills. Although interventions that directly target decoding help students with reading problems to improve their skills, some students continue to have reading difficulties. Decoding training using phonics should be central to whole class instruction. However, reading difficulties have multiple causes and correlates, and so interventions that combine phonics with training of related cognitive and attentional skills may be beneficial for readers who continue to struggle despite good instruction. Online programs that provide integrated decoding and fluency training may provide effective and accessible interventions for struggling readers.

Keywords: reading, reading difficulties, dyslexia, intervention

Learning to Read



Learning to read is a complex skill that must be taught. Because reading is essential to modern life, there have been decades of research on the most effective ways of teaching reading (Castles et al., 2018; Ontario Human Rights Commission, 2022; Snowling et al., 2020). Despite the plethora of research, there is a wide gap between research on learning to read and the use of that research to develop effective reading instruction for struggling readers (Castles et al., 2018; Moats, 2007; Ontario Human Rights Commission, 2022). Finding effective interventions is critical and timely. In 2022, the Ontario Human Rights Commission found that for 2018-2019, 26% of Ontario students were not meeting the provincial standards (Ontario Human Rights Commission, 2022). This number is far from the 10% that would be expected if early screening and science-based instruction was widely available (McArthur & Hogben, 2012). Early diagnosis and targeted intervention are critical because reading difficulties affect all areas of life; people who struggle with reading may have difficulty in school, at work, and in social situations (Ontario Human Rights Commission, 2022; Tanner, 2009).

**EARLY DIAGNOSIS AND TARGETED
INTERVENTION ARE CRITICAL**

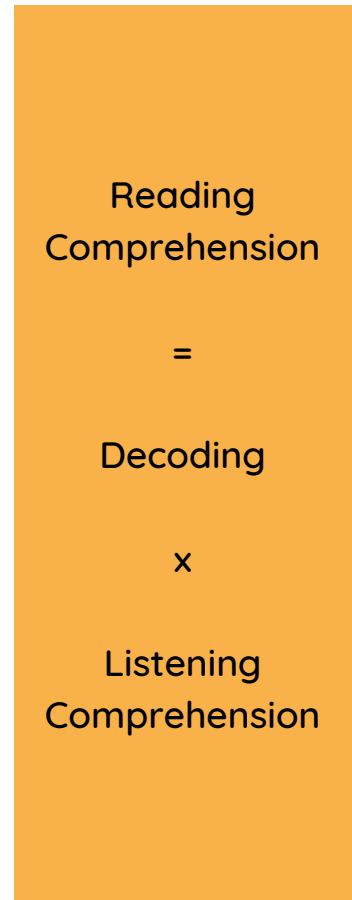
Reading Acquisition

Reading, ultimately, is about accessing the meaning of the text. According to Perfetti and Stafura's (2014) Reading Systems Framework, reading comprehension is supported by three constructs: knowledge (i.e., general, linguistic, orthographic), processes (i.e., decoding, identifying words, activating word meanings, forming inferences and causal connections within and across sentences), and general cognitive skills (i.e., memory, perception, attention). The most well-supported theoretical model for explaining reading comprehension is the simple view of reading (Hjetland et al., 2019). According to this model, the two key pathways to reading comprehension are decoding (i.e., associating arbitrary written symbols with sound) and language comprehension; Gough & Tunmer, 1986). Together, these pathways support students' developing reading skills. Hjetland et al. (2019) Language comprehension encompasses listening comprehension, vocabulary, grammar, and verbal working memory (Hjetland et al., 2019).

According to the simple view of reading, decoding is a key bottleneck in learning to read. In alphabetic languages like English, children must learn to decode words, that is, to map the phonology (sound) to the orthography (letters or groups of letters) to retrieve word meanings (Gough & Tunmer, 1986; Rayner et al., 2001).



SIMPLE VIEW OF READING



Decoding: associating written symbols with sound

Listening comprehension: understanding meaning from audio stimuli

Because alphabetic languages vary in how closely orthography connects to phonology, the language in which children learn to read influences the difficulty of that learning (Aro, 2013; Castles et al., 2018). For example, English has many inconsistent relations between sounds and letter patterns and thus the translation of orthography to phonology is complex in English.

Consider the pronunciations of

cough,
tough,
through.

In contrast, some languages such as Spanish and Finnish have very consistent mappings between phonology and orthography and are easier to learn (Aro, 2013; Seymour et al., 2003; Ziegler et al., 2010). As readers improve their decoding skills, they become more efficient at recognizing words (Snowling et al., 2020). Orthographic knowledge of letter patterns and, eventually, whole words, develops through experience and eventually allows readers fluent access to whole words (Metsala & David, 2021).

In summary, readers need to learn the connections between sounds and letters to build strong and accessible word knowledge.

Orthography: (groups of) letters

Phonology: sound

Approaches to Reading Instruction

There are three main approaches to teaching reading: the phonics approach (i.e., explicitly teaching sound-symbol mappings to access meaning; Ehri et al., 2001), the whole-language approach (i.e., promoting reading for meaning by relying on exposure to a literacy rich environment rather than on code-based instruction; Moats, 2007), and the three-cueing approach (i.e., teaching children to guess word identities based on syntax, semantics, and letter-sound cues; Adams, 1998). However, only the phonics approach is strongly supported by research (Castles et al., 2018; Snowling et al., 2020). The most effective way to teach reading skills is through the systematic instruction of letter-sound relations to develop decoding skills, combined with practice to support fluency (Bus & van Ijzendoorn, 1999; Castles et al., 2018; Ehri et al., 2001; Galuschka et al., 2014; Melby-Lervåg et al., 2012; Moats, 2007; Rayner et al., 2001).

Reading Difficulties

People with reading difficulties typically show slow or inaccurate decoding skill, but they may also have weak cognitive skills (e.g., problems with short-term memory, auditory processing, or visual attention; Galuschka et al., 2014; Hulme & Snowling, 2013; Rayner et al., 2001; Snowling et al., 2020). The term “dyslexia” is used for people whose reading difficulties are particularly severe.

Defining dyslexia: The American Psychological Association (2013) Diagnostic and Statistical Manual of Mental Disorders (DSM-5) classifies dyslexia as a form of neurodevelopmental disorder, which means it has an early onset, is heritable, and has life-long consequences. In the DSM-5, a diagnosis of dyslexia requires that a person has problems with reading accuracy and fluency, poor decoding, and poor spelling that have persisted for a minimum of six months despite targeted interventions.

**APPROXIMATELY
40% OF CHILDREN
WITH DYSLEXIA
HAVE ONE OR
MORE OTHER
DISORDERS THAT
AFFECT LEARNING**

Difficulty connecting sounds and letters is a central issue in dyslexia, but it is possible to have dyslexia without having phonological deficits (Hulme & Snowling, 2013; Pennington, 2006; Rayner et al., 2001; Snowling et al., 2020). Other possible causes of dyslexia include problems with vision (e.g., tracking or focusing), attention, working memory, and/or processing speed (Alt et al., 2022; Pasqualotto & Venuti, 2020; Rayner et al., 2001; Sala & Gobet, 2020; Snowling et al., 2020). Although dyslexia can occur alone, it also co-occurs with other learning difficulties more frequently than is expected by chance: Approximately 40% of children with dyslexia have one or more other disorders that affect learning such as ADHD, anxiety, depression, dyscalculia, or language disorders (Moll et al., 2020; Peters & Ansari, 2019).

Researchers have argued against the view that dyslexia is a distinct disorder that has clear boundaries; the assessment criteria for a dyslexia diagnosis are arbitrary, and as such, children that fall below this threshold are not qualitatively different from those above it (Peters & Ansari, 2019). Research on dyslexia is complicated by several factors. First, not all studies use the same assessment criteria. Second, it is difficult to recruit large samples of participants, and thus many studies involving dyslexia interventions are underpowered and risk overestimating effects (Peters & Ansari, 2019; Toffalini et al., 2021).

In terms of choosing appropriate interventions to help struggling readers, therefore, a diagnosis of dyslexia may be less critical than a clear understanding of the nature and extent of students' reading problems and their other cognitive difficulties.

Factors that Influence the Development of Reading Skill

Phonological Processes

Although phonics, phonemic awareness, and phonological awareness are often used synonymously, they are not equivalent concepts. Phonics refers to the relation between phonemes (smallest unit of sound) and graphemes (smallest unit of writing) and thus phonics interventions focus on helping students link letters and sounds. Phonological awareness refers to people's ability to perceive and process the sounds of spoken words (Konza, 2011; Melby-Lervåg et al., 2012). Although quite similar, phonemic awareness is the more specific ability to perceive the separate phonemes that make up words (Konza, 2011). Often, the term 'phonological processes' is used as an umbrella construct to describe language-related sound perception. Examples of phonological processes include segmenting (i.e., separating the individual sounds of a word, as in "c-a-t") and blending (i.e., putting sounds together, as in "cat"). Most people with reading difficulties will have experienced some challenges using phonological processes. However, not all reading difficulties are caused by phonological processing problems.



FOX



RAIN

Phonics: relation between phonemes and graphemes

Phonological awareness: ability to perceive and process the sounds of spoken words

Phonemic awareness: ability to perceive the separate phonemes that make up words

Executive Functions

Executive functions are the processes involved in the control of cognition and behaviour (Miyake & Friedman, 2012). The three executive functions that are involved in reading are working memory (i.e., ability to temporarily store and manipulate relevant information) (Baddeley, 2003), cognitive flexibility (i.e., ability to shift between tasks) (Buttelmann & Karbach, 2017), and inhibitory control (i.e., ability to suppress irrelevant information to maintain focus on relevant stimuli) (Christopher et al., 2012). These executive functions have different roles in the reading process (Christopher et al., 2012; Park & Mackey, 2022; Pasqualotto & Venuti, 2020).

Working memory is important for reading at all levels, from decoding to reading comprehension (Christopher et al., 2012; Seigneuric & Ehrlich, 2005). For example, readers use verbal working memory to decode words and temporarily store words and phrases as they process sentences (Baddeley, 2003; Pasqualotto & Venuti, 2020). Once children have mastered the ability to read individual words, working memory predicts their reading comprehension skills (Seigneuric & Ehrlich, 2005). In contrast, cognitive flexibility and inhibitory control are important primarily for reading comprehension. Cognitive flexibility in the form of shifting is important because reading requires the simultaneous processing of decoding words and understanding their meaning (Cartwright, 2007, 2012; Colé et al., 2014). Inhibitory control is also crucial for reading comprehension (Borella et al., 2010; Christopher et al., 2012; Gernsbacher & Faust, 1991). For example, when reading, readers need to ignore distracting stimuli from the environment (e.g., phone notifications), wayward thoughts (e.g., wondering what's for dinner), or the different senses of a word (e.g., *crane* could refer to a bird or to a machine).

Working memory: ability to temporarily store and manipulate relevant information

Cognitive flexibility: ability to shift between tasks

Inhibitory control: ability to suppress irrelevant information to maintain focus on relevant stimuli

DOES TRAINING EXECUTIVE FUNCTIONS IMPROVE COMPLEX COGNITIVE SKILLS, SUCH AS READING?

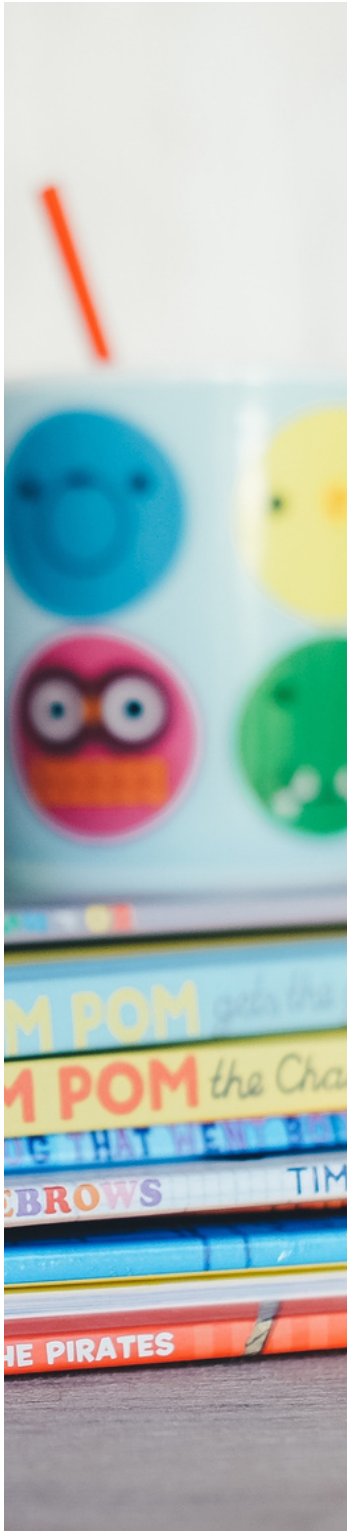
Executive functions can be difficult to measure and target in interventions because they must be embedded within other tasks (Miyake & Friedman, 2012). For example, training working memory requires that participants remember *something* (e.g., a sequence of numbers, a list of words, a spatial pattern). Therefore, it is impossible to completely separate the effects of working memory from those of other processes involved in the task (e.g., number processing). With respect to reading, interventions targeting executive functions have most often been focussed on training working memory because it is central to reading. Nevertheless, the effectiveness of training working memory to address reading problems is inconclusive. Working memory training sometimes supports better performance on very similar tasks as those that were trained (Peijnenborgh et al., 2016), however, there is no conclusive evidence that training significantly improves participants' working memory skills more generally, or that training improves reading skills (Melby-Lervåg et al., 2016; Melby-Lervåg & Hulme, 2013; Sala & Gobet, 2017, 2020). However, training working memory in the context where it will be used, for example, training working memory and reading simultaneously, may result in overall better transfer to reading than training reading alone (Pasqualotto & Venuti, 2020; Peijnenborgh et al., 2016).

In general, research on training executive functions shows evidence of near transfer (i.e., the trained activities improve), but rarely shows evidence of far transfer (i.e., the target academic skills do not improve; Katz et al., 2018; Park & Mackey, 2022; Pasqualotto & Venuti, 2020; Sala & Gobet, 2020). However, more research is needed on the effect of training executive functions and core reading skills together.

Affective Influences

Non-cognitive factors (i.e., motivation, self-efficacy, anxiety) are also correlates of reading (Guthrie et al., 1999; Macdonald et al., 2021; Pollack et al., 2021; Ramirez et al., 2019) and, although the evidence to support this view is scarce, reading interventions that target affective and motivational factors in the context of cognitive skills may also support reading improvement.

Reading Interventions



Phonics interventions are the most common and the most effective approach for training reading.

Reading interventions are numerous and diverse in design and the skills they target, although the vast majority will include training in both decoding accuracy and reading fluency. Some interventions target one specific area of skill (e.g., training phonological skills) whereas others cover multiple areas of skill (e.g., training *executive functions* and *phonological processes*). Meta-analyses and systematic reviews have shown that phonics interventions are the most common and the most effective approach for training reading (Galuschka et al., 2014; Toffalini et al., 2021). Other common interventions target phonemic awareness, reading fluency, working memory, and more recently, visual-attentional skills (Galuschka et al., 2014; Toffalini et al., 2021).

In contrast to the slow and error-prone decoding of a beginning reader, fluent readers process written text and extract meaning quickly and accurately (Hudson et al., 2005; Schreiber, 1980). Accuracy, speed, and prosody (rhythm/intonation) are the key elements of reading fluency (Hudson et al., 2005). Accordingly, repeated reading (i.e., successively reading the same text) results in improved reading fluency (Stevens et al., 2017; Wexler et al., 2008; Zimmermann et al., 2021). Meta-analyses have shown that non-repetitive reading (i.e., using the same procedures but on different texts) is a feasible alternative to repeated reading interventions in improving reading fluency (Wexler et al., 2008; Zimmermann et al., 2021). Although decoding and fluency training are sometimes discussed together, more research is needed to understand how to best combine these aspects of reading interventions for people with severe reading difficulties.

Not all interventions are equally appropriate for all students. The Institute of Education practice guide (Gersten et al., 2009) provides an overview of the multi-tiered classification of reading interventions for elementary students.

1

Tier 1 interventions are high-quality reading instruction provided to the whole classroom. Most children should learn to read successfully with good Tier 1 instruction.

2

Tier 2 interventions provide supplemental instruction of reading skills and are intended for children who struggle to keep up with peers or who have been identified via screening as having reading difficulties. Tier 2 interventions are typically done in small groups within the classroom, although computer-based individual interventions may also be considered Tier 2 if they are suitable for students with less severe problems.

3

Tier 3 interventions are intended for children who have been identified as having reading problems and who do not improve with Tier 2 interventions. Tier 3 interventions are the most intensive and are typically given in a one-on-one setting (e.g., tutoring).

Regardless of the intervention tier, it is important for students to first learn the most basic skills (i.e., letter-sound mappings) and then build on this knowledge to achieve fluency (Park & Mackey, 2022; Pasqualotto & Venuti, 2020).

However, the most effective interventions will depend on students' current skills. For example, interventions targeting phonological awareness are more beneficial for younger than for older students (Bus & van Ijzendoorn, 1999; Ehri et al., 2001; Suggate, 2010). In meta-analyses, Ehri et al. reported larger effect sizes when phonological instruction began early ($d = 0.55$) than when it began after Grade 1 ($d = 0.27$); Suggate (2010) found that phonics interventions appeared to be advantageous until Grade 1, at which point mixed and comprehension interventions became more beneficial for students through Grade 7. Thus, interventions for older students who have a history of reading difficulties may need to address multiple skills.

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Computer-based delivery of instruction is becoming more common. Although quality of computer-based instruction varies widely by skill and by program, compared to offline games, online reading games typically provide training for more skills, and deliver higher quality instruction for core reading skills like grapheme-phoneme relations and phonological awareness (Wood et al., 2015). Ultimately, Tier 2 and 3 interventions may be most efficient and accessible if they can be provided online.

Examples of Multi-Skill Reading Interventions



There are many reading interventions that are consistent with the simple view of reading (see Ehri et al., 2001; Galuschka et al., 2014; Toffalini et al., 2021). However, even the most effective interventions (e.g., phonics training), show small effect sizes for students with dyslexia (e.g., Toffalini et al., 2021) and do not help all struggling readers. Research has shown that Tier 1 instruction which targets strong decoding skills is effective in teaching most children to read (Shanahan, 2021), however, for the 10% of children who continue to struggle, Tier 2 and 3 approaches that train more skills or attempt to help children integrate across skills may be needed. Accordingly, on the assumption that reading interventions for students with severe reading difficulties may need to target multiple cognitive deficiencies, here we consider some interventions that are designed to train a range of phonological, visual, and attentional skills simultaneously. Our goal in this section was to provide examples of digital multi-skill interventions at different levels. This overview is not comprehensive but focusses on a few commonly used approaches.

ABRACADABRA



ABRACADABRA (A Balanced Reading Approach for Children Always Designed to Achieve Best Results for All) – ABRA for short – is a Canadian interactive computer-based intervention. It includes an assortment of activities and stories designed to help primary school students develop early literacy skills (Centre for the Study of Learning and Performance, 2022). Intervention studies have shown positive effects of ABRA on literacy skills, especially improvements in letter knowledge and phonological awareness (Piquette et al., 2014; Savage et al., 2009). In a randomized control study of 1067 elementary school children from across Canada, the ABRA intervention group had significant improvements in letter-sound knowledge and

phonological blending ability compared to the control group (Savage et al., 2013). In further support of ABRA, a meta-analysis of 17 studies by Abrami et al. (2020) showed positive effects on reading skills, with a significant overall weighted average improvement of $g = 0.78$ for phonemic awareness. ABRA is a school-based intervention designed to be used in classrooms. As a Tier 1 intervention, it appears to be very successful for supporting the development of good decoding skills. Less information is available, however, on whether it helps support readers at risk for reading difficulties.

The Orton-Gillingham Approach

The Orton-Gillingham approach to reading is described as a “direct, explicit, multisensory, structured, sequential, diagnostic, and prescriptive way” to teaching spelling and reading. It was developed early in the 20th century (Orton-Gillingham Academy, 2022). The Orton-Gillingham method is intended to be used in a one-on-one setting with students whose reading difficulties are severe (i.e., Tier 3). Elements of the Orton-Gillingham approach,



specifically, the idea that multiple sensory systems should be engaged simultaneously, have been adopted in various unbranded interventions (Stevens et al., 2021). However, despite widespread use of the Orton-Gillingham approach, there is limited evidence to support its efficacy (Ring et al., 2017; Ritchey & Goeke, 2006; Stevens et al., 2017). Stevens et al. (2021) conducted a meta-analysis of interventions using the Orton-Gillingham approach. They identified 24 studies that had (a) experimental, quasi-experimental, or single-case design, (b) students from kindergarten to grade 12 that were identified with reading difficulties or were at risk for reading difficulties, (c) used the Orton-Gillingham approach in a one-on-one setting or in small groups, (d) assessed either word reading, phonics, phonological awareness, oral reading fluency, spelling, vocabulary, listening or reading comprehension, and (e) been printed in English before March 2019. Most of the studies had small samples, and few had explicit descriptions of the features of the intervention or of comparison reading conditions. The average effect size of $g = .22$ was not statistically significant but was within the range of other small effect sizes reported by Galushka et al. (2014) in a more general meta-analytic review of reading interventions. Thus, Stevens et al. (2021) concluded that more high-quality work is needed to determine whether the Orton-Gillingham method is an effective intervention.

MORE RESEARCH IS
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COMBINED WITH
PHONOLOGICAL
TRAINING CAN BEST
SUPPORT TIER 2
AND TIER 3 READING
INTERVENTIONS.

Combining Cognitive Training and Phonological Training

Brain-HQ is an online computer program that has exercises designed to improve executive functions such as “attention, brain speed, memory, people skills, navigation, and intelligence” (Posit Science, 2022). To determine whether cognitive training in executive functions could support reading intervention, Pasqualotto and Venuti (2020) combined Brain-HQ training with separate phonological-based training. They tested 49 Italian-speaking children with dyslexia and found that phonological training alone led to significant improvements in reading accuracy, but not fluency, relative to a control group. Cognitive training with Brain-HQ alone did not result in significant improvement in reading, however, the group that had Brain-HQ training followed by phonological training improved in both reading accuracy and fluency. These results support the view that combining training on executive functions and phonics may support gains in both the accuracy and fluency of word reading for struggling readers. Considerably more research is needed, however, to determine how cognitive training combined with phonological training can best support Tier 2 and Tier 3 reading interventions.



Conclusions



Interventions that combine phonics training with training of related cognitive and attentional skills may be beneficial for readers who continue to struggle despite good Tier 1 instruction.

Canada has one of the highest levels of average literacy skill in the world (Grenier et al., 2008). However, for the 2018-2019 school year, 26% of Ontario students were below provincial literacy standards (Ontario Human Rights Commission, 2022). Some of these students may have received inadequate instruction; others may have deficits in key cognitive skills, such as phonological awareness; and others may have attentional or sensory processing difficulties. Decoding skill is a bottleneck for developing adequate reading, regardless of the cause of the decoding difficulties. Accordingly, reading instruction in regular classrooms (i.e., Tier 1) needs to provide students with good-enough decoding skills in the early grades. Even with high-quality Tier 1 instruction, however, approximately 10% of students will continue to have difficulty reading either because of continued weak decoding or because their language and related comprehension skills are weak. Interventions that directly target decoding may help people with reading problems to improve their skills. Reading difficulties have multiple causes and correlates, however, and so interventions that combine phonics training with training of related cognitive and attentional skills may be beneficial for readers who continue to struggle despite good Tier 1 instruction.

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