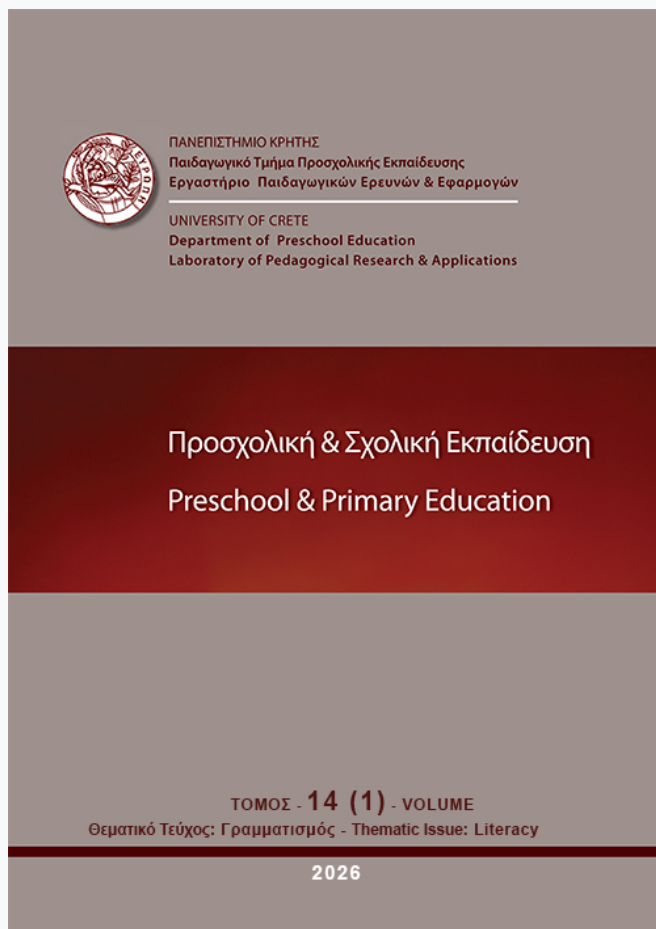


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### Remedial intervention programs to develop written word identification and reading comprehension in dyslexic students aged 9 to 12: a review of the literature

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# Remedial intervention programs to develop written word identification and reading comprehension in dyslexic students aged 9 to 12: a review of the literature

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**Abstract.** The academic success of all learners depends on learning to read. The age of 9-12 is a key moment in this learning process, as students have to read and understand increasingly complex texts and identify increasingly difficult words in all subjects. At this age, students with persistent reading difficulties, including dyslexic students, need remedial interventions to improve reading comprehension and written word identification. These interventions need to be based on re-education programs that are supported by research evidence and adapted to their language of learning, including English and French. The aim of this article is to present the results of an integrative review of the scientific literature on these programs. This review follows Jackson's method (1980; Fortin & Gagnon, 2016) and examines these writings in six steps to propose an integrative conceptualization of them. It analyzes the various effects documented in experimental research and highlights the methodological contributions and limitations of this research. The results show that little research has been carried out on this subject, but that it is of high quality. The resulting avenues for research and intervention in the context of learning French and English are discussed.

**Keywords:** Reading, reading comprehension, identification of written words, dyslexia, remedial intervention, rehabilitation program, integrative writing review

## Introduction

The aim of this article is to present the results of an integrative review of scientific literature on reading remedial programs designed to develop written word identification and reading comprehension in students aged 9 to 12 with dyslexia. Since their academic and social success relies on adapted remedial interventions that help them finally access to learning and give age-appropriate tasks, this article presents a critical analysis of experimental research evaluating the effect of programs offering a coherent package of remedial objectives and activities. It focuses on the few experimental research studies conducted in French and English, aimed at helping dyslexic students in French and English contexts to meet the challenge of identifying words written in languages with some of the most complex spelling and understand diverse texts in these languages. Recognizing that remedial interventions

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would benefit from being delivered in schools and structured in programs that are based on research evidence, this article identifies the contributions and limitations of the different methodologies used for evaluating the effect of such programs. It thus lays the groundwork for future experimental research with these learners, who have significant abilities, but whose difficulties are severe and persistent, despite appropriate and research-based interventions. Although the difficulties of these students concern both reading and writing, this article focuses on reading while making the link with writing, knowing that reading is a basic skill essential to success in school and in life.

The section following deals with the challenges of learning to read in dyslexic pupils aged 9 to 12, and how to overcome them. It addresses three themes: learning to read and write, difficulties in this learning process, including dyslexia, and re-educative interventions in reading -writing.

### *Learning to read*

Learning to read is a complex, multidimensional process that takes place throughout the learner's school career and in different life contexts (Canadian Council on Learning, 2008; Écalle & Magnan, 2002, 2015; Moreau et al., 2013). According to these authors, it involves communicating effectively in writing with a variety of media (e.g., reading and writing on paper, on-screen text) and making connections between reading, writing and speaking. Indeed, reading involves understanding the meaning of a text by identifying words that include written symbols representing oral units, and writing aims to produce meaning in a text by producing words that include written language codes, in each language. This learning process depends on several interacting factors, including the learner's linguistic, individual and social characteristics. Depending on these factors, learning to read and write may be facilitated or hindered.

According to the literature on the subject (e.g. Billard et al., 2008; Desrochers et al., 2012; Ehri et al., 2014), under the influence of these factors, this learning takes place through the progressive and interactive use of different reading and writing processes that gain in complexity along the way and enable effective communication. Various authors (e.g. Berninger, Garcia & Abbott, 2008; Écalle & Magnan, 2002, 2015; Hayes & Flower, 1980; Laplante, 2011; VanGalen, 1991) have developed frameworks to account for the main components identified in theoretical and empirical research on reading and writing skills, including the identification of written words and reading comprehension in English and French. From a cognitive and developmental perspective, the schematic representation of key processes in reading and writing (Laplante, 2011) captures central elements of highly influential frameworks and models, including those in reading (e.g., Gough & Tunmer, 1986), writing (e.g., Hayes & Flower, 1980; Hoover & Gough, 1990) and dealing with both reading and writing (e.g., Seymour, 2008). It provides essential clarification of all the processes involved in learning to read and write, and the dynamics that interrelate them. It is therefore an essential part of an integrative review of scientific literature on reading-writing re-education programs aimed at developing written word identification and reading comprehension in 9-12-year-olds with specific reading-writing disorders of cognitive and developmental origin. It has the advantage of identifying the priority of processes to be developed at the age of 9-12 in English- and French-speaking contexts, and of helping these students meet the challenge of learning to read and write in languages whose lexical orthography is among the most complex in the world (Sprenger-Charolles, 2004; Stanké et al., 2008). These processes are: (1) metacognitive processes which enable the effective management of all cognitive processes according to the reading-writing intention; (2) non-specific processes, i.e. high-level language processes leading to the comprehension or production of meaning; (3) writing-specific processes (low-level processes enabling the

identification or production of written words), which may be actualized differently depending on the medium (e.g. reading on screen, reading on paper).

Thus, non-specific processes are first made up of the situation model. The latter allows the apprentice to develop an abstract representation of the text to be understood and to translate it into representations by using different processes simultaneously. The latter are related to syntactic analysis, propositional analysis, microprocesses, macroprocesses and ellipses, as proposed by the model of reading comprehension by Kintsch and Van Dijk (1978), which is very influential in the field of remediation. Syntactic analysis promotes the understanding of different phrase structures by using sentence punctuation, while propositional analysis helps to understand the basis of the text, i.e. the basic content of the text, and to clarify the meaning of the text. The semantic propositions of the text are organized into a coherent whole thanks to microprocesses and macroprocesses. Microprocesses help to understand micro propositions ordered sentence by sentence, with markers of discontinuity or continuity also called connectors or words of relationship, e.g. "because, then, therefore" and anaphors as words that replace others, e.g. "he, she, this one, this one". Macroprocesses, on the other hand, help build the overall structure of the text by using macro rules to prioritize the information to be understood. For example, the reader will delete and generalize information and use the text schema, i.e. the structure of the text to understand it (e.g., narrative schema, structure of informative texts). Since information in the text cannot be fully explicit, the learner uses inferences to understand the implicit information. All these non-specific processes that make it possible to produce meaning are used interactively with specific processes.

Laplante (2011) then draws on Seymour's (2008) developmental structural model, a model describing the essential processing to be developed to help students identify and produce written words, by making links between oral and written units, the basis of English and French lexical orthography. This model actually has the advantage of being validated with learners from all backgrounds and with difficulties in these languages, unlike other models such as dual-track models in reading (Colheart et al., 2001) and writing (Barry, 1994) which are certainly very influential, but are based on the procedures of expert readers (Frith, 1985; Richards et al., 2006; Sprenger-Charolles, 2012; Seymour, 2008). Indeed, in reading, Coltheart et al.'s (2001) model postulates that the identification of written words is carried out according to two main pathways that would operate independently of each other (Bégin, 2008). The indirect route, also known as the assembly route, allows the word to be segmented into linguistic units by the expert reader, i.e. syllables and phonemes, and then recognized orally; This indirect pathway is also observed in reading and writing regular words (Barry, 1997). The direct route would make it possible to recognize it instantaneously, without resorting to this segmentation, which would also be observed in writing (Barry, 1997). However, many authors (e.g.: Frith, 1985; Richards et al., 2006; Sprenger-Charolles, 2012) point out that most learners with dyslexia have difficulties in learning these two pathways, indicating that their developmental dynamics may be different from those postulated in dual-track models.

In this regard, Laplante (2011) points out that logographic and alphabetic processing represent the foundations of this model. Logographic processing enables accurate and fluent reading and writing of a limited number of words that are frequently encountered before the end of the first school year (e.g.: *maman* → *mom*), which is usually done accurately and fluently before the end of the first school year. However, this treatment is different from the direct route proposed by Barry (1994), since it allows the identification of only a few words. Alphabetic processing, on the other hand, involves the association between phonemes and graphemes, as proposed by Barry (1994) (indirect route). This process is essential in languages such as French and English which are based on this association. This processing is sequential. It involves being aware of the smallest sound units in words, the phonemes, to take account

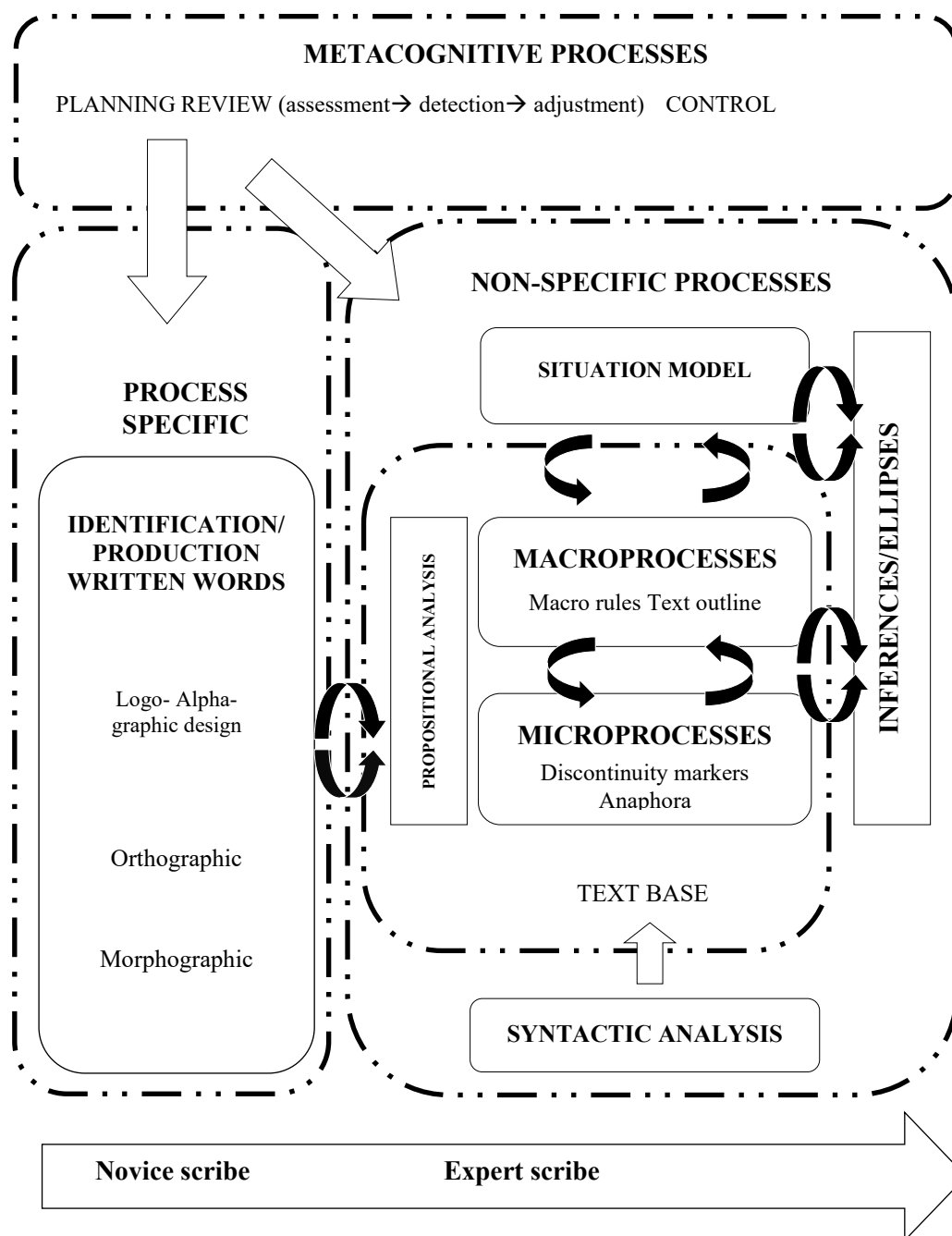
of the phonological level. It therefore calls on phonological memory and rapid naming of linguistic units in written words (Niolaki et al., 2022). It therefore enables the identification and production of regular words which is generally automated by the end of the second year. For example, to write "table", the learner segments the word into syllables, then phonemes, to select the graphemes and transcribe them in order and then check the phonological plausibility of the written word.

Subsequently, orthographic (or visuo-orthographic) processing enables us to identify and produce written words containing graphemes that are not always associated with the same phoneme. This opacity is common in identifying and producing written words in French and English (e.g., in French, the letter *x* represents the sound [z] in *deuxième* (*second*) but [s] in *soixante* (*sixty*); in English, the phoneme [e] corresponds, among others, to the graphemes *a*, *ay* → *pay*, *ey* → *hey*, *ea* → *great*, unlike other languages in which opacity is observed in word production only (e.g.: Greek) (Niolaki & Masterson, 2013). In this regard, these authors point out that some graphemes are more frequent than others (e.g.: in French *ss* is more frequent than *ç*) and that, others, more or less regularly represent a phoneme depending on their position in the word (e.g.: the phoneme [ɛ], is generally written *and* at the end of the word and never *ei*, as in *jouet* (*toy*). In addition, some words have atypical grapheme sequences (e.g. *monsieur*; *mister*) or irregular (e.g. *femme*; *women*) (Niolaki & Masterson, 2013). Orthographic processing, also known as visuo-orthographic processing, therefore involves paying visual attention to the positioning of graphemes within words, and to the visual form of words: it therefore makes heavy demands on attentional resources. Since it involves a linguistic processing of words at the orthographic level, it differs from the direct route described by Barry (1994), by specifying the type of graphemes/items treated. Indeed, according to Seymour, this processing makes it possible to identify an increasing number of words, by making links between the constituents of the words through a linguistic processing of increasingly complex and broad linguistic units; they then refer to the accuracy and fluidity of the identification of written words. However, contrary to this author, Seymour (2008) adds a final phase favouring the use of morphographic processing.

In addition, the learner develops morphographic processing, learning to write plurimorphemic words made up of a base word and an affix (e.g. *rub* + *ed* → *rubbed*), omnipresent in French: morphographic processing (Bégin, 2010; Casalis et al., 2011). He then becomes aware of the smallest meaning-carrying units, morphemes, and can produce words with graphemes derivable by morphology silent letters (e.g. *chocolat*; *chocolate*). According to Seymour (2008), this treatment, like all the treatments in his model, would develop interactively by making links between oral and written units.

Although learners develop the same processes for identifying and producing written words, many authors claim that producing a written word is more difficult than identifying it (Chaves et al., 2012; Eme & Golder, 2005; Fayol et al., 2009). According to these authors, identifying a written word implies only recognizing it, which is possible using partially functional processing and partial lexical representations, whereas producing it implies remembering the entire graphic sequence while rereading the written word, which is possible using functional processing and complete lexical representations.

Laplante (2013) emphasizes the fact that when too many cognitive resources are allocated to specific processes, the learner falls into cognitive overload, which does not allow him or her to devote enough resources to non-specific and metacognitive processes to achieve his or her goals. As a result, the quality of text comprehension is significantly affected. This phenomenon, often observed in students with dyslexia, prevents them from understanding texts that would correspond to their abilities (Fletcher et al., 2013; Sprenger-Charolles, 2012).



**Figure 1** Schematic representation of the development of processes reading and writing (Laplante, 2011)

Admittedly, this schematic representation highlights the synergy between diverse processes of understanding and identifying written words, as well as the close links they forge with writing processes. Their development is essential to meet the increased demands of reading (Ministry of Education, Recreation and Sports, 2009). Indeed, at this age, students are expected to understand elaborate texts containing complex vocabulary, while making connections with writing and speaking. In the classroom, even if requirements can be adapted and accompanied by appropriate interventions, many learners fail to reach a level of competence that enables them to achieve the expected learning outcomes in reading (Ministry of Education, Recreation and Sports, 2009).

### *Difficulties in learning to read, including dyslexia*

Difficulties in learning to read can be transient or persistent, depending on whether they affect the specific or non-specific processes of reading and writing, or both (Landerl et al., 2013; Tunmer & Greany, 2009). Persistent difficulties are often linked to a learning disability of neurodevelopmental origin, such as dyslexia, which affects around 5% of people.

Throughout history, definitions of dyslexia have evolved in the light of research from different disciplines (Fontaine, 2019). From a historical and multidisciplinary perspective, conceptual analysis of the main definitions of this disorder (American Psychiatric Association, 2013; Lyon et al., 2004; Tunmer & Greany, 2009), including a recent one that tends towards consensus (Carroll et al., 2025) and which allows the definition to be revised in light of the recommendations of several authors (e.g. Catts et al., 2024) is based on empirical research from different disciplines, including neuroscience, linguistics, psychology and the didactics of reading and writing. It states that neurological in origin, it leads variably to persistent difficulties in identifying and producing written words accurately and fluently in normally developing learners, across the lifespan, in different languages and despite appropriate interventions. Since the difficulties of these learners affect both the identification and the production of written words, many authors specify that dyslexia is systematically associated with dysorthographia and vice versa. These difficulties are influenced by a variety of factors and can therefore affect reading comprehension, writing, and the learning of disciplines involving reading and writing. They are mainly due to phonological deficits, but deficits in lexical-orthographic memory and visual impairments, more specifically in visuo-attentional span, can amplify the challenges faced by these learners. However, these learners may also suffer from other difficulties. The definition given by Carroll et al. (2025) takes account of these central elements and is therefore retained for this review.

“Dyslexia is a set of processing difficulties that affect the acquisition of reading and spelling. In dyslexia, some or all aspects of literacy attainment are weak in relation to age, standard teaching and instruction, and level of other attainments. Across languages and age groups, difficulties in reading fluency and spelling are a key marker of dyslexia. Dyslexic difficulties exist on a continuum and can be experienced to various degrees of severity. The nature and developmental trajectory of dyslexia depend on multiple genetic and environmental influences. Dyslexia can affect the acquisition of other skills, such as mathematics, reading comprehension, or learning another language. The most observed cognitive impairment in dyslexia is a difficulty in phonological processing (i.e. in phonological awareness, phonological processing speed or phonological memory). However, phonological difficulties do not fully explain the variability that is observed. Working memory, processing speed, and orthographic skills can contribute to the impact of dyslexia. Dyslexia frequently co-occurs with one or more other developmental difficulties, including

developmental language disorder, dyscalculia, ADHD, and developmental coordination disorder (Caroll et al., 2025, p.1072)."

More specifically, the authors (Fletcher et al., 2013; Kavale & Forness, 2000) point out that the neurological origin is confirmed by neuroimaging studies (Chaix, 2018; Ecalle, 2017), showing differences in the brain, including under activation of the left posterior temporal region, which affects phonological awareness, rapid naming and phonological working memory. However, some authors (Bosse et al., 2009; Valdois, 2017) mention that these difficulties may also stem from visual deficits. These visual deficits, suspected since the 19th century, affect the visual analysis of the word's orthographic sequence and the attentional resources dedicated to this processing. This visual deficit is linked to under-activation of parietal regions.

The implications of these deficits may vary depending on the language learned, but they hinder text comprehension and production, as learners cannot dedicate sufficient cognitive resources to the level text, making it difficult to process several pieces of information simultaneously (Lefebvre, 2016). This is truer for languages with complex lexical orthographies such as English and French (Caravolas, 2005). In general, it has been observed that students with poor skills in reading and writing, including those with dyslexia, often present oral deficits (Ullman et al., 2020). For example, reading comprehension has been associated with difficulties and poor oral grammatical skills. Indeed, it was observed that among English-speaking students with poor reading comprehension skills, more than half had deficits in comprehension and production of oral verb tense (Adlof & Catts, 2015). Among French-speaking students, it was observed that those with poor reading comprehension skills had poor oral pronominal anaphora resolution skills, i.e. deficits in oral comprehension of pronouns used to restate information which hinder the actualization of non-specific processes (Adlof & Catts, 2015).

In reading, the latter students' difficulties variably affect their ability to identify written words accurately and fluently in English and French (Fontaine, 2019; Yang et al., 2022). According to these authors, they hinder the development of the main processes that enable the accurate and fluent identification of written words in different types of tasks (e.g.: reading isolated words, reading text) and with different media (e.g.: paper medium, versus technological medium). More specifically, phonological deficits hinder the development of alphabetic processing and therefore their ability to make links between graphemes and phonemes. Those with lexical orthographic memory store grapheme positioning and word form in their memory, enabling them to accurately and quickly read irregular words, which is essential for the development of orthographic processing. And visual attentional disorders amplify the challenges of developing this processing and morphographic processing, due to the difficulty in visually paying attention to linguistic units (e.g. graphemes and their positioning, morphemes including silent letters) (Stanké, 2016). Students must then compensate for their difficulties by relying on word meaning and text comprehension, among other things. All this processing is necessary to master the reading of written words with alphabetic, orthographic and morphographic orthography, such as English and French (Landerl et al., 2023). According to these authors, they then make numerous reading errors, have difficulty transferring their learning from one task to another, read slowly and hesitantly, and understand written text less than read text. These consequences of dyslexia can be diminished if students develop high-level comprehension processes for which they have abilities, despite their specific deficits. Studies of young English speakers with dyslexia suggest that they rely more on semantic context than typical readers (Deacon et al., 2019). For example, young dyslexics would find it easier to identify a word correctly if it is preceded by a sentence providing semantic context, rather than if it is presented in isolation.

At age 9-12, the reading challenge for these students is to coordinate the key strategies of written word identification and comprehension, to read a variety of texts across disciplines (Hall et al., 2023). According to these authors, at this age, when expectations are raised in reading, as students must read and comprehend increasingly complex texts and identify increasingly difficult words in all disciplines, these students need interventions adapted to their reading needs, including remedial interventions in reading-writing. Since this article deals more specifically with the reading difficulties of these learners, the term "dyslexia" is maintained, bearing in mind, moreover, that dyslexia is associated with dysorthographie.

To assess the extent to which students can contextualize their learning and make connections between oral and written language in the face of increasing expectations, different tasks can be proposed (Desrochers & Stanké, 2017; Shapiro, 2004, Valencia & Buly, 2004). As mentioned by (Fontaine, 2019), in order to take into account the interactions between processes and the specificity of each one, these tasks can be located on a continuum, ranging from decontextualized tasks to contextualized tasks, the ultimate task being the authentic situation of text comprehension. For example, tasks involving the manipulation of oral units (such as syllables, phonemes, or morphemes) can be used to assess phonological or morphological awareness; pseudo-word identification tasks generally serve to evaluate alphabetic processing; and tasks requiring the identification of isolated words can tap logographic, alphabetic, orthographic, or morphographic processing, either simultaneously or selectively, depending on the characteristics of the items presented. Contextualized tasks that promote the identification of written words in linguistic units that are more complex than words (e.g., increasingly elaborate sentences or texts) can also be administered (Shapiro, 2004) to assess the identification of written words, in interaction with reading comprehension. Depending on the process being evaluated, various development indicators may be considered in these tasks, including accuracy and fluency (Abdel Latif, 2013).

### ***Rehabilitation interventions in reading***

In Canada, students with dyslexia are considered learning disabled. They receive reading and writing interventions adapted to their needs and environment (Office des professions du Québec, 2013). According to these authors, a non-categorical or pedagogical approach that focuses on the student's abilities and needs rather than on the identification of a specific disorder is being promoted in Canadian schools. It involves intervening in the most normal setting possible, favoring inclusion in the regular classroom. Interventions in reading and writing essentially consist of adaptive measures and re-educative interventions to help them overcome and compensate for their persistent difficulties. They vary from school to school, region to region and learner to learner. These interventions aim to prevent or re-educate reading and writing processes, in collaboration with the players involved and based on research data. Thus, in reading, remedial can be a) corrective, seeking to make deficit processes such as the identification of written words efficient, or b) compensatory, reinforcing functional processes or promoting the use of tools, including technological aids that the student uses in different life contexts, or c) of the mixed type (Brodeur et al., 2015; Rousseau, 2014).

Whether from one or other of these perspectives, rehabilitation benefits from being based on the guiding principles of validated remedial interventions with these students (Wharton-McDonald, 2011; Williams et al., 2017). Explicit, targeted, flexible, individualized, intensive and long-term teaching combines all these principles. This teaching is said to be explicit, because it models, guides and practices the targeted processes with micro-graded tasks, immediate feedback and support for the transfer of learning. It is targeted, as it focuses on priority strategies to be developed by the student at this point in his or her development. It is also flexible, as it involves planning and regulating interventions according to student

progress. What's more, it is individualized and intensive, thanks to modalities that enable intervention in small, homogeneous sub-groups, outside the classroom, with in-class support. This teaching is intensive, i.e. it lasts from 30 minutes to 3 hours a day, and prolonged, i.e. it extends over several weeks or months, to achieve objectives in a variety of tasks and life contexts. It thus contributes to meeting school requirements.

Remedial reading intervention is therefore based on structured, coherent intervention programs tailored to the needs of each student (Fontaine, 2019). However, few reading and writing remedial intervention programs have been evaluated specifically for students with dyslexia, particularly in French, as highlighted in recent meta-analyses of remedial programs for students with learning difficulties in primary school (Galuschka et al. 2019; Hall et al., 2023). According to these authors, these programs can help them overcome their difficulties in identifying written words, but at the end of them, their difficulties generally persist. They still have a major impact on comprehension. In fact, these authors point out that variable results, far from the norm and not allowing students to function or update their abilities, are observed in written word identification. These programs train one or two strategies for reading isolated words, interacting with certain comprehension processes in a few cases, which is too little to help them access comprehension and develop their deficient strategies in this area. In addition, these programs did not incorporate newly developed technological tools frequently used by these students daily, in the classroom and at home to access the identification and understanding of texts and thus compensate for their difficulties. For example, these students frequently use text-to-speech, a voice that reads text, to support the identification of written words, and graphic organizers, to support reading comprehension, by identifying essential information.

According to Galuschka et al. 2019 and Hall et al., 2023 over the past 20 years, remedial intervention programs that offer explicit, targeted, individualized, flexible and intensive teaching over an extended period have generally improved this process in dyslexic nine- to twelve-year-olds resistant to quality initial interventions, as well as improving reading comprehension in some cases. Such programs, implemented by an interventionist trained in teaching reading and writing, generally help these learners to make links between oral and written language (e.g., links between graphemes and the phonemes they represent; links with vocabulary known orally to understand the meaning of a word), by being guided step by step in the use of reading strategies to solve problems linked to the identification of written words or reading comprehension. Although these programs generally offer corrective strategies to facilitate written word identification, experimental research on them differs in terms of the learning targeted and the methodologies used. Indeed, most of these studies enabled learners to develop accuracy in identifying isolated words (Berninger, Garcia et al., 2008; Berninger, Lee et al., 2013), while some others also developed fluency in identifying written words when reading text (Donegan et al., 2020; Miciak et al., 2018). In addition, one study offered mixed remedial interventions, also developing reading comprehension (Toste et al., 2019). In all these studies, conducted with an experimental protocol, the remedial strategy significantly (small effect sizes) but variably improved written word identification skills (accuracy and fluency). One also improved reading comprehension (Toste et al., 2019).

According to the authors of the experimental research already mentioned, although the improvements enabled dyslexic students to identify trained items more accurately, the programs described in this section did not generally enable them to meet age-appropriate expectations for isolated word identification, or to understand texts that corresponded to their abilities. However, according to these authors, an improvement in these areas is essential to allow them to access the content of texts, in all school disciplines. These students will therefore need a new combination of variables to progress.

The results of this research can be explained by the fact that, from a methodological point of view, designing and implementing reading rehabilitation programs poses significant

methodological challenges, each study having its own contributions and limitations, regarding to the general criteria applicable to all experimental research (see Figure 2). To date, the literature reviews conducted have provided little clarification on these issues, as they focus more broadly on reading and writing programs for students with special needs, and not specifically those for dyslexic students aged 9 to 12 (e.g.: Galuschka et al. 2019; Hall et al., 2023). However, the recognition of dyslexia as a specific disorder is a major advance in the last twenty-five years. It would therefore be relevant to carry out an integrative review focused on these aspects, to integrate aspects that have been little or not covered at all in the reviews conducted to date on the subject and thus have a current overview.

<b>General criteria applicable to all experimental research</b>
① Internal validity (the relationships observed between VI and VD) cannot be explained by other variables;
② External validity (these relationships are not context-dependent);
③ Ecological (social) validity.
④ Construct validity (whether explanatory concepts account for test performance);
⑤ The validity of statistical conclusions (the validity of inferences about the existence of causal relationships between VI and VD).

**Figure 2** Criteria of scientific rigor (Bryman et al., 2008)

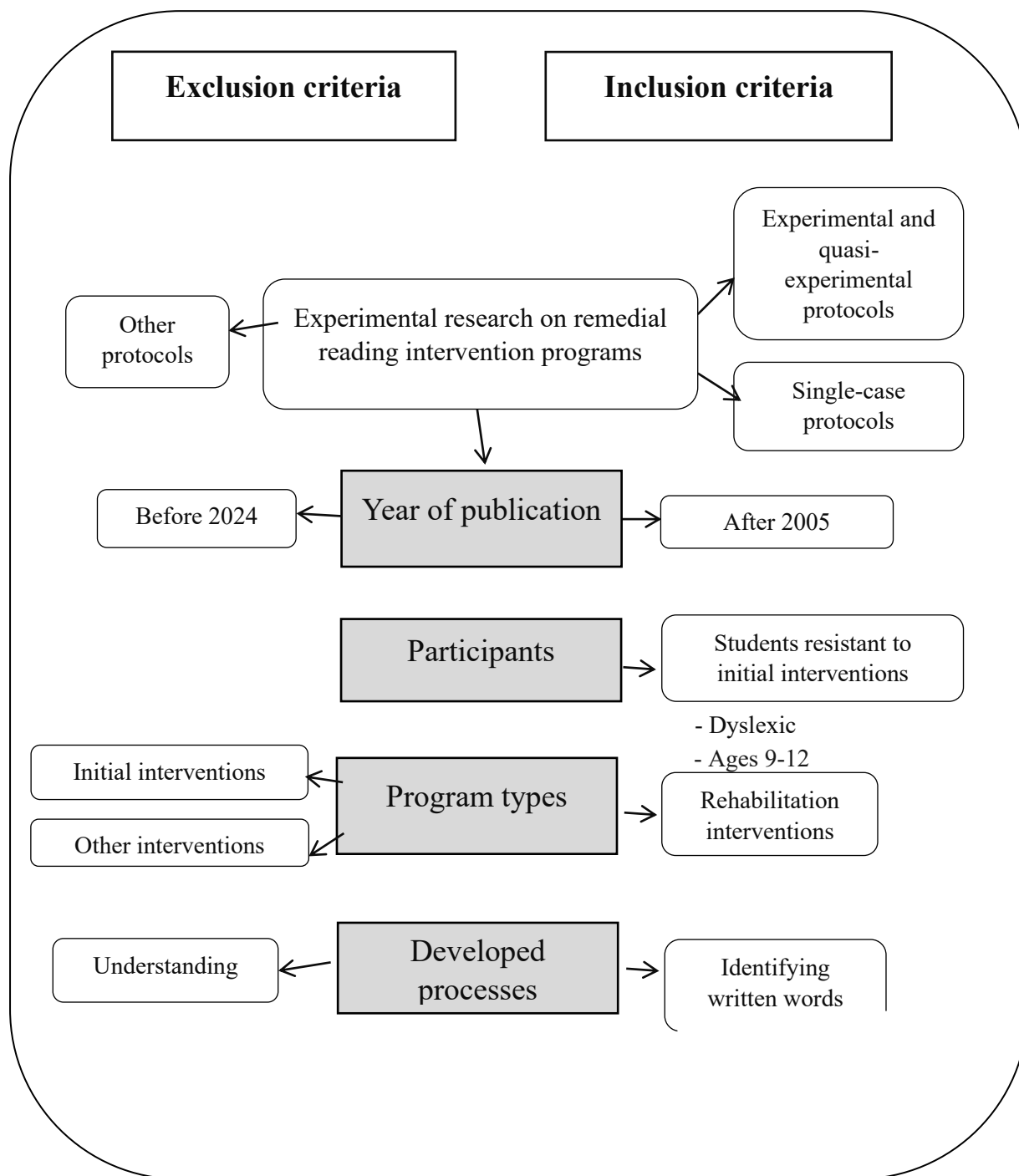
### **Purpose of the study**

With this in mind, this article presents the results of the first-ever integrative review of scientific literature dealing specifically with remedial reading intervention programs to develop written word identification and reading comprehension in students with dyslexia. This review answers the following specific question: what are the contributions and limitations of the different methodologies used in the experimental research evaluating the effects of remedial programs on the written word identification and reading comprehension of dyslexic students aged 9 to 12?

### **Methodology**

This integrative literature review follows Jackson's method (Fortin & Gagnon, 2016; Jackson, 1980). This six-step method seeks first and foremost to deduce generalizations about important issues, based on a set of studies dealing directly with these issues. It allows us to rigorously analyze a series of scientific writings on substantive issues in a field, to make links between these writings, and then to propose an original, integrative conceptualization of the subject under study. It was carried out with inspiration from a review already carried out by the first author of this article (Fontaine et al., 2021). Here are the steps followed:

1. Identifying the subject of study and identifying secondary sources. This step led to the formulation of the specific research question, by reading titles and abstracts of scientific articles on the subject under study, including literature reviews.
2. Select relevant databases and define a concept map. This step enabled us to find documents related to the subject, using specialized educational databases (ERIC, Education Source and PsychINFO). It led to the development of a concept map to guide the search, specifying inclusion and exclusion criteria (see Figure 3).
3. Identify primary sources, select search terms and limit the search. According to these criteria, research on remedial reading intervention programs could have been conducted using an experimental or quasi-experimental protocol, or a single-case design. At this stage, research evaluating the effects of a remedial program on the written word identification and/or reading comprehension of dyslexic students aged 9 to 12 was included; all others were excluded. More specifically, a search of peer-reviewed scientific journals was carried out to find primary studies, conducted from 2005 to 2024, in these databases. In order to search for studies that evaluated the effects of the independent variable of interest, the first terms chosen were: "program", "intervention" or "remediation", followed by "reading". Secondly, in order to find those whose participants were students resistant to quality initial interventions, and whose dyslexia was identified, the terms "dyslexia" or "dysorthographia" were chosen, knowing that dyslexia and dysorthographia are associated. Thirdly, the terms "reading" or "word identification" or "reading comprehension" were preferred to find primary studies specifically aimed at developing the targeted dependent variables. In addition, the search was limited by age group ("9 to 12" or "grade 3 to 6"). Secondly, in order to find studies targeting French-speaking students, we carried out a second search replicating the above-mentioned criteria but adding the term "French".
4. Examine the relevance and quality of sources. The titles and abstracts of the primary sources found were read, then eight were finely evaluated according to the inclusion criteria. Reading records were used to gather information on their objectives, participants, variables and results (see Table 1). Five English-language and four French-language studies were retained; the remaining 13 were excluded because they did not meet all the criteria (e.g., some were not experimental or proposed other types of intervention, such as parenting support).
5. Evaluate sources critically. To analyze these studies according to their protocol type, an assessment grid was used for those with an experimental or quasi-experimental protocol (Gersten et al., 2005, see Table 2). This analysis, carried out by the first author of this article, was based on the grids proposed by these authors. For each indicator, we assessed whether the study met the essential and desirable criteria. The score corresponding to these criteria and the total score were then calculated.
6. Analyze and synthesize the information, then organize and write a literature review, based on the specific question. This step leads to a critical synthesis of the five studies identified, grouping them according to the type of protocol used. This was done by making links with the criteria of scientific rigor applicable to all experimental research and the criteria specific to research with a single-case protocol. This critical summary is supported in the following sections.



**Figure 3** Concepts of the object of study

**Table 1** Examples of reading guides

Objective	Partici- pants	Independent variable(s)	Dependent variable(s)	Results
<b>Studies targeting English-speaking students</b>				
<b>(1) Berninger et al. (2008)</b>				
Evaluating the effects of intervention programs on the accuracy of English written word identification of dyslexic 9-14 years old students.	22 dyslexic students aged 9-14	Program to develop spelling processing VS Morphographic processing development program	Identifying written words Lexical spelling	Significant improvements for all dependent variables
<b>(2) Berninger et al. (2013)</b>				
Evaluating the effects of intervention programs on the accuracy of English written word identification of dyslexic 9-14 years old students.	24 dyslexic students aged 9-14	Group A: reading program to develop alphabetic processing, then reading-writing program to develop alphabetic and orthographic processing Group B: a reading program aimed at developing alphabetic processing, followed by a reading-writing program focusing on morphographic processing.	Ditto	Ditto
<b>Miciak et al. (2018)</b>				
To evaluate the effects of intensive intervention programs on the accuracy and fluency of English written word identification and reading comprehension of 9-10-year-old dyslexic students.	270 dyslexic students aged 9-10	To compare the effects of a reading-writing remedial program with various components offered over one year, versus offered over two years, versus usual interventions.	Ditto	Significant improvements on dependent variables (a) among students who attended the one-year and two-year programs

Objective	Participants	Independent variable(s)	Dependent variable(s)	Results
Evaluating the effects of a remedial intervention program on the accuracy and fluency of English written word identification and reading comprehension of 9-10-year-old dyslexic students.	153 dyslexic students aged 9-10	<b>Donegan et al. (2020)</b> Compare the effects of a reading-writing remedial program with various components offered intensively, versus the same program, but offered non-intensively .	Ditto	No significant difference between groups
Ditto	108 dyslexic students aged 9-11	<b>Toste et al. (2019)</b> Group A: Program focused on reading multisyllabic words Group B: Same as Group A, but with support for metacognitive processes Group C: Usual interventions	(a) Identification of written words (accuracy and fluency) (b) Reading comprehension (c) Morphological awareness (d) Lexical spelling	Improvements on all dependent variables for groups A and B
<b>Studies targeting French-speaking students</b>				
To evaluate the effects of a multimodal intervention program (phonological and visual) on the written word identification skills of French-speaking students with and without dyslexia. The program is	24 dyslexic students of 9-11 year-olds and a control group of 11 9-11 year-olds.	<b>(6) Jucla et al. (2010)<sup>1</sup></b> Compare the effects of a 6-week program in an experimental group of dyslexic students VS a control group of non-dyslexic students.	Word identification using a visual lexical decision task, where participants read a word and have to respond whether it is a real word or not (words vs. pseudowords vs. pseudohomo	Although both groups improved on the task after the interventions, dyslexic students improved specifically in identifying real words.

implemented by parents and speech therapists.			phones vs. nonwords)	
<b>(7) Turcotte Tousignant et al. (2024)<sup>1</sup></b>				
To evaluate the effects of a program aimed at re-educating different components of written language on grapho-phonological correspondences and orthographic representations	6 dyslexic or at-risk students aged 9-11	To compare the effects of a reading-writing remedial program with various "Des mots pour les maux" components (24-week duration, measurement at 8, 16 and 24 weeks), VS usual orthopedic interventions (6 weeks).	Several reading and spelling skills targeting grapho-phonological correspondence and orthographic representations	Significant improvements on the following dependent variables: speed of non-word and rare-word decoding, word spelling. No improvement on other variables.
<b>(8) Bedoin et al. (2010)<sup>2</sup></b>				
Evaluating the effects of a computerized visual attentional training remediation program 4-week on reading and spelling skills.	12 dyslexic students: 7 in the trained group and 5 in the control group, all aged 9-11.	To compare the effects of a 4-week visual attentional training program in an experimental group VS a control group receiving a vocabulary intervention.	Various reading and spelling skills targeting grapho-phonological correspondence, orthographic representations and visual-attention skills	Significant improvements on the following dependent variables for the youth group trained only: identification of frequent words, identification of regular words
<b>(9) Zoubrinetzky et al. (2019)<sup>2</sup></b>				
To evaluate the effects of a computerized visual-attention training remediation program and a computerized phonological perception training program on	45 dyslexic students 10 years on average.	Comparing the effects of a visual attentional span remedial program VS a phonological perception remedial program.	A: Visual attentional skills, B: Phonological perception, C: Phonological awareness D: Identification of D1 regular words, D2 irregular words and	For both programs, enhancement on C, D1, E. Visual attentional program: improvement on A, D2. Phonological perception program: B, D3

reading skills, for 6 weeks, 5 days a week and 15 min a day.	D3 pseudowords , E: Text reading (time and accuracy).
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Notes <sup>1</sup>: These articles come from the same method of literature review of English-language articles. The search on the same three databases included a similar distribution of English keywords, but with the addition of "French", Français, to target French-speaking participants. <sup>2</sup>: These articles were found via the list of references from the articles identified in 1.

**Table 2** Quality indicators for reaches with experimental and quasi-experimental experimental and quasi-experimental protocol (Gersten et al., 2005)

Criteria	Assessment				
	(1)	(2)	(3)	(4)	(5)
<b>Essential criteria</b>					
1. <i>Study conceptualization</i>					
- Does the study contribute to the advancement of knowledge in the field?	1	1	1	1	1
- If an innovative approach is proposed, is it based on a causal model derived from research?	1	1	1	1	1
- Are the research questions appropriate and well formulated? Are the arguments presented valid to support the nature of the intervention in the groups?	1	1	1	1	1
2. <i>Participants/sample</i>					
- Are appropriate procedures used to ensure that participants are comparable between conditions?	1	1	1	1	1
- Is sufficient information provided to determine or confirm whether participants present the targeted difficulties?	1	1	1	1	1
- Are appropriate procedures used to increase the likelihood that stakeholders will be comparable between conditions?	1	1	1	1	1
3. <i>Location of intervention and nature of comparison condition</i>					
- Is the intervention clearly described?	1	1	1	1	1
- Are the procedures for ensuring fidelity of implementation described?	1	1	1	1	1
- Is the nature of the teaching/services offered described in the conditions?	1	1	1	1	1
4. <i>Measures</i>					
- Are different measures offered that provide a balance between measures related to the intervention offered and overall performance?	1	1	1	1	1
- Are the measurements of high quality?	1	1	1	1	1

5 *Analysis*

- |  |   |   |   |   |   |
|--|---|---|---|---|---|
| - Are the analysis techniques appropriate and linked to the research questions and hypotheses?               | 1 | 1 | 1 | 1 | 1 |
| - Is the variability between each sample taken into account by different sampling or statistical techniques? | 1 | 1 | 1 | 1 | 1 |
| - Is an analysis performed to determine the effect size?   | 1 | 1 | 1 | 1 | 1 |

**Desirable criteria**

- |   |   |   |   |   |   |
|---|---|---|---|---|---|
| 1. Are the effects of the intervention measured beyond an immediate post-test?  | 0 | 0 | 0 | 0 | 0 |
| 2. Are the measurements valid? If not, will it be estimated from research results or obtained with other samples?   | 1 | 1 | 1 | 1 | 1 |
| 3. Will the research team document in detail the fidelity (e.g., number of minutes allocated, application of procedures) and quality of the implementation? | 0 | 0 | 0 | 0 | 0 |
| 4. Will the research include recordings of the intervention?  | 1 | 1 | 0 | 0 | 0 |
| 5. Does the researcher perform adequate analyses for different levels of statistical analysis?  | 1 | 1 | 1 | 1 | 1 |

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<b>Score for essential criteria</b>	14/	14/	14/	14/	14/
	14	14	14	14	14
<b>Score for desirable criteria</b>	3/5	3/5	2/5	2/5	2/5
<b>Total score</b>	17/	17/	17/	17/	17/
	19	19	19	19	19

**Legend 0:** Does not meet criteria  
**1:** Meets the criteria

**Results and Discussion**

This analysis compares five experimental studies targeting English-speaking students and four targeting French-speaking students. These studies evaluated the effects of remedial programs on the written word identification and reading comprehension of dyslexic students aged 9 to 12. They were all conducted using an experimental or quasi-experimental protocol: no research with a single-case protocol was found. In the studies, the types of tasks used to assess reading processes are mentioned (e.g.: word identification, pseudowords identification), but the specific treatments or strategies targeted have yet to be specified in most studies, depending on the items proposed to students in each of them.

***Studies targeting English-speaking students***

Two studies (Berninger, Garcia et al., 2008; Berninger, Lee et al., 2013) aimed to evaluate the effects of remedial intervention programs on the accuracy of English written word identification and lexical spelling of dyslexic pupils aged 9-14. The first study (Berninger et al., 2008) initially compared two 30-hour programs with 22 participants aged 9-14 randomly distributed in two groups. The first program aimed to develop orthographic processing

(learning orthographic rules and regularities, according to the positioning of graphemes in words) and the second, morphographic processing (learning frequent morphemes making the link with the meaning of words). Students read words to discover the linguistic units to be learned, record their discoveries and then produce isolated words under dictation. They also produced narrative and informative texts using text processing. They were then taught metacognitive processes for managing text production: planning, editing and revising. In the same initial study, Berninger et al. (2008) also compared two programs focused on science learning. The first offered explicit instruction in language skills (phonological memory, spelling processing, science report writing), while the second focused on non-verbal problem solving (activities virtual reality, map drawing and building model). These four 30-hour programs were offered 15 days in a row, for two hours a day, at a university summer camp in the United States. Their effects were evaluated using short, standardized reading-writing tests of isolated words, pseudowords and texts, which were analyzed quantitatively. More specifically, a pseudoword identification test involving alphabetic processing was used to assess the accuracy of written word identification. The results showed significant improvements for all dependent variables, including small effects in written word identification (Partial  $\eta^2$  effect size estimate, Cohen's  $d$  not reported), as well as results far from the norms. The second study (Berninger et al., 2013) compared two combined 30-hour programs with two groups of dyslexics 12 students aged 9-14. The two began with oral exercises to develop alphabetic processing reading interventions (activity 1). Group A continued to then develop alphabetic processing with interventions enabling them to make links between reading and writing words containing the targeted graphemes (activities 2), followed by activities aimed at developing orthographic and morphographic processing focused on word production, and fluency in identifying written words (activities 3). Group B took part in phonemic awareness activities (4), followed by activities 3 and 2. Both groups integrated reading and writing into their activities. These 30-hour programs were offered at the university, twice a week for five months. The results of the alphabetic processing pseudoword identification test showed no significant difference between the groups (effects sizes not reported).

For their part, Donegan and Wanzek (2021) and Miciak et al. (2018) studied how reading-writing remedial programs can improve the identification of written words in 9-11-year-old dyslexic students, observing comparing the intensity, duration and size of intervention groups. For their part, Donegan et al. (2020) and Miciak et al. (2018) studied how reading-writing remedial programs can improve the identification of written words in dyslexic 9-11-year-old pupils, comparing intensity, duration and size of the intervention groups. The study by Donegan et al (2020) used the "Passport" program, which combines two components. The first, Word Works, explicitly teaches alphabetic processing, by teaching the association between graphemes and phonemes, the segmentation of words into syllables and decoding strategies. In this component, therefore, isolated word-reading activities are the focus. The second component, Read to Understand, explicitly teaches vocabulary, comprehension processes and reading fluency based on the same text. The vocabulary contained in the text is worked on before reading, then the text is read, and non-specific comprehension processes are taught, such as macroprocesses, microprocesses and inferences. Finally, the text is read repeatedly to develop fluency. This study randomly assigned 154 students to two groups at their school: one group that received the Passport program for 30 minutes a day with 7 students per group, and another group that received the same program plus an additional 15 minutes of fluency practice with 2-3 students per subgroup. The results, measured by standardized tests showed no significant difference for accuracy and fluency of written word identification, or in reading comprehension (the type of tasks is not mentioned). The study by Miciak et al (2018) involved 270 pupils randomly assigned to three groups: one that attended 30-40-minute sessions in small groups for 1 year, one that attended the same

sessions for two years, and a control group that attended the usual sessions at school. The intervention had four components. The first, the text reading program, encouraged reading independent or paired with regular stops to summarize and ask questions. The second, word study, encouraged the development of logographic processing by reading frequent sight words, with word lists adapted to each student. Thirdly, vocabulary instruction was integrated with text reading, working on five words contained in each text. Finally, the self-regulation component helped students set goals, stay motivated and assess their progress and perseverance. The results, also measured by standardized tests, showed that the first two groups made significant progress over the control group in terms of fluency in identifying written words in reading pseudowords (phonetically regular nonsense words) and in accuracy in reading words. They also indicate that the two-year intervention group performed better than the one-year group. However, the effects were small (e.g., Cohen's  $d = 0.14, 0.36$  and  $0.26$ ) and neither group made significant progress in reading comprehension, measured by tasks of reading expository and narrative passages and answering multiple choice questions related to the passage.

Toste et al., (2019) evaluated the effects of a remedial intervention program on the accuracy and fluency of written word identification and reading comprehension of 9-11-year-old dyslexic students. One hundred and eight dyslexic 9-11-year-old students were randomly assigned to three groups: (1) Program focused on reading multisyllabic words; (2) Same as group (1), but with support for metacognitive processes; (3) Usual interventions. The program consists of seven activities, including warm-up, morpheme instruction, word play, timed word reading, word writing, speed reading and text reading. Metacognitive support was aimed at strengthening students' goal setting, planning and process regulation, through positive self-talk about reading. The program was delivered in small groups of 2-3 students, with four 40-minute sessions per week, over a 10-week period. Quantitative analyses using standardized measures showed improvements on all dependent variables for groups A and B (size effects not reported). Measures of word identification were tasks of reading words in isolation and reading nonsense and measures of comprehension were to identify a missing word from a passage.

### ***Studies targeting students French-speaking***

Turcotte Tousignant and colleagues (2024) evaluated the effects of program "Des mots pour les maux", aimed at re-educating different components of written language on graph phonological correspondences and orthographic representations. Six dyslexic or at-risk students aged 9-11 took part in the study. Administered in a school setting, the 24-week experimental program was preceded by a 6-week block of standard interventions. The effects of the experimental program were assessed on several reading and spelling skills, targeting graph phonological correspondences and orthographic representations, at various times before and during the "Des mots pour les maux" program. The authors noted significant improvements in some skills at weeks 16 and 24 of the program, with moderate effect sizes on some skills (effects sizes not reported). Students improved in graph phonological correspondence, with increased speed reading of non-words and rare words. In terms of orthographic representations, the authors observed a reduction in the number of errors in the spelling of regular and irregular words.

Two studies have evaluated the effect of visual attentional remediation programs on improving the reading skills of students with dyslexia. Bedoin et al. (2010) evaluated the effects of a computerized remediation program for training visual attention, on the identification and production of written words in young dyslexics whose major impairment is a visual/attention deficit. The proposed program consisted of 5 sessions per week for 4 weeks, administered individually. During the first ten sessions, one exercise focused on

stimuli representing traffic signs and two exercises consisted of matching a target with one of the two hierarchical stimuli presented below, only one with a common element with the target. The next ten required global attention and inhibition of detail on similar stimuli. At each session, a curve allowed children to follow their progress. Twelve dyslexic children aged 9 to 11 took part in the study. Seven of them received training and constituted the trained dyslexic group, and five children received vocabulary training and constituted the control group. As part of their usual follow-up, they did exercises to enrich their oral vocabulary. The two groups were matched in age and observed reading delay. The effects of the remediation program were evaluated in a pre- and post-phase training. The evolution of written word identification and production, targeting the development of alphabetic and orthographic processing (reading and writing of frequent, regular and irregular words) was assessed using standardized tests, and visual-attention skills were evaluated using an experimental test. The results showed significant improvements for the dyslexic youth group trained when compared to the control group in reading, specifically on the identification of frequent words and the identification of regular words, and in visual attentional skills (effect sizes not reported). Zoubirintzky and colleagues (2019) also evaluated the effect of a computerized remediation program for visual attentional skills, named MAEVA, but this time in comparison with the effects of a computerized program for phonological perception skills, named RAPDYS. MAEVA aims to improve children's visual ability by increasing the number of items that can be processed simultaneously. Training includes visual categorization tasks with five types of characters. In each session, participants must identify the families of characters presented, with the difficulty of trials adjusted in real time to maximize learning. The process includes trials with variable durations and character strings, and a feedback system to maintain motivation. RAPDYS is a software program used for the perceptual discrimination of phonemes in children, based on an acoustic fading task. It offers training sessions of five blocks of 20 trials, with increasing levels of difficulty. Children receive visual rewards for correct responses and encouraging messages to keep them motivated. Each session is tailored to the child's performance, with a bonus block for the best results. Forty-five dyslexic pupils aged 10 on average were assessed in terms of phonological awareness, skills pseudoword reading, alphabetic processing, text reading, visual-attention and phonological perception. The programs, lasting 15 minutes a day, 5 days a week for 6 weeks, were implemented sequentially, with half the group starting with the MAEVA program and the other half with RAPDYS. Significant improvements, with effect sizes ranging from small to large, were observed in students common to both programs on the plan of phonological awareness, accuracy of regular word identification (alphabetic processing) and text reading. The program MAEVA aimed to improve visual attention, as well as the accuracy of reading. pseudoword (effects sizes: 0.47, 0.63, 1.21, 0.55, 0.46, 0.43, 0.45). The RAPDYS program targeting phonological perception skills improved these, as well as the accuracy of irregular word identification (effects sizes: 0.47, 0.63, 1.21, 0.55, 0.46, 0.43, 0.45).

Jucla and colleagues (2010) evaluated the effects of a multimodal intervention program (phonological and visual) on the written word identification skills of students with and without dyslexia. The experimental group of 24 dyslexic 9–11-year-olds and the control group of 11 9–11-year-olds completed the program which was administered by parents or their speech therapist. The rehabilitation program included phonological and visual training sessions six days a week. Phonological exercises, alternating weekly, included phoneme detection and word repetition. Visual exercises were initially non-verbal, then moved on to spelling tasks. Parents and speech therapists provided feedback and corrected the children's responses, following precise guidelines. The effects of the program were assessed on word identification skills using a visual lexical decision task, where participants read a word and had to respond whether it was a real word or not (words vs. pseudowords vs. pseudo homophones vs. nonwords). The results indicate that although improvement was observed

in both groups after the interventions, dyslexic students improved specifically in the identification of real words (effect sizes not reported).

A critical analysis of these studies shows that their methodology has important contributions and limitations for achieving research objectives. In all of them, research was conducted using an experimental protocol; in that context, randomization of participants makes it possible to create balanced groups and control for individual differences. What is more, by taking place in schools, in the speech therapist's office or in the home, and therefore in a natural environment, strengthens external validity, while limiting internal validity (Gersten et al., 2005). Considering the great individual differences between participants and their rarity in certain intervention contexts, particularly in the French-speaking context (Bedoin et al., 2010; Jucla et al., 2010; Turcotte Thousignant et al., 2024) the use of an individual protocol, such as the single-case protocol, would be indicated (Juhel, 2008). This type of protocol would have made it possible to finely monitor students' progress, planning and regulating interventions in such a way as to make them even more individualized and flexible, as in similar research conducted in writing with students (e.g.: Fontaine, 2019; Fontaine et al., 2025). In addition, together, the studies reviewed shed important light by measuring the effects of several programs on different dependent variables. The methodological contributions and limitations of these studies are reflected at all levels: conceptualization, participants, program implementation and quantitative measurement and analysis.

In terms of conceptualization, all the experimental studies reviewed have the advantage of proposing rehabilitation programs offered in contrasting modalities, thus orienting rehabilitation in the school context. In this context, the number of participants is more than significant in many of these studies (Berninger 2009; Berninger et al., 2013; Donegan et al., 2020; Miciak et al., 2018). It makes it possible to use a group protocol, as these students are often identified in the United States, unlike other contexts, such as Canada, in which these students are more rarely identified and integrated into regular classrooms (Office des professions du Québec, 2013). In addition, the description of student profiles in terms of specific reading and writing abilities and needs would benefit from further substantiation in all studies reviewed. In those studies, program implementation has also been well supported in training-accompaniment, with procedures to ensure fidelity, although this is not documented, which is a limitation, as in most of the experimental research (Swanson et al., 2013). Yet the programs offer a coherent set of objectives and micro-graduated activities. By opting essentially for explicit teaching, they make it possible in part to develop priority processes reading in pupils aged 9-12, by making links with writing and speaking (Berninger et al., 2013; 2013; Donegan et al., 2019; Miciak et al. 2020; Toast et al., 2019; TurcotteTousignant et al., 2024). Indeed, in all studies reviewed they gradually lead pupils to develop one or two processes for accurately and/or fluently identifying written words, by making the link with associated skills that are often deficient in pupils with dyslexia (e.g. phonological awareness and visual-attention skills). The process of identifying written words was worked on in conjunction with reading comprehension processes in some cases (e.g. macroprocesses, microprocesses and inferences) and by supporting the development of metacognitive processes in one of them (e.g. planning, adjustment, revision) (Berninger et al., 2009; 2013; Donegan et al., 2019; Miciak et al. 2018; Toste et al., 2019; Turcotte Tousignant et al., 2024). Several of the programs surveyed offer word and text reading-writing tasks, which is an advantage when compared with similar studies conducted with students with learning difficulties (Galuschka et al., 2019). In some cases, however, reading comprehension tasks seem short compared with the elaborate tasks usually completed in class by pupils at this age (ex: Toste et al., (2019). Thus, the tasks would benefit from being more elaborate and linking with those offered in class in various disciplines. To make them accessible, it would be advisable to offer the same adaptation measures to students, including the use of

technological reading aids (e.g. text reading by voice synthesis, use of graphic organizers). In-class support would also help to make interventions more intensive.

To be more targeted and individualized, interventions would also benefit from enabling students to pursue individual goals tailored to their needs, by planning and regulating the reading processes implemented in texts they choose, for example. As for standardized measures, they have the advantage of evaluating the student's results in different tasks, before and after the intervention program. Their limitations, however, are that they are sometimes far removed from the tasks proposed in the intervention program, and do not allow students to demonstrate their learning, as they usually do in class, with accommodations such as technological aids. Furthermore, although dyslexic students present persistent difficulties, the measures do not go beyond an immediate post-test, which is another limitation noted in most experimental research conducted in schools (Gersten et al., 2005). What is more, analyses based on overall scores, rather than scores for specific items, make it possible to partially understand which processes have been developed by students and which processes remain to be worked on. These methodological limitations therefore make it partially possible to plan and adjust interventions according to students' progress, which is at the heart of rehabilitation (Wharton-McDonald, 2011).

## Conclusions

In short, this critical analysis shows that the rare research studies that have evaluated the effect of remedial programs on written word identification and reading comprehension in dyslexic students are of high quality: this is an important contribution (Gersten et al., 2005). Another contribution is that their experimental protocol is highly relevant in the United States for measuring the effect of programs with a large number of participants (e.g.: Berninger et al., 2008; Berninger et al., 2013; Donegan et al., 2019; Miciak et al., 2018), although it is not always possible to implement it in a context of inclusion of these students in regular classes, as is the case in Canada (e.g.: Turcotte Tousignant and colleagues, 2024). This analysis underlines that in experimental research, everything depends on the conceptualization of the study. It can lead to a program that combines a set of reading strategies and intervention principles that act synergistically and implements them with procedures that allow interventions to be planned and adapted according to students' progress (Gersten et al., 2005). This is partly the case in the studies reviewed. So, the limitations concern mainly the programs and the measurements. One of them is to offer the same program to all participants, even though their needs are diverse. The second is to propose tasks that do not always make it possible to closely monitor the progress of students regarding the targeted processes or treatments. Indeed, the tasks are essentially concerned with the students' general performance in identifying written words and comprehension, rather than their progress regarding the processes, treatments and strategies in particular that are taught.

Considering the overall approach, the discussion identified three avenues for research and intervention: 1) offering sequences of activities; 2) fine-tuning assessment of student progress; 3) integrating reading supports that make learning and the targeted tasks accessible, such as technological aids. They are presented below.

### *Offer sequences of activities*

Rather than offering the same program to all participants, remedial programs would benefit from offering sequences of activities to develop the main word identification and reading comprehension processes, including those described in the schematic representation used for this review (Laplante, 2011). With regard to these treatments and processes, the

priority items/graphemes/texts to be trained would benefit from being targeted according to the student's individual profile in tasks that gain in complexity, by bridging with the learning achieved in class, which makes the link with the definition of dyslexia adopted, according to which action must be taken on various environmental factors to support students suffering from it. Thus, selection criteria for the specific profiles of reading-writing participants would benefit from being established, in line with the implications of this disorder (e.g.: Hall et al., 2023). This suggests a new combination of variables to enable the student to make further progress, by supporting metacognitive strategies that enable these tasks to be managed effectively. From this perspective, which implies offering blended remedial intervention, future programs would benefit from leveraging speaking and writing, in support of reading comprehension (e.g.: Fontaine, 2019; Fontaine et al., 2025). For example, in comparison with existing programs, the addition of tasks such as recalling or summarizing texts in various disciplines would be indicated. They would have the advantage of offering interventions over a continuous period, which is an important issue for achieving the targeted learning at ages 9-12; for example, one-hour sessions could be offered, rather than 30-45-minute sessions as in the programs identified.

### *Fine-tuning student progress*

The addition of these types of tasks would facilitate better planning and regulation of interventions according to student progress, making interventions more targeted, in line with the guiding principles of remedial interventions (e.g. Wharton & MacDonald, 2011). To this end, the addition of measures for fine-tuning progress would be relevant, in addition to general performance tasks. For example, artifacts of certain recalls and text summaries would be indicated to assess macroprocesses as well as responses to inference questions. These measures would generate quantitative data (e.g. number of pieces of information) and qualitative data (e.g. nature of this information) that could be analyzed with artificial intelligence tools, as in studies carried out with university adults (Appel et al., 2023). They would also enable students to obtain immediate and informative feedback on their ability to understand texts, thanks to evolution graphs. This feedback, combined with support for the transfer of learning to the classroom, and even the teacher's proposal of this type of task to all the students in the class, would also intensify interventions, in line with the guiding principles of remedial interventions (e.g.: Wharton & MacDonald, 2011).

### *Integrate reading aids that make learning and the targeted tasks accessible, such as technological aids*

With a view to ensuring continuity with the classroom, future rehabilitation programs would benefit from incorporating technological aids, which are also used in the classroom by pupils from age 9-12 for the rest of their progress (Almgren Bäck et al., 2023). According to these authors, these include: (1) the immersive reader, which has the potential to support alphabetic processing (speech synthesis to read words) and orthographic processing (highlighting visual features of words), essential for identifying written words; (2) graphic organizers, which have the potential to support macroprocesses, essential for reading comprehension. In this way, explicit instruction in their use could first be offered, and then used in a flexible sequence of remedial activities to work finely on these processes or processing. This teaching would help the student to know when, why and how to use them, which is an important issue if they are to be used effectively. Interventions would be explicit, individualized, targeted and flexible according to use.

In summary, the analysis of research evaluating the effect of remedial intervention programs for written word identification and reading comprehension shows the contribution and limitations of the methodologies used. This research is of high quality, helps to develop

the main reading strategies and respects the guiding principles of validated interventions with these pupils; it would nevertheless benefit from being even more explicit, targeted, individualized, intensive and flexible according to the pupils' progress. They also use a medium that offers little feedback or support for the transfer of learning: paper. These programs therefore train some strategies for identifying written words in short reading tasks of isolated words and texts but leave significant individual needs to be met in reading comprehension. Their procedures, however, do little to capture these needs. Future remedial programs would therefore benefit from proposing sequences of re-educative activities incorporating technological aids, while finely capturing pupils' progress.

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