Chapter 7
AI to the rescue: Helping children at risk for dyslexia surmount educational barriers

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Introduction

Unlike the broader umbrella term 'reading difficulty', which describes developmental and *acquired* pathological symptoms related to language and literacy (Shaywitz, 1998) that can result from inadequate exposure to high-quality instruction (Torgesen, 2002), dyslexia is a specific learning disability: namely, a neurodevelopmental disorder characterized by unexpected and persistent difficulties in accurate and/or fluent word recognition, as well as spelling problems, despite adequate intelligence and educational opportunity (International Dyslexia Association, 2002; Shaywitz & Shaywitz, 2005). Dyslexia is likely to be genetically inherited, manifesting as brain differences in individuals with this neurobiological disorder compared to those without (Ramus, 2004; Shaywitz & Shaywitz, 2005). Children with dyslexia typically exhibit relatively intact intelligence and higher order cognitive and linguistic functions, except in the literacy domain, where deficits are more pronounced (e.g. Shankweiler et al., 1995; Tunmer & Greaney, 2009).

As the most prevalent learning disability, dyslexia affects approximately one in every 10 school-age children across different languages (Wagner et al., 2020), with its negative consequences starkly evident (Livingston et al., 2018). Students with dyslexia frequently experience early academic failure, increased risk of emotional and behavioural problems, low self-esteem, peer rejection, higher anxiety, and depression (McNulty, 2003; Mugnaini et al., 2009). Furthermore, the achievement gap between children with dyslexia and their neurotypical peers (i.e. individuals with a pattern of thinking or cognitive processing that corresponds with the majority of others in society; Cooper, 2006) can persist and even widen from early primary school through adolescence (e.g. Duff, 2022; Ferrer et al., 2015).

Despite the significant number of primary and secondary students diagnosed with dyslexia, only a small percentage (0.2%-0.4%) of university-level students report having a history of dyslexia (MacCullagh, 2014). This discrepancy suggests that many students with dyslexia may not pursue higher education. One possible reason for this is the early educational barriers they encounter. According to Nevill and Forsey's (2023) analysis of 70 qualitative studies on the experiences of individuals with dyslexia in primary and secondary school, 40 of the studies indicated that students with dyslexia consistently reported a lack of positive schooling experience. The key factor contributing to this lack was their negative interactions with primary school teachers, resulting in low self-esteem and high anxiety. A study by Singer (2007) on Dutch students with dyslexia, for instance, found that, due to their slow progress in reading and spelling, negative emotional responses from teachers such as anger or frustration greatly affected their self-esteem. Macdonald (2009) also revealed that students with dyslexia often reported feeling embarrassed or humiliated in front of their classmates by teachers attributing their reading and writing problems to laziness and/or lack of intelligence.

Another disadvantage that further compromises the quality of education for students with dyslexia involves the inadequate allocation of educational resources. For example, despite the endorsement of inclusive education in mainstream schools in the Republic of Ireland (Lindsay, 2007), the implementation of the General Allocation Model (GAM), designed to provide additional teaching support for students with special educational needs (SEN), has been inconsistent, leaving some SEN students, including those with dyslexia, underserved. Moreover, initial teacher education often lacks appropriate training on dyslexia (Beck et al., 2017), which is recognized as a primary reason why teachers do not adequately meet the learning needs of these students (e.g. Chista & Mpofu, 2016; Ross, 2017). Not surprisingly, teachers, in turn, often report their own limited understanding of dyslexia, the exact problems these students face, and how to rectify the situation and provide the requisite support (e.g. Chitsa & Mpofu, 2016; Griffiths, 2024; Indrarathne, 2019; Nevill & Forsey, 2023). In addition, many teachers feel constrained by the extra time and work required to differentiate and personalize instruction and support for students with dyslexia, further hindering the quality of education they receive (Siam & Al-Natour, 2016).

What this evidence makes clear is that millions of children with dyslexia worldwide are not receiving the quality education they need and deserve.

Research overview

Two key ways to offset the challenges faced by children with dyslexia is to implement early detection and timely intervention. However, due to global learning challenges related to dyslexia and appropriate resources, many countries struggle to implement early screening and identification for this disorder. Our analysis of socially and economically developed countries (i.e. Australia, Canada, Japan, Norway, Singapore, the United Kingdom of Great Britain and Northern Ireland and the United States of America) and developing countries (i.e. Brazil, China, India, and Kenya) indicates four commonalities regarding the identification of dyslexia. First, the target age for diagnosis is relatively late, typically occurring at 6 years and above, i.e. when reading difficulties become more evident beginning in primary school. Second, most diagnostic processes are inefficient and are often initiated in classrooms when concerned teachers observe children's difficulties in reading and/or writing and recommend formal assessment to parents (e.g. British Dyslexia Association, n.d.). Third, the current model of diagnosis relies on a traditional homogeneous, deficits-based approach that assesses deficiencies in processing speed, memory, phonological skills, and word reading/writing, while neglecting these students' potential strengths, such as nonverbal creativity, musical aptitude, and social-emotional skills (Tong, 2023). Fourth, the diagnostic process is costly and labour-intensive, usually involving one-on-one sessions with licensed psychologists who are either members of nationally-accredited psychological associations, employees of associations specializing in dyslexia, or school personnel experienced with SEN children. The existence of these limitations in current diagnostic assessments necessitates the development of a more efficient, less costly, and heterogeneous strengths-deficits-based approach that notably emphasizes earlier screening and detection of dyslexia across countries and languages.

Why early screening and intervention matters

Recent research has demonstrated that dyslexia can manifest before formal reading instruction begins (e.g. Gabrieli, 2009; Molfese, 2000). This highlights the importance of early detection of children at risk for dyslexia, which enables optimal intervention during a critical time window for mitigating future reading difficulties. Furthermore, key cognitive skills that underpin reading, such as implicit statistical learning (i.e. the ability to automatically detect patterns from environmental inputs), can be assessed at a very early age, even in infancy (Tong et al., 2020; 2023). The benefits of early diagnosis experienced by students with dyslexia include 1) emotional relief by providing them with an evidence-based explanation of their difficulties while removing incorrect and demeaning attributions such as laziness or lack of intelligence (Glazzard, 2010; Stampoltzis & Polychronopoulou, 2009); 2) the ability to develop greater self-acceptance (Dale et al., 2001; Riddick, 2010); and 3) possible increased support from schools and parents (for a review, see Nevill & Forsey, 2023).

Moreover, our review of the specific countries noted above reveals that only Canada, India, Norway, Singapore, the United Kingdom of Great Britain and Northern Ireland and the United States of America emphasize the use of screening prior to primary school (e.g. Andresen & Monsrud, 2021; British Dyslexia Association, n.d.; Decoding Dyslexia Ontario, 2021; Dyslexia Association of Singapore, 2023; Misquitta & Panshikar, 2022; Odegard et al., 2020) indicating an understanding that earlier is better even though, in practice, they continue to assess and diagnose mostly during the school years. Also noteworthy is that five of these six countries have a very high Human Development Index (HDI) of 0.9 and above (United Nations, 2024), with the exception of India where clinicians have access to the Dyslexia Assessment for Languages of India (DALI; Rao et al., 2021), a screening tool made possible through a collaboration between the UNESCO Mahatma Gandhi Institute of Education for Peace and Sustainable Development (MGIEP) and Delhi University. Overall, global discrepancies in the availability of early dyslexia screening highlight the disparities in resource allocation between countries with relatively low and high levels of development. What is needed, then, aside from making this the norm, are diagnostic and intervention tools that can provide assessment prior to primary school and thus without the sole intervention of teachers.

Another point worth addressing is that most dyslexia diagnostic assessments primarily target monolingual readers, while often neglecting bilingual and multilingual readers. Among the aforementioned 11 countries we reviewed, only India has developed a bilingual diagnostic tool, DALI, to assess a child's abilities across two languages, in this case, either Hindi or Marathi and

English (DALI; Rao et al., 2021). While some states in the United States of America do provide screening in other languages, these tests are based primarily on English language features and may not always consider the child's native language characteristics, especially when that language is nonalphabetic. Given the prevalence of bilingual children across the globe, it is crucial to develop a bilingual dyslexic assessment tool tailored to their specific dual linguistic needs. Related to early assessment, research has shown that reading intervention is effective. A recent meta-analysis aggregating 40 years of reading intervention studies for 5- to 11-year-old students with or at risk of dyslexia has demonstrated that the intervention group outperformed the non-intervention group in reading and spelling performance, and that younger children benefited more from intervention than older children (Hall et al., 2022).

Nevertheless, since reading is a cultural-cognitive skill, establishing a worldwide (i.e. cultural) standard for reading intervention is not feasible. Written languages are characterized by unique features that require language-specific components during intervention. For example, as a morphosyllabic language, Chinese utilizes logographic characters to represent meanings and syllables. These mappings differ from those in alphabetic languages like English, where letters represent the smallest units of sound. Therefore, reading interventions for children learning non-alphabetic scripts, such as Chinese characters and Japanese kanji, may require additional meaning-based morphological and visual-spatial components (Zhang et al., 2023). Furthermore, in societies such as Hong Kong, India, and the Philippines where children need to learn multiple written languages, reading interventions for dyslexia should consider the dominant language while also targeting language-general and language-specific skills (Tong et al., 2023). More empirical evidence is needed to assess the efficacy of reading interventions that target languages other than English, especially for bi- and multilingual learners.

How AI and educational technology (EdTech) are transforming dyslexia diagnosis and intervention

Timely diagnosis and intervention of children at risk for dyslexia remain significant global challenges. Specifically, traditional human-delivered paper-and-pencil tests are not only costly, but constrained by space and time, resulting in delayed and inefficient diagnosis and intervention strategies. This presents a critical need for innovative solutions that can facilitate effective detection and intervention.

Perhaps the most important innovative solution involves the use of advanced artificial intelligence (AI) to enhance the precision and efficiency of dyslexia diagnosis and intervention. AI algorithms, particularly machine learning models, have demonstrated promising results for detecting dyslexia using various types of data inputs. Utilizing advanced computational techniques to detect patterns indicative of dyslexia, these tools often achieve high levels of accuracy and efficiency. For example, one approach involves using machine learning techniques, such as neural networks and support vector machine (SVM) algorithms, to analyse eye movement patterns during text reading. This approach is based on evidence that individuals with dyslexia often exhibit distinct patterns of eye movement, including longer fixations, more frequent regression, and irregular saccades (e.g. Fisher et al., 1993; Pan et al., 2014). By combining machine learning algorithms with these patterns, computational models can predict individuals at risk for dyslexia or low-literacy skills with high accuracy (Lou et al, 2018; Prabha & Bhargavi, 2019). However, since eye-tracking studies require the participants to read sentences or connected text, this approach has been used primarily for adults, and children in intermediate and upper elementary grades or higher, leaving early intervention (i.e. before age 6) largely untested.

Another AI approach involves using multiple machine learning algorithms to analyse word writing or handwriting patterns. For example, Lee et al. (2022) trained six machine learning models – Naive Bayes (NB), support vector machine (SVM), K-nearest neighbour (KNN), Decision Tree (DT), artificial neural network (ANN), and logistic regression (LR) – to detect human-coded errors of written characters from Chinese children with and without dyslexia. Results demonstrated that these algorithms can sufficiently distinguish Chinese children with dyslexia from their neurotypical peers, with SVM achieving 80% accuracy using only the most predictive features (i.e. stroke, grade, lexicality, and character configuration) (Lee et al, 2022). Liu et al. (2024) have extended this previous work by developing an automated Dyslexia Dictation Detection system that analyses handwriting images of 100,000 Chinese characters from 483 children with dyslexia and 568 neurotypical peers in Grades 2-6. The best performing model achieved 85% accuracy based on handwriting features and grade (Liu

et al., 2024). Given the commonality and simplicity of handwriting tasks, these findings indicate the potential for real-time AI prediction of children at risk for dyslexia using handwriting features.

An additional AI trend combines machine learning with multimodal learning devices to detect and support children with dyslexia. Meena et al. (2023), for example, have developed a multimodal Hindi language eye-gaze-assisted learning system based on a virtual keyboard that uses an eye tracker to detect typing errors and provide feedback. Their validation experiment involving 16 children with and without dyslexia showed that the machine learning model, trained with the typing speed from the virtual keyboard, can classify children with dyslexia with high accuracy (Meena et al., 2023). Thus, the virtual keyboard with eye tracker is a promising dyslexia detection tool that allows for dynamic interaction and immediate feedback. Nevertheless, relying solely on typing speed may not comprehensively capture multiple manifestations of dyslexia. Therefore, combining a multimodal machine learning system with other assessment tools (e.g. cognitive and linguistic assessments) is necessary to enhance the accuracy and effectiveness of dyslexia detection.

In addition to AI, the use of smart mobile applications (apps) can offer a cost-effective and potentially efficient means for screening and treating children with dyslexia. In recent years, this intervention has surged. The Dyslexia Quest app. for instance, developed at the Bristol Dyslexia Centre and the Belgrave School in Bristol, United Kingdom of Great Britain and Northern Ireland, engages children in fun, game-like assessments of six cognitive-linguistic ability domains: working memory, phonological awareness, processing speed, visual and auditory sequential memory, and visual memory (Carbol, 2014). A systematic review by Politi-Georgousi and Drigas (2020) found that between 2012 and 2019, 26 studies were published on the development of smart mobile app. for dyslexia, with 12 focused on screening and 14 aimed at intervention. These app. have been created in various countries (e.g. Brazil, Ecuador, Greece, Malaysia, Mexico, Spain, and Sri Lanka) and across multiple languages, highlighting their growing popularity. However, the majority of these app. focus solely on reading- or writing-related problems and are designed for single-language use, with some tested and validated only on a small sample size. Thus, further work is needed to make these app. more accessible and available in multiple languages, and to ensure that they are effective for a larger sample.

In conjunction with the rapid development of digital or computer-based screening is an increase in online game-based training programmes. In particular, the Nessy Learning programme and Wordshark, both developed with specialist teachers at the Bristol Dyslexia Centre, engage children through fun, animated activities that teach them systematic synthetic phonetics and word reading and spelling, while enabling teachers to create individualized single-word English reading and spelling lists for children at different performance levels. A case study on the use of these two programmes with four elementary school-aged children (9- to 11-year-olds) with comorbid dyslexia and attention deficit hyperactivity disorder (ADHD) in Singapore showed positive behavioural changes, including sustained attention and increased engagement and motivation, though no significant improvement on English word reading and spelling was observed after 40 hours of training (Tan & Chua, 2012).

Yet another emerging approach combines natural language processing (NLP) with virtual reality (VR) games to create an immersive and stimulating screening experience (ElSayed et al., 2023). ElSayed and colleagues (2023) have proposed a tool that would embed cognitive-linguistic assessments of phonological awareness skills, working memory, and sight word reading to screen Arabic-speaking pre-schoolers at risk for dyslexia. NLP and speech recognition would be employed to analyse and identify patterns specific to these children. While this approach may likely create a more engaging and interactive screening process, its usability and validity have yet to be tested on children with and without dyslexia. Moreover, augmented reality (AR) and VR technologies, combined with AI-based analysis, can create immersive learning environments that make abstract concepts more concrete for learners with dyslexia (Wang al., 2021; Zingoni et al., 2021).

Finally, various assistive technologies, such as text-to-speech, aid individuals with dyslexia by converting written text into audio for easier comprehension (Dawson et al., 2018; Draffan et al., 2007; Smith & Hattingh, 2020). This feature is commonly found in electronic tablets and smartphones, as well as on specific software such as Natural Reader and Kurzweil 3000 (Dawson et al., 2018; Fitria, 2022; Lerga et al., 2021). By allowing individuals with dyslexia to listen to written content, text-to-speech technology facilitates comprehension by reducing the cognitive load associated with reading (Dawson et al., 2018). However, a potential drawback of this tool is its ability to deter individuals from learning to read orthographically.

The use of AI and educational technologies to assist in the detection of and remediation for dyslexia (and other 'reading difficulties') is *the* current transformative approach to a more effective and personalized solution for identifying and treating dyslexia. Relying on a synergy between machine learning algorithms and digital cognitive-linguistic assessments, this approach will almost certainly engender a more accommodating, inclusive, and personalized learning environment for children with dyslexia.

Synthesis of research findings

Based on a systematic analysis of existing research on academic barriers encountered by children with dyslexia, several key findings have emerged. First, it is crucial to differentiate dyslexia, as a specific neurobiological disorder, from general reading difficulties, which often include acquired deficiencies. Thus, children with dyslexia struggle to attain age-appropriate reading and writing skills, not, as in the case of many general reading difficulties, due to inadequate language input or lack of appropriate guidance or teaching (Lyon et al., 2003; Tunmer & Greaney, 2009), but because of inherent brain differences or neurobiological conditions (for a review, see Shaywitz & Shaywitz, 2005). Second, the academic challenges experienced by children with dyslexia not only impact their educational performance, but exert adverse effects on their mental well-being, leading to issues such as low self-esteem, anxiety, and depression (e.g. Bazen et al., 2022; Livingston et al., 2018; for a meta-analysis, see Francis et al., 2019). These academic challenges, it must be stated, do not result solely because of dyslexia per se, but also from the fact that 1) structural inequality is evident in traditional educational systems, whereby students who are not neurotypical are considered disadvantaged, and 2) teachers often lack the necessary training to meet the unique learning needs of children with dyslexia (for a review, see Nevill & Forsey, 2023). Thirdly, early detection and intervention of dyslexia (i.e. prior to age 6) are also lacking, resulting in negative consequences regarding academic progress and mental health (Nevill & Forsey, 2023). Therefore, improved strategies to identify and support children with dyslexia at an early age are increasingly in demand.

Fortunately, the advancement of AI and educational technology has led to the development of AI-powered tools and mobile app. that offer promising solutions for dyslexia diagnosis and intervention. These tools leverage gamification techniques to engage students in multisensory learning experiences that provide immediate feedback and tangible rewards (for a review, see Politi-Georgousi & Drigas, 2020). Specifically, for pre-school children (5-years-old and under) at risk for dyslexia, computer-based early screening has focused mainly on phonological skills and visual and cognitive processing, with differences in performance level identified between children with and without risk for dyslexia (e.g. Gaggi et al., 2017; Rauschenberger et al., 2019; Van den Audenaeren et al., 2013). Advancements in earlier work on education technology in dyslexia screening have provided technology-assisted intervention with promising, though limited, results, mostly demonstrated by improved visual, cognitive and literacy skills of participating 5- to 7-year-old children (e.g. Romero et al., 2023). However, given that the implementation of these technologies has been small-scale and regionally based, the incorporation of machine learning algorithms and cognitive-linguistic assessments may provide the added benefit of enhancing the accuracy and customization of these tools to cater to individual learning needs (e.g. Dawson et al., 2018; Smith & Hattingh, 2020).

Despite the potential benefits of these assistive technologies, several critical issues have been identified. First, the majority of these technologies have been tested mostly in controlled environments using limited sample sizes of pre-school children at risk for, or school-age children diagnosed with, dyslexia. It is therefore essential to conduct large-scale, longitudinal evaluations, preferably in actual educational settings, to ensure the clinical robustness and scalability of these technologies. Second, as most existing technologies are tailored to specific languages and cultures, the need exists to evaluate their relative effectiveness across diverse linguistic and cultural contexts. Easy customization is required to not only meet the specific needs and practices of individuals across linguistic contexts, but to also prioritize and ensure their unique cultural well-being. Third, it is important to recognize that these tools are designed to assist, not replace, human-delivered diagnosis and intervention (Dawson et al., 2018). Even with rigorously trained and tested computational models, human expert intervention remains essential to ensure that all content is appropriate for children with dyslexia. Thus, these assistive technologies should be viewed as supplementary tools that enhance the capabilities of human clinical and educational experts.

Insights for policy and practice

AI is rapidly transforming the educational landscape, offering a promising potential for personalized, adaptive, and accessible learning methods tailored to meet the specific needs of children with special educational needs, including those struggling with dyslexia (for a review, see Barua et al., 2022). Governments worldwide must therefore urgently translate their goal commitments into actions by updating their national educational strategies and policies (Garner, 2021; Johnston & Scanlon, 2021). One effective way to achieve this is to harness AI's potential to foster early detection and intervention in children at risk for dyslexia.

The educational transformations propelled by AI are ineluctable (Williamson & Eynon, 2020; Yang et al., 2021). Sooner or later, most, if not all, nations will want to replace traditional twentieth century modes of acquiring and assessing knowledge with the cutting-edge innovations and ideas that AI and other digital technologies can offer. The concomitant impacts on economic and societal developments are also projected to prove significantly beneficial. Any novel innovation takes time to be accepted and incorporated into the existing system (e.g. Iyer et al., 2024; Ward, 2013). However, AI is advancing faster than expected and is already reshaping the educational landscape. For students with dyslexia, AI is exceptionally promising and may be the key that enhances their quality of learning (Garg & Sharma, 2020; Hopcan et al., 2022). Therefore, the sooner AI is harnessed to complement existing diagnostic assessments and intervention tools, the sooner it can begin to positively reshape the learning trajectory of individuals with dyslexia.

The following key issues related to the global learning challenges of dyslexia need to be addressed.

Key issue 1. Most current governments and policy-makers are focused primarily on deficit-based diagnosis and intervention of dyslexia (e.g. Rappolt-Schlichtmann et al., 2018; Sanfilipp. et al., 2020). This is influenced by an adherence to the biomedical model that considers dyslexia as 'an individual deficit resulting from neurological dysfunction' (Nevill & Forsey, 2023, p. 2). In contrast, the social model views dyslexia as 'a neurological variation' underserved by educational and economic systems (Nevill & Forsey, 2023, p. 2). In other words, learning challenges are attributed less to the individual's neurobiological condition and more to a lack of proper societal and economic support for their unique educational needs (Macdonald & Deacon, 2019). In fact, understanding diverse experiences among learners, which would include those with dyslexia, represents a global paradigm shift towards defining learning as a convergence of various biological, social contextual, and environmental influences, which has been endorsed by UNESCO (Duraiappah, et al., 2022), as a means to transforming learning and education for the twenty-first century.

The emergent response is to recognize, and certainly not dismiss, dyslexia's neurological roots (i.e. deficits), while placing greater focus on the societal and economic barriers that impede individuals with dyslexia from not only reaching their full potential but exhibiting possible neurodiverse talents (i.e. strengths). The idea is that adopting only a traditional deficit-based approach to dyslexia overemphasizes the negative consequences and deficiencies of these individuals, while neglecting the very real possibility that they may possess underutilized potentials and strengths (Rappolt-Schlichtmann et al., 2018) or cognitive and linguistic processes different to what is considered the norm in the world around them (e.g. Zhou et al., 2024). One example from recent research demonstrates that children with dyslexia can achieve comparable levels of performance as their neurotypical peers when provided with increased exposure to learning materials (He & Tong, 2017). Furthermore, unlike their neurotypical peers who consistently utilize working memory to recognize familiar items (i.e. exploitation strategy), children with dyslexia allocate working memory resources to both familiar and unfamiliar items (i.e. exploration strategy) (Zhou et al., 2024). With respect to these differences within a rapidly developing technological world characterized by advanced AI tools, national and local governments can consider shifting dyslexia diagnosis and intervention from biological deficit-based approaches to an integrated strengths-deficits-based approach that recognizes individual differences in learning while fostering an educational climate centred on neurodiversity, inclusion, and equity.

Key issue 2. Early and precise screening, as well as timely prevention and intervention, for children at risk for dyslexia, continue to pose significant and unresolved challenges in numerous countries. The prevailing practice of screening for dyslexia at 6 years of age or older neglects the evidence that neurocognitive-linguistic indicators of dyslexia can be identified even before children learn to read (i.e. under 6 years of age) (Gabrieli, 2009; Sanfilipp. et al., 2020). Moreover, the prolonged and slow process of human-delivered screening and diagnosis leads to further delays, with an average of four years

from suspecting to confirming a diagnosis of dyslexia (Earey, 2013; Mattson & Roll-Pettersson, 2007; Riddick 2010). This issue of timely diagnosis and intervention is significantly heightened for bi- and multilingual children as current diagnostic tools are often based on a single language, thus overlooking their multiple language learning reality and diverse learning contexts and needs.

However, the emergence of AI-driven tools has the potential to transform the early detection of dyslexia by offering more accessible and affordable methods of diagnostic precision and efficiency. Given that school-based implementation of AI-powered diagnosis and intervention relies on expertise from learning scientists, computer scientists, and educational practitioners, governments and policy-makers can consider establishing an interdisciplinary expert advisory board to gradually transition their educational intervention policies from costly traditional human-delivery methods to more cost-effective AI-driven approaches (Holmes & Luckin, 2016). AI and education technology are likely to yield long-term societal and economic benefits for both schools and families, particularly those of low socioeconomic backgrounds.

Key issue 3. The absence of teacher training that includes a mandatory understanding of neurobiological, cognitive and behavioural aspects of dyslexia remains a prominent issue in many countries (Knight, 2018; Nevill & Forsey, 2023). As Nevill and Forsey (2023) highlighted, one negative school experience often reported by students with dyslexia is feeling stressed and anxious due to their teachers' lack of knowledge about their condition. Despite extensive research on, and the growing number of children at risk for, dyslexia, many teachers remain unaware of such key issues as the potential strengths and weaknesses of individuals with dyslexia, the unique academic challenges they face, and the availability of assistive technology to improve their educational experience (e.g. Smith & Hattingh, 2020; Worthy et al., 2016). Therefore, teacher education should incorporate an understanding of dyslexia as a neurological variation and recognize that difficulties faced by individuals with dyslexia are also linked to systematic factors, including educational, but also societal and economic, barriers.

Key issue 4. An insufficient amount of interdisciplinary research is involved in designing and developing intelligent diagnostic and intervention tools for dyslexia. While cognitive-linguistic measures and machine learning algorithms have shown potential for classifying and predicting dyslexia (Lee et al., 2022; Liu et al., 2024), application in the real-world is limited. This is due in part to the lack of mechanisms and incentives that encourage collaborative knowledge production and policy formulation among learning scientists, policy-makers, and clinical and educational practitioners. A further need exists to enhance communication and collaboration among computer scientists, engineers, researchers, teachers, and individuals with dyslexia to accelerate a deeper understanding of dyslexia and the advancement of technological tools that promote a more inclusive and supportive learning environment for these students.

The educational barriers encountered by children with dyslexia demand urgent attention. Emerging AI technologies offer an unprecedented opportunity to tackle these barriers by rapidly transforming standardized teaching methods into personalized, adaptive learning approaches that cater to the specific needs of these students. With diverse stakeholders recognizing the need for change, government guidance is essential to prioritize and drive this rapidly increasing innovation.

To support this transformative process, the following evidence-based insights are proposed:

Insight 1. National and local governments should consider prioritizing early detection of children at risk for dyslexia so as to at least mitigate potential future reading failure. Once reading difficulties are evident, it is already too late to prevent potential failures (Reynolds & Shaywitz, 2009). Thus, proper resources must be allocated to conduct mandatory screening for dyslexia during pre-school years (i.e. before children learn to read).

Insight 2. National and local governments should consider implementing personalized intervention and instruction for students with dyslexia. Reading is culturally and cognitively dependent, and no single reading intervention approach can help all students across all cultures and developmental skill levels (e.g. Guise et al., 2016; Kourea et al., 2017; Pfost et al., 2014; Tong et al., 2023). Therefore, every student should receive the individual support they need to succeed regardless of cultural background or initial skill set.

Insight 3. National and local governments should consider collaborating with AI experts and experts in the science of learning to establish educational guidelines for implementing early screening to identify the distinct needs of children at risk for dyslexia. Ideally, a strengths-deficits-based approach should be advocated so that children with dyslexia are not stigmatized as incapable of learning but are instead recognized as having a neurodivergent condition that requires a modified approach to optimize their

potential. In this regard, teacher training on dyslexia will be key (Badjanova & Ilisko, 2015).

Insight 4. National and local governments should consider collaborating with experts and researchers in the science of learning to redefine dyslexia by shifting the focus from reading outcomes to learning processes and strategies.

Developing a more comprehensive understanding of learning strategies of children with dyslexia requires a research paradigm shift from a group-difference-based performance method (children with dyslexia versus neurotypical peers) to a more fine-grained approach that analyses multiple factors contributing to learning, such as the familiarity and difficulty of learning items.

Conclusion

Labelling children with dyslexia as simply having deficits in reading or learning fails to comprehensively reflect their unique abilities and characteristics and does not elucidate the specific learning needs they require (Tamboer et al., 2016; Zhou et al., 2024). Thus, policy-makers, families, schools, and other stakeholders should recognize the discrepancy between children with dyslexia and their neurotypical peers as a *difference in learning processes and strategies*, rather than viewing children with dyslexia as atypical learners. By understanding and addressing these differences in processing and strategy use, educational systems worldwide can better tailor intervention and support for students with dyslexia.

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