Pediatric ophthalmology and childhood reading difficulties

Overview of reading development and assessments for the pediatric ophthalmologist

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Reading difficulties are common in the pediatric population. According to the 2015 National Assessment of Education Progress, only 46% of white children achieved expected reading proficiency by the end of fourth grade.[1] An even poorer performance was found among minority students, with only 21% of Hispanic and 18% of African American students reading at grade level. In addition to racial disparities, significant socioeconomic disparities exist. Of children who did not qualify for a subsidized school lunch (an indicator of poverty), 52% achieved reading proficiency at the 4th grade level, whereas only 21% of students qualifying for free or reduced cost lunch achieved the same metric.

In order to read well, children need to see clearly and have the neurocognitive skills to process what is seen.[2] Because some vision problems can interfere with the process of reading, it has been recommended that children with a suspected learning disability undergo a comprehensive eye examination to detect treatable vision problems.[3] There is a significant body of literature related to reading difficulties and vision problems, and whereas the vast majority of reading disorders are not directly related to vision, it is anticipated that pediatric eye care providers will continue to evaluate many children with reading difficulties.[4-7] We present an overview of the process of learning to read and the most widely used reading assessments for preschool and school-age children.

Understanding Reading

Reading is a multifaceted and complex skill. McCardle and colleagues[8] define skilled reading as "the ability to derive meaning from text accurately and efficiently." The National Reading Panel[9] identified five main components of reading instruction: phonemic awareness, phonics, fluency, vocabulary, and comprehension. *Phonemic awareness* is the ability to discriminate and manipulate individual phonemes (or sounds) in spoken words and is related to speaking and listening.[10] Although it does not require printed material, it is highly correlated with later reading skills and is considered necessary for learning to read. *Phonics* is the knowledge of the relationships between letters and sounds. This skill allows students to decode written text into spoken words.[11] *Fluency* describes how well a child is able to produce oral language from written text.[12] It includes speed, accuracy, and expression used when reading aloud. Without mastering fluency, children are not able to advance on to higher levels of reading.[13] *Vocabulary* refers to the words known by a child. A strong vocabulary assists with decoding, fluency, and comprehension; a limited vocabulary hampers a child's ability to read. *Comprehension* describes the ultimate goal of reading, which is generating meaning from a text.[14] Together, development of these five component skills leads to children becoming expert readers.

Although each component is necessary for skilled reading, they are taught and assessed at different time points as children are learning to read. Phonemic awareness is the first skill and is assessed in young children, beginning in preschool and continuing until first grade. Phonics is assessed during the first years of formal schooling (grades kindergarten [K]-2). Fluency is assessed starting in first grade and continuing each year, as students develop skills of decoding and word recognition. It is used throughout elementary grades as a quick and reliable indicator of reading progress. Vocabulary is assessed throughout reading development. Comprehension assessment generally occurs later in the development of reading skills when students are able to read simple text for meaning. As students develop more expert reading skills, comprehension becomes the main component assessed. For students with reading difficulties, all areas should be tested in order to identify weaknesses and plan an appropriate instructional intervention.

Reading Development

Reading is taught in the early years of elementary school education. Students who experience difficulty reading are

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Table 1. Reading development by age[a]

	Emergent reader	Early reader	Transitional readers	Self-extending readers
Approximate age range	2-7 years	5-7 years	5-7 years	6-9 years
Approximate grade	Preschool to early 1	K-1	K-2	Grades 1-3
Description	Beginning to make links between oral and written language but obtains most information from pictures	Reads familiar texts with fluency and relies less on pictures for information	Reads most texts with fluency and reads longer more complex text	Reads a wide range of texts independently for meaning and problem solving

K, kindergarten.
[a]Adapted from Fountas and Pinnell[19] and US Department of Education Reading Milestones.[20]

at risk for difficulty with academic achievement.[15] In fact, achieving reading proficiency on the Woodcock Johnson reading battery by the end of second grade accurately predicts later reading ability.[16,17] Other longitudinal studies have reported that early reading proficiency is related to better midlife wellbeing and less alcohol use.[18] Table 1 outlines four broad capabilities that may be distinguished.[19,20]

Effects of Socioeconomic Status on Reading Development

Reading subskills develop at different rates in children.[20] There is substantial evidence that reading development varies with socioeconomic status (SES) and early childhood exposure to literacy. Liu and colleagues[21] created a statistical model of children's reading development and found that those children with higher SES were more likely to move into a higher reading ability group. Bhattacharya and colleagues[22] found that for American children from lower SES, less home literacy exposure was associated with slower reading development. However, in households where reading was encouraged as part of the family routine (such as reading charts or recipes together), children tended to exhibit age-expected reading ability. Conradi and colleagues[23] investigated the variance of specific reading subskills in children of lower SES and found that fluency was associated most with silent reading comprehension, and semantic knowledge was most associated with oral reading comprehension. Since these are skills that can be improved with practice and feedback from an adult, the work of Bhattacharya[22] and Conradi and colleagues[23] supports the importance of positive and plentiful in-home literacy experiences in reading development, especially in lower SES families.

Reading in preterm children develops differently and often more slowly. A meta-analysis by Kovachy and colleagues[24] reported that preterm children (≤32 weeks' gestational age) perform significantly worse than those born at term in reading ability, particularly in the subskills of decoding (phonics) and comprehension, and this deficit was independent of SES, intellectual disability and major disability. They also found that preterm children did not "catch up" to their peers, with an increasing disparity in reading comprehension with increasing age.

Reading Assessments

There are four different types of reading assessments performed to monitor reading development: screening, diagnostic, progress monitoring, and outcomes. Depending on age and indication, these assessments can be used for different purposes and measure a variety of reading subskills or focus on a single skill. For example, the Woodcock-Johnson Diagnostic Reading Battery includes subtests in phonemic awareness, phonics, fluency, vocabulary, and comprehension.[25] The commonly used reading assessments are described in the Appendix.

Screening assessments are used to identify students at risk of reading failure and provide appropriate intervention. Screening assessments tend to be short and simple to administer because they are given to all students and usually do not assess all components of reading. As an example, the Dynamic Indicators of Basic Early Literacy (DIBELS), which takes approximately one minute to administer, is frequently given to all children in early primary grades (K-2) to quickly identify students who are at risk of not reaching grade level expectations.[26]

Diagnostic measures are used to examine specific strengths and weaknesses of those students identified as at risk of reading. One such assessment is the Early Reading Diagnostic Assessment (ERDA).[45] The ERDA takes 45-60 minutes to administer and includes multiple subtests. This length of testing is common with diagnostic assessments because they should probe the full range of reading skills to identify skills the student needs to achieve proficiency.

Progress monitoring is an ongoing assessment to track whether a student is making expected improvement over time and allows teachers to adapt instruction accordingly. Although progress monitoring should occur with all learners, students reading below grade level should undergo more frequent assessments. A common example of progress monitoring uses the Benchmark Assessment System (BAS), which has students read a text (or portion of a text) out loud to assess fluency, then have a conversation with the assessor about the text to assess comprehension.[29] The BAS can be used to identify a reading level and can be given multiple times a year to track whether a student is making adequate progress.

Outcomes assessments refer to summative measures administered to all students that typically only occur once a year.

These may include high-stakes tests, such as the standardized tests associated with publicly reported school accountability and ratings. Two commonly used outcomes assessments are Partnership for Assessment of Readiness for College and Careers (PARCC) and the Smarter Balanced tests, both based on the Common Core State Standards.[39,49]

Reading and the Hyperopia Connection

There is consensus that undiagnosed or untreated vision problems contribute to reading difficulty, although the extent to which treatment will improve reading performance is not well established. A 2011 joint report from the American Academy of Ophthalmology, the American Association for Pediatric Ophthalmology and Strabismus, and the American Association of Certified Orthoptists states that significant hyperopic and astigmatic refractive errors make reading more difficult, while convergence insufficiency and poor accommodation can interfere with the physical act of reading.[3]

Although much of the early work on vision and reading has focused on children with dyslexia or other learning disorders, recent work has begun to investigate the effect of uncorrected hyperopia on reading development in children without underlying learning orders. The Vision in Preschoolers–Hyperopia in Preschools study group found that uncorrected hyperopia is associated with significantly worse performance on a test of early literacy in preschoolers.[50] In a pilot study of 321 early elementary school students, the Baltimore Reading and Eye Disease Study showed that students with uncorrected hyperopia did not perform as well on baseline reading assessments as their emmetropic counterparts (Collins ME, et al. J AAPOS 2016;20:e29 Abstract 107).

As research continues to evolve in this area, the pediatric eye care provider will be called on to weigh additional scientific evidence and work closely with parents, pediatricians, school nurses, and teachers to educate them about current evaluation techniques of the visual system and to discuss treatment recommendations for children with reading difficulty.

Conclusions

Learning to read is a complex and dynamic process. Significant racial and socioeconomic disparities exist in learning to read, although some of this may be overcome with increased exposure to reading in the early years of a child's development. Underlying medical issues and a history of preterm birth can place children at risk for poor reading achievement. Poor vision may also interfere with the process of learning to read. Although the majority of reading problems, especially those related to dyslexia and learning disabilities, are not caused by vision problems, a vision assessment is recommended for poor readers with suspected vision issues.[3] Pediatric eye care providers are an integral part of the multidisciplinary team to provide those baseline evaluation and management recommendations.

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Reading difficulties and the pediatric ophthalmologist

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Reading

Reading is the complex process of extracting meaning from written symbolic characters. Learning to read in English is particularly challenging because of the large number of irregular words, and most of kindergarten through 3rd grade is dedicated to learning this difficult task. Reading requires adequate vision and memory, ability to sound out and recognize words, vocabulary, knowledge of word and language structures, ability to name objects rapidly, and capacity to sustain attention. Good oral language skills have been shown to be the foundation for reading. Reading to young children is one of the best ways to develop their vocabulary, language, and background knowledge. Although speaking is an innate process, reading is not. There is no single location in the brain that serves as a "reading center;" rather, existing brain areas that serve oral language and object recognition must adapt to facilitate reading.[1]

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The Phonological Model of Reading

The most accepted model for development of reading ability is based on phonology. Phonemes are the smallest units of sound used to form words. They are coarticulated at 8-10 phonemes per second, with individual sounds

Appendix. Commonly used reading assessments in the United States

Test	Components: phonemic awareness (PA), phonics (P), fluency (F), vocabulary (V) and comprehension (C)					Grade/age range	Use: screening (S), diagnostic (D), progress monitoring (PM) and outcomes (O)				Administration setting: group (G) or individual (I)	Duration, minutes	Context
	PA	P	F	V	C		S	D	PM	O			
DIBELS[26]	X	X	X	X	X	K-6	X	X	X		I	1	Paper
CTOPP-2[27]	X					4-24y	X	X	X		I	30	Paper
WRMT-III[28]	X	X	X	X	X	K-12	X		X	X	I	15-45	Paper
WJIII DRB[25]	X	X	X	X	X	>90y	X	X	X		I	50-60	Paper
BAS[29]			X		X	K-8	X	X	X	X	I	20-40	Paper
DRA-2[30]			X		X	K-8		X	X	X	I	10-20	Paper
PPVT[31]				X		>2.5y	X		X	X	I	10-15	Paper or Computer
AIMSweb[32]			X		X	K-8	X		X		I or G	1-3	Paper
i-Ready[33]	X	X		X	X	K-12		X	X		G	35-60	Computer
MAP[34]		X			X	K-12	X	X	X		G	30-45	Computer
Observation Survey of Early Literacy Assessment[35]	X	X	X	X	X	K-3	X	X	X		I	45	Paper
Predictive Assessment of Reading[36]	X	X		X		PreK-3	X		X		I	15	Paper
GRADE[37]	X	X		X	X	PreK-12					G	50-90	Paper
SRI[38]	X	X			X	K-12	X		X		G	30	Computer
PARCC Tests[39]				X	X	3-12				X	G	255-310	Computer
GMRT[40]	X	X		X	X	K-12	X	X	X	X	G	55	Paper
GORT-4[41]			X		X	6-23y		X		X	I	15-45	Paper
PALS[42,43]	X	X	X		X	K-3	X	X	X		I	25	Paper
DAR[44]	X	X	X	X	X	5-24y		X			I	40	Paper
ERDA[45]	X	X	X	X	X	K-3		X			I	45-60	Paper
QRI[46]			X		X	K-12		X			I	45-60	Paper
TOWRE[47]		X	X			6-24y	X	X			I	5-10	Paper
Yopp-Singer Test of Segmentation[48]	X					K-1	X				I	5-10	Paper
Smarter Balanced Tests[49]				X	X	3rd-12th				X	G	210-240	Computer

BAS, Benchmark Assessment System; *CTOPP-2*, Comprehensive Test of Phonological Processing – Second Edition; *DAR*, Diagnostic Assessments of Reading; *DIBELS*, Dynamic Indicators of Basic Early Literacy; *DRA-2*, Developmental Reading Assessment 2; *ERDA*, Early Reading Diagnostic Assessment; *GORT-4*, Gray Oral Reading Test; *GMRT*, Gates-MacGinitie Reading Tests; *GRADE*, Group Reading Assessment and Diagnostic Evaluation; *MAP*, Measures of Academic Progress; *PALS*, Phonological Awareness Literacy Screening; *PARCC*, Partnership for Assessment of Readiness for College and Careers Tests; *PPVT*, Peabody Picture Vocabulary Test; *QRI*, Qualitative Reading Inventory; *SRI*, Scholastic Reading Inventory College & Career; *TOWRE*, Test of Word Reading Efficiency *WJIII DRB*, Woodcock-Johnson Diagnostic Reading Battery; *WRMT-III*, Woodcock Reading Mastery Tests.