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Amblyopia and slow reading

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Reading promotes imagination and learning, is fundamental to academic achievement, and relies on a complex interplay of visual and motor capabilities. Loss of the ability to read affects virtually all aspects of modern life, from school, to leisure, to the very activities of daily living. For optimal reading, text must be sequentially fixated by the fovea using coordinated, high-velocity, short-duration saccades. About 85% of eye movements during reading are *forward* saccades, with amplitudes of about 2°, or 8 letters of average-sized print text.¹ *Regressive*, or backward, saccades (15% of eye movements during reading) are used to recheck words, provide a second chance for decoding and comprehension, and move to the beginning of the next line of text.² Visual perception is suppressed during saccades, so word recognition and phoneme decoding occur during the *fixational pauses* that occur between saccades; these pauses constitute 90% of reading time.^{1,3}

Using natural, binocular silent reading of age-appropriate paragraphs of text, we recently reported that children with amblyopia read slowly compared with controls and nonamblyopic strabismic children, regardless of amblyopia type (ie, strabismic or anisometropic).⁴ Unlike earlier reading studies that focused on strabismus,^{5–8} our study clearly identified that amblyopia alone is sufficient to impair reading. Importantly, comprehension did not differ significantly between amblyopic children and controls, indicating that amblyopic children did not read slowly because they had dyslexia or a learning disability.

Dyslexia is a receptive language-based learning disability in which there is a deficit in the phonologic component of language that results in difficulties with decoding, fluent word recognition, rapid automatic naming, and/or reading-comprehension skills.⁹ The increased duration of *fixational pauses* and increased number of *regressive* saccades that characterize dyslexic readers are direct results of decoding and comprehension difficulties rather than a primary abnormality of oculomotor control systems. Unlike dyslexic readers, amblyopic children in our study read more slowly because they made more *forward* saccades during reading. It is likely that the increased number of forward saccades during reading reflects oculomotor control system deficits. Amblyopia is associated with substantial fixation instability.^{10–12} Fixation instability has been implicated in slower reading in normally-sighted¹³ and visually impaired adults with macular disease, albinism, or glaucoma.^{14,15}

More recently, we reported that fixation instability, and an increased number of forward saccades was associated with slower reading in children with anisometropic amblyopia (Kelly, et al. J AAPOS 2017;21:e10 Abstract 024). Unstable fixation may make it difficult to plan and/or execute accurate forward saccades during reading. Additionally, similar to small central scotomas in macular disease, monofixation in amblyopia may reduce the visual span, resulting in poor saccadic accuracy and increased number of saccades during binocular reading.^{16–18}

When a reader moves fixation forward to a new word, the preferred “landing position” is the center of the new word; other landing positions result in the word being processed more slowly and make it more likely that the word will be refixated with a corrective saccade.^{19–21} In a visuomotor task requiring a saccade to a target dot prior to reaching and touching that dot, amblyopic adults exhibit greater variability in saccade amplitude and a higher frequency of corrective saccades compared with visually normal adults.^{22,23} In addition, amblyopic adults lack the binocular advantage for saccade initiation that is present in visually normal adults who initiate saccades about 10% faster when viewing binocularly compared to viewing monocularly. Taken together, slower saccade initiation, saccade amplitude variability, and increased frequency of secondary saccades can be expected to significantly slow reading speed in amblyopic children.

Saccadic eye movements clearly play a key role in efficient reading, a key component of academic achievement. There is a solid evidence base demonstrating slower initiation of saccades and more variable saccade amplitudes in amblyopic individuals.^{22,23} Even though it usually results in poor vision in just one eye, amblyopia can reduce reading speed in natural, binocular reading by 20%–50% and negatively affect academic performance. We have also found that amblyopic children are slower at transferring answers from a standardized test to a Scantron answer sheet compared with visually normal controls (Birch et al. J AAPOS 2015;19:e10 Abstract 006). Longer Scantron completion times may exacerbate the problem of slow reading when amblyopic children are administered standardized tests that are time-sensitive, limiting the child’s academic success. The child’s academic achievement, in turn, is a major contributor to the child’s developing self-perception,^{24,25} which has been shown to be affected by amblyopia.²⁶ Positive self-perception has an important influence on well-being and quality of life.²⁷

In the United States, the Individuals with Disabilities Education Act (IDEA; Public Law No. 94–142) ensures visually impaired students are provided with Free Appropriate Public Education (FAPE) that is tailored to their individual needs, affording the same opportunity for education as normally-sighted students. However, the definition of visual impairment at both the federal and state level is having 20/40 or worse vision *in the better-seeing eye*, even with eyeglasses (see, for example, definitions provided by the US National Eye Institute https://nei.nih.gov/eyedata/vision_impaired and the US Centers for Disease Control and Prevention <https://www.cdc.gov/healthcommunication/toolstemplates/entertainment/tips/blindness.html>). This definition excludes children with amblyopia, because they have 20/20 vision when viewing with both eyes. As a result, amblyopic children are not considered for accommodations and modifications for their slow reading speed. Section §504 of the US Rehabilitation Act of 1973 (an antidiscrimination, civil rights statute) requires schools to

accommodate children's disabilities if the student has a disability that is substantially limiting, affects a major life activity, and affects the student's education. Reading is now a major life activity that the US Congress added to the list in the Americans with Disabilities Act Amendments Act of 2008 (ADAAA) and the education code of most US states now requires schools to evaluate reading progress in kindergarten and grade 1 and, if needed, to implement a reading program that appropriately addresses students' reading difficulties. Unfortunately, this legislation is employed to identify accommodations for blindness or bilateral visual impairment (large print or Braille), or for determining eligibility for specialized reading instruction for dyslexia. Reading speed is rarely tested as an indicator of impaired reading, so amblyopic children with normal vision in one eye and no comprehension difficulties are left without the accommodations they need to set a fair playing field in school.

Reading is fundamental to cognitive development and academic achievement.²⁸ Slow reading can be detrimental to academic performance and learning, not to mention the accompanying social stigma and esteem issues. Since amblyopia is the most common cause of monocular visual impairment in children, affecting 2%–4% of children or about one in every classroom, it is imperative to understand how amblyopic children are affected academically. While currently there is no evidence that training eye movements will help amblyopic children read faster, parents and educators can work together to implement accommodations (eg, extra time) to help amblyopic students succeed in their daily school tasks, and improve their performance on the timed, standardized tests that are critical for promotion and admission to magnet schools, TAG programs, high schools, and colleges. Children with other visual disorders that cause visual impairment in one eye (eg, glaucoma, cataract, trauma, etc) should also be considered for academic accommodations.

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