



The Science of Reading Begins with Vision

Learning to read, and acquiring comprehension, require well-tuned visual systems. An educator may struggle to teach reading fundamentals to a child who suffers from untreated (and often undiagnosed) limitations of visual performance.

Babies are not born with the ability to perform complex eye movements. Most newborns have rudimentary vision skills including tracking (visually following objects in space), convergence (moving the eyes inward together), and divergence (moving the eyes outward together). Most infants can attain fixation of the two eyes that enables rudimentary binocular depth perception (reaching out to touch a nearby object) within six months.

By age 2, a child usually exhibits a useful degree of eye movement control (e.g., enough spatial recognition to allow the child to attain sufficient depth perception to recognize and put different shaped blocks into appropriate holes); still, precise eye movement skills (oculomotor) and binocular depth perception is continuing to develop through age 5 or 6, about the time children are learning to read. When oculomotor and focusing development is delayed or stalled, children suffer decoding challenges and find it nearly impossible to draw meaning from the letters and words in written form; as words get smaller and closer together, the accuracy of eye movements can deteriorate further. Although some educators report that excessive fidgeting or covering an eye can be an indication of visual system problems, most often vision-related problems are not apparent and have no outward signs. Rarely is the child aware of their own underperforming visual system making self-reporting of such issues highly unlikely.

Additionally, reading and decoding requires precise focus or “accommodation.” For this to happen efficiently the ciliary muscle inside each eye at the base of the iris (colored part of the eye) must contract precisely and remain contracted for extended periods of time to maintain the proper intraocular lens configuration matched to the child’s reading distance. Children having trouble performing this function can experience symptoms of blur, headache, tiredness, and discomfort when trying to read.

When a child with oculomotor deficiencies attempts to read, instead of building upon a functional visual system that supports development of efficient reading skills, the seemingly simple, yet complex act of changing the focal point to different words across the page can elicit conflicting sensory information. This is due to the connection between the visual system and the vestibular (semi-circular canals in the inner ear) which sends signals via the nervous system to the eye muscles through an automatic function known as the vestibulo-ocular reflex (VOR). The VOR maintains balance and controls eye positions (through innervation to six different eye muscles in each eye) while the head moves so that the gaze remains stable.

When the head rotates, the eyes rotate at the same speed but in the opposite direction. This allows the gaze to be stabilized during rotation so that the image being looked at remains on the center of the visual axis. When eye focus and movements are not exact and equally balanced, the brain receives conflicting information that disengages decoding and disables cognition.

These vision difficulties might persist throughout life if not discovered early. For example, ‘convergence insufficiency’—difficulty in keeping the two eyes aligned with one another—a condition a vision screening is not designed to identify – can result in the child intermittently seeing double, experiencing eye fatigue and/or avoiding close-up visual tasks, such as reading.

The complexity of reading and subsequent comprehension of the information to be processed cannot be overstated. Ironically, many children with oculomotor and focusing issues may still have “20/20” vision when tested on an eye chart at 20 feet. Consequently, they may do well in the initial stages of their reading development (phonics, fluency and vocabulary) because they can see and recognize letters and combinations of letters. But in later stages, they will be unsuccessful at extracting meaning (comprehension) from their reading material. Children must be able to decipher and recognize words on the page, and they need to be able to make meaning of the words that they read.ⁱ It is at this crucial second stage, “reading to learn,” that children with untreated or undiagnosed vision problems truly suffer.

Children and educators are held back by preventive approaches that do not address the eye and vision health of children before teaching them to read. Two out of every five children taught reading have undiagnosed visual system disorders that slow or prevent decoding and cognition. While a need to build foundational skills that underlie oral reading fluency has been identified, there is also a complementary need to identify and treat all vision disorders as early as possible to allow for normal eye movement development.^{ii iii}

Even if some children with vision system problems eventually learn to read slowly, they do so with reduced psychomotor speed and are not able to retain information, because strain on cognition impairs short- and long-term memory. Without “recognition memory” of visual objects and spatial information, decoding is impossible. These children might not socially thrive or achieve executive function of high-level thinking and decision making.^{iv} These children might also be misidentified as having attention-deficit hyperactivity disorder (ADHD) and/or the need for an Individualized Education Plan (IEP) when their only problem is the need for glasses or other treatments to their visual system.^v

Often the educator and the parents are misled by their reliance on a vision screening which does not evaluate any of the visual system concerns causing reading difficulties.

As U.S. schools reach the end of a severely disrupted 2020-21 academic year, administrators and teachers will need to address students' learning loss after months of remote schooling. Plans for recovery should include fully addressing children’s visual systems.^{vi} This examination should be performed by an eye doctor (doctor of optometry/optometrist) by age 3 to 5 and then annually, to help get reading right.^{vii}

ⁱ <https://www.edweek.org/teaching-learning/how-do-kids-learn-to-read-what-the-science-says/2019/10>

ⁱⁱ <https://nces.ed.gov/nationsreportcard/studies/orf/>

ⁱⁱⁱ <https://www.aoa.org/AOA/Documents/Practice%20Management/Clinical%20Guidelines/EBO%20Guidelines/Comprehensive%20Pediatric%20Eye%20and%20Vision%20Exam.pdf>

^{iv} <https://www.cambridgecognition.com/blog/entry/what-is-cognition>

^v DeCarlo DK, ADHD and Vision Problems in the National Survey of Children's Health. *Optom Vis Sci.* 2016 May;93(5):459-65.

^{vi} <https://www.aoa.org/news/clinical-eye-care/public-health/childrens-vision-summit-recap>

^{vii} <https://www.aoa.org/AOA/Documents/About%20the%20AOA/Get%20Involved/AOA%20Pediatric%20Guidelines%20for%20GPs%20and%20FPs%202.19.21%5B1%5D.pdf>