Problems with the Human “Letter Box”: A Component of Dyslexia

Oct 6, 2015 by Martha Burns, Ph.D

Key Points:

- The human brain is not “wired” for reading.
- Children need to perceive speech sounds and letters quickly and accurately as a precursor for reading.
- In the occipital lobe, there is a “letter box”—the visual word form area of the brain.
- Recent research indicates that dyslexics have trouble with both hearing the sounds within words & recognizing letters.
- For many with dyslexia, the “letter box” part of the brain is not responding the way it does in typical readers.

How much of dyslexia is visual vs. auditory?

The human brain is designed to naturally acquire many skills. As all parents know well, most children easily learn to walk and talk without any special instruction. But what many of us don’t realize is that the human brain was not designed to read. Anthropologists say that Homo sapiens has been on earth for 200,000 years but the alphabet is only 4,000 years old. Even after human written language appeared, very few adults could read or write. In fact, it wasn't until 1917 that all states in the U.S. had compulsory education laws.

Stanislas Dehaene, one of the foremost experts involved in research on reading and math in the brain, has noted that in order to read, we have to recruit brain architecture that was designed for other purposes. We can think about this as a kind of neurological recycling – using brain circuits specifically adapted over centuries for one purpose, like communication, to become part of newer circuits, like those needed for reading. Fortunately, the language and visual object recognition networks of the brain mature in early pre-school years, and then multitask in a way to reconfigure for reading.

To understand this brain recycling process, it is helpful to remind ourselves of what underlying capacities are needed for reading. With an alphabetic language like English, reading requires that we integrate the speech sounds of our language, the phonemes, with the letters, graphemes. This “sound-letter (or phoneme-grapheme) correspondence” necessitates two capacities - the ability to perceive speech sounds quickly and accurately as well as the ability to perceive letters quickly and accurately. It is the latter skill that Dr. Dehaene discusses in a journal article entitled “Inside the Letter Box”.

According to Dr. Dehaene, the visual word form area of the brain, a region at the base of the the visual part of the brain (the occipital lobe) in the left hemisphere, is the brain's "letter box". It is called the "letter box" because it shows stronger activation to written words than to other kinds of visual stimuli (like faces or places). And, for all of us who can read, it is located in the same spot, very specifically housed between the areas of the occipital lobe that are activated when we see pictured objects and faces. Dehaene and others have noted that if the "letter box" is damaged or disconnected from other brain regions by a stroke or other form of localized brain injury, the individual often loses the capacity to read.

Interestingly, Dr. Dehaene states that the "letter box" doesn't just enable us to recognize words. It has other highly sophisticated capabilities that are essential for fluent reading. For example, it lights up first when a person is asked to determine whether the words written as "READ" and "read", are the same words. Although to most readers of the this blog, that seems like a simple task, uppercase and lowercase letters such as "A" and "a" or "R" and "r" or even "D" and "d" are actually not at all alike in shape or configuration. We have to learn to "see" them as the same letter even though they are very different shapes. That doesn't happen with other visual objects – we don't ever see a circle and triangle as the same shapes or our husband's and brother-in-law's faces as indistinguishable. So letters are unique in that way – in fact, not only are upper and lower case letters identified as equivalent, we also read script letters, from many different handwriting styles as the same.

A logical question raised then, when trying to understand children with dyslexia, is whether the visual word form area is functioning the same way when children struggle to learn to read or to read fluently. Former blog posts have discussed how most children diagnosed with dyslexia show problems with the ability to perceive speech sounds, the other half of the "sound to letter" correspondence capacity. But are there also problems with identification of letters visually? Dr. Dehaene research suggests the answer is 'yes'.

Recent brain imaging research reported in the journal *Neuroimage* by Dr. Dehaene, and his colleagues confirmed that good readers do, in fact, show a well-developed visual word form area (the letter box). Dyslexics, on the other hand, showed no such specialization for written words. So, not only do children who struggle to read have problems perceiving the sounds within words, they also appear to have trouble recognizing letters – at least the "letter box" part of the brain is not responding the way it does in typical readers. It is interesting that the first efforts to treat dyslexia in the 1950's and 60's actually focused on the importance of letter recognition. But early researchers may have misunderstood what was happening. Some early dyslexia researchers thought that children with reading problems were reading words and letters backwards. Dehaene has shown, though, that all young readers have a tendency to confuse letter orientation. Children have to learn that a **d**and a **b** are not the same even though they have a line and a circle at the bottom. Children also have to learn that a word is not an object, and that the internal detail of a word is as important as the outline. **House** and **Horse** look a lot alike at first glance, but the difference in the third letter makes a huge different in pronunciation and meaning. It takes time for children to figure this out – but it does not mean they have dyslexia. And research in the last few decades has emphasized that many children who do have dyslexia have marked problems with auditory perceptual, phonological awareness and language components of reading. So, it now appears that both sides of the reading equation – auditory/linguistic and visual are important.

This new research points to the importance of reading interventions that improve all components of reading disorders: auditory perception, phonological awareness, language skills and visual letter recognition. It also points to the importance of interventions that have evidence-based data revealing the underlying brain structural changes that coincide with the intervention components. Neuroscience-designed interventions like Fast ForWord that have research with dyslexic children and adults employing brain imaging technology are helpful because they indicate when brain area activation increases and the correlation to standardized reading test improvements. Such a study, performed by Elise Temple and her colleagues using fMRI actually showed that with children who were diagnosed with dyslexia, the Fast ForWord Language program actually increased activation in language areas as well as the visual word form area.

Reading is a relatively new skill for the human brain, but underlying language areas and visual perceptual skills that have strong neurological underpinnings are recruited to make that wonderful capacity of understanding the written word possible. However, in some children and adults diagnosed with dyslexia, decreased activation of certain brain areas seems to be a factor in the problems those individuals have learning to read. Fortunately, brain science is not only helping us understand these important brain regions, it is also providing research to show how specific targeted interventions, like Fast ForWord, not only improve reading skills but activate those very areas that appear essential to successful reading achievement.

Suggested readings

Dehaene, S. (2013) Inside the Letterbox: How Literacy Transforms the Human Brain. *Cerebrum.* May-June:7. Published online 2013 Jun 3.

Monzalvo, Fluss, Billard, Dahaene, & Dehaene-Lambertz, (2012). Cortical networks for vision and language in dyslexic and normal children of variable socio-economic status. *Neuroimage,* 61 (2012) 258-274

Temple, E., Deutsch, G. K., Poldrack, R. A., Miller, S.L., Tallal, P., Merzenich, M. M., & Gabrieli, J. D. E. (2003). Neural deficits in children with dyslexia ameliorated by behavioral remediation: Evidence from functional MRI. Proceedings of the National Academy of Sciences, 100(5), 2860-2865.