Dyslexia and the Brain: Research Shows that Reading Ability Can be Improved

Insights for parents, teachers, and educators from research by Dr. Elise Temple, Assistant Professor in the Department of Education, Dartmouth College and former faculty member in the Department of Human Development, Cornell University.

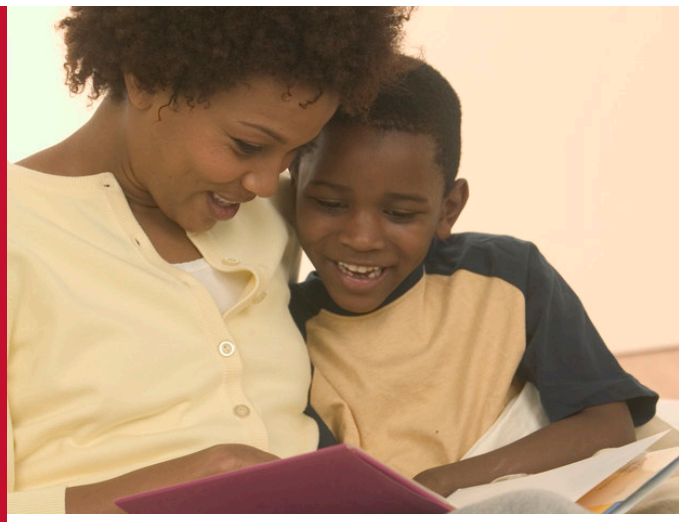
Kimberly Kopko, Ph.D., Extension Associate

Elise Temple's research findings dispel the false belief that children who experience developmental dyslexia are simply "not motivated" or not "trying hard enough." Dyslexic children are not lazy or unintelligent. Their brains simply work differently when it comes to processing information, and, as Temple's research demonstrates, there is something that can be done to change that.

Temple explores the mechanisms of the brain underlying reading and language. Specifically, her studies seek to uncover and explain how these brain mechanisms develop as children age, gain educational experience, and become literate. One focus of Temple's research is developmental dyslexia, which is defined as a specific disability in reading in children who have intelligence, motivation and the appropriate level of education necessary to read successfully. Developmental dyslexia differs from acquired dyslexia, which usually occurs as a result of trauma or brain injury after the individual has already learned to read successfully and without difficulty. Below are a few key points from Temple's research on developmental dyslexia.

Developmental Dyslexia is Biological—It's in the Brain!

A number of different methods used by researchers suggest a neurobiological basis for developmental dyslexia. The primary cause, however, remains unidentified. Developmental dyslexia affects between 5% and 17% of the population, representing a very large number of children. Although dyslexia is biological, reading can be improved with specific kinds of instruction and practice.



"Developmental dyslexia affects between 5% and 17% of the population, representing a very large number of children."

While biology is implicated in developmental dyslexia, it is important to understand that other risk factors account for difficulty in reading that are not biological. These factors include the type of literacy environment in the home, and economic and social factors, which studies show have an important influence on children's reading

skills and abilities. The biological basis for developmental dyslexia is considered when a reading deficit still exists after these other factors have been considered and ruled out.

Inadequate Awareness and Processing of Sounds Characterize Developmental Dyslexia

Many researchers believe that developmental dyslexia is characterized by difficulties in phonological processing, specifically phonological awareness which is the ability to identify and manipulate the sound structure of words. In order to listen to and understand speech, an individual must be able to identify, or be aware of individual sounds, called phonemes, that make up words. Phonological processing is the ability to recognize phonemes and subsequently identify their combination into specific words. One myth surrounding dyslexia is that children "flip letters" or "read backwards." What actually occurs is that children with phonological processing deficits do not map letters onto the correct sounds. Proper understanding of phonological processing has been shown to be a core deficit in children with developmental dyslexia. Individuals with dyslexia also have difficulty distinguishing rhyming sounds, counting the syllables of words, and sounding out novel words such as "stroat" or "traim." Phonological awareness and processing can be improved with targeted practice.

In addition to a deficit in phonological processing, researchers have discovered that children with dyslexia also experience a deficit in auditory processing. Auditory processing is a term that describes the process of how the brain recognizes and interprets sounds in the environment. A deficit in auditory processing simply means that something is affecting how sounds are processed or interpreted. Individuals with dyslexia have difficulty processing auditory sounds that are entering the nervous system at rapid speeds (10's of milliseconds). This deficit in processing rapid auditory stimuli is thought to impact language and subsequently reading. The idea behind the rapid auditory processing hypothesis of developmental dyslexia is that without this ability to detect rapid auditory signals the child is unable to distinguish certain phonemes and, as a result, develops an inadequate or "fuzzy" understanding of the phonology or sounds of his/her language. This inadequate understanding of the sounds of the words in the language is especially problematic when the child learns to read and is required to map letters onto their appropriate sounds.

The Brain is Plastic: Behavioral Interventions Can Change Brain Function

Temple's pioneering study on developmental dyslexia shows changes in brain function after behavioral training in 8-12-year-old children with developmental dyslexia. This study was the first to use fMRI—functional magnetic resonance imaging—which allows researchers to see the ways in which the brain functions. The training consisted of a research-based intervention, Fast ForWord Language, which is a computer-based program that focuses on oral language and auditory processing. After training, the children with dyslexia improved in both their reading skills and language ability with the dyslexic children showing changes in both left- and right-brain function.

Regarding left-brain changes, dyslexic children showed an increase in left-brain activity after training. Prior to the intervention, this brain region was underactive in children with developmental dyslexia compared to normally reading children. The increase in brain function had a normalizing effect, resulting in brain function of dyslexic children that more closely approximated the brain function of normal-reading children. However, the increased level of activity did not reach the same levels that normal-reading children show in this region.

Increased right side brain activity of dyslexic children was also observed in regions not normally involved in phonological processing. These regions on the right side of the brain are mirror images of the normal areas in the left side of the brain responsible for processing language. This increase of activity may reflect a compensation effect such that the right side of the brain becomes involved to "compensate" for the left side. Before the intervention, the dyslexic children showed no evidence of brain activity specific to this task in these regions.

Brain plasticity—the ability of the brain to adapt and reorganize neural pathways as a result of new experiences or learning— continues throughout life. The brain continues to adapt and form new pathways or alter existing pathways well into adulthood. This is particularly encouraging news considering that reading deficits of children with developmental dyslexia persist into adolescence and adulthood. Given what researchers know about brain plasticity, children, adolescents and even adults may benefit from a behavioral intervention program.

Temple points out that from an evolutionary perspective, the ability to read is a fairly recent adaptation for humans. We are designed to learn language, which is perhaps one reason why we see fewer children

experiencing difficulty in learning to speak as opposed to learning to read. As Temple notes, reading is a complex process that involves multiple brain systems. Whenever a process requires multiple systems to work together, so, too, exist multiple opportunities for problems to present themselves.

Behavioral Intervention Programs

Temple is quick to explain that the use of the computer-based Fast ForWord Language training program used in her research is not an endorsement of this particular intervention. She notes that researchers may select a particular intervention for a number of reasons, including the fit of the intervention with the design of the research study. She points out that a separate group of researchers used a different intervention which required one-on-one tutoring with dyslexic children for one year. Both studies showed an increase in brain function. There is a clear need for a scientific review, examination, and evaluation of research-based intervention programs for developmental dyslexia. Until this type of rigorous evaluation is undertaken, no specific program can be recommended.

Summary

The implications of Temple's research provide an optimistic outlook for children with developmental dyslexia, as well as their parents and teachers. Specifically, her study shows that:

- It is possible to study the effects of training on the brains of children with dyslexia. Although the technique of functional magnetic resonance imaging (fMRI) has been utilized in research on adult brains, Temple has successfully adapted the technique for use with young children.
- A specific remediation program, Fast ForWord Language, resulted in changes in brain function in children with dyslexia while improving their reading ability. This finding opens up the possibility for future research that explores different interventions and educational strategies.
- Brain dysfunction in dyslexia can be improved.

Further Resources

Fast ForWord Language: http://www.scilearn.com

Developmental Reading Disorder: http://www.nlm.nih.gov/medlineplus/ency/article/001406.htm

Put Reading First: Helping Your Child Learn to Read (publication from the National Reading Panel designed for parents of young children): http://www.nationalreadingpanel.org/Publications/helpingread.htm

Put Reading First: The Research Building Blocks for Teaching Children to Read (publication from the National Reading Panel designed for teachers): http://www.nationalreadingpanel.org/Publications/researchread.htm

National Institute of Neurological Disorders and Stroke (NINDS) Dyslexia Information Page (with links to additional organizations): http://www.ninds.nih.gov/disorders/dyslexia/dyslexia.htm

National Center for Learning Disabilities—Dyslexia: http://www.ncld.org/content/view/454/391/

References

Segelken, R. (2006, November). Further adventures of the incredible plastic brain. *Human Ecology, 34*(2), 16-19, from http://www.human.cornell.edu/Outreach-extension/loader.cfm?csModule=security/getfiles&PageID=60757

Temple, E., Deutsch, G.K., Poldrack, R.A., Miller, S.L., Tallal, P., Merzenich, M.M., & Gabrieli, J.D. (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, from http://www.pnas.org/cgi/doi/10.1073/pnas.0030098100

Temple, E., Poldrack. R.A., Salidis, J., Deutsch, G.K., Tallal, P., Merzenich, M.M. & Gabrieli, J.D. (2001). Disrupted neural responses to phonological and orthographic processing in dyslexic children: an fMRI study. *NeuroReport, 12,* 299-307.

Development of this publication was supported by Smith Lever funds from the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture. Any opinions, findings, conclusions, or recommendations expressed here are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.