

## **Are There Subtypes of Developmental Dyslexia?**

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The possible existence of dyslexic subtypes has intrigued researchers and practitioners for nearly a century. If dyslexic children have different kinds of underlying cognitive or neural information processing deficits, this has implications for identification, diagnosis and educational intervention. Scientists now have the tools to address this issue from genetic, cognitive-behavioral and neurological perspectives. This should lead to a convergence of findings and a clearer picture of dyslexia.

Genetic studies of dyslexia have focused on whether particular kinds of reading deficits are inherited, and on the identification of genes for dyslexia. Twin and family studies have shown that the classic dyslexic problems with phonological awareness and sounding out words appear to have a strong genetic basis, whereas there is less of a genetic effect on sight word learning. Molecular genetic studies of families with dyslexia have identified several candidate genes, most notably on chromosome 6 and chromosome 15. Chromosome 6 may be associated with phonological skill and chromosome 15 more broadly with word recognition skill. The genes in question don't appear to work in an all or nothing fashion, and they don't appear to be specialized "dyslexia" genes, but rather genes that determine reading skill in the population at large. The implication is that dyslexia is a matter of degree and that the severity and possibly the type of reading difficulty can depend on both genetic and environmental factors.

Cognitive processes are a second active area of investigation. Three different subtyping frameworks are being explored. First, the reading subtype approach identifies different profiles of reading and spelling difficulty in dyslexic children. Phonological dyslexics have problems storing and utilizing phonological information in memory and hence in sounding out unfamiliar words. Surface dyslexics have relatively normal phonological skills, but difficulty learning to recognize the spelling patterns in printed words quickly and automatically. Mixed dyslexics have both types of problems and hence a more severe reading difficulty. Second, the double deficit framework focuses on variation in two primary areas, phonological awareness and rapid automatic naming of symbols (such as digits and letters). Severe dyslexics tend to have both of these problems, but children can be found with one or the other deficit. A deficit in rapid naming may underlie problems in achieving fluency in reading. In a third approach, scientists have reported that many dyslexics have difficulty detecting flickering or moving visual stimuli, and may have reduced visual sensitivity. These studies have identified potential sources of variation in dyslexics. Scientists need to study dyslexic children simultaneously using tests of reading, phonological processing, and visual sensitivity to determine which children have which combination of deficits, and how the deficits specifically affect reading performance.

Many studies are underway focusing on the neurological bases of dyslexia. What is known from Positron Emission Tomography (PET) and Functional Magnetic Resonance Imaging (fMRI) imaging studies is that some of the key cognitive deficits in dyslexia (such as phonological awareness and sounding out words) correspond to reduced brain activity. Reduced brain activity occurs particularly in the rear left hemisphere regions of the brain associated with phonological processing and naming

of visual objects, such as letters, pictures and words. However, brain activation studies have not yet focused on subtypes. In addition, it has not been determined whether reduced brain activity is an effect of poor reading and of attempts to compensate for reading problems, or if it results from structural differences in dyslexics' brains or in the connectivity between different regions of the brain. Studies now underway will explore these issues, including a joint study of brain imaging and reading at USC and UCLA directed by myself, in collaboration with Dr. Susan Bookheimer and other colleagues.

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