What Brain Imaging Can Tell Us About Developmental Disorders

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Why do some children have difficulty learning to read or to develop social skills? Today, it is universally accepted among scientists that differences in how the brain functions are the root cause of common behavioral and learning problems like dyslexia and autism/Asperger's Disorder. Yet it has only been in the past 10 years that researchers have had the tools needed to explore how the brain works in children. In 1992, researchers discovered that Magnetic Resonance Imaging (MRI) could be adapted to show not just brain *structure* — what the brain looks like — but also brain *function* — how the brain works. In this new technique, called functional MRI or fMRI, the patient or research subject performs a task of interest, like reading or looking at facial expressions, while their brain is being scanned. Areas of the brain that are necessary for that task have to work harder; more blood flows to those areas, and the MRI scans are sensitive to this increased blood flow. Because MRI is completely safe and non-invasive, even young children can have fMRI scans.

Although fMRI is still young, it has already taught us quite a lot about how the brain learns to read and what goes wrong in dyslexia, and is starting to yield new information about autism. Using fMRI, we can now "see" which areas of the brain are working and how they communicate with each other when a child is reading words. Comparing these scans to those of children with dyslexia trying to read can teach us which areas of the brain do not work properly or are not communicating with the rest of the brain normally.

Several laboratories, such as at the Yale Child Studies Center and at our lab at UCLA, have examined the brain pathways involved in reading and the impairment in dyslexia. When children are first learning to read, their job is to learn to associate letters with sounds, and to combine and sequence these sounds quickly until they recognize them as a familiar word. FMRI studies have shown that developing these skills uses a pathway that begins in the visual cortex where children recognize the letters, and transfers this information to the superior (top) temporal lobe. The temporal lobe is responsible for hearing sounds and, in the left side of the brain, translating sounds into words. This information is then sent to the frontal lobes where combinations of sounds are put into a sequence and read aloud. Together, the pathway from the visual cortex to the temporal and frontal lobes is called the "phonological route." In adults and children who have become good readers, a second pathway in the brain appears to dominate. This pathway also starts in the visual cortex, but instead heads to the inferior (bottom) temporal lobe. The inferior temporal lobe is important for recognizing objects. In the experienced reader, this area of the brain effectively sees the word as an object, instantly recognizing it and its meaning, without the need to sound it out. This pathway is known as the "visual route", and only becomes involved in reading after much experience and practice. Because not all words can be instantly recognized (for instance, less common or very long words) the brain must always use both pathways to some extent.

FMRI research in children with dyslexia has shown that the phonological route is not normally functioning in the large majority of children with dyslexia. Because the visual route only develops with reading experience, it too is rarely active in children with dyslexia. Thus, fMRI studies show reduced activity in the two left hemisphere pathways that are necessary for reading. Dyslexic children tend to show more activity in the right hemisphere, and more activity in the frontal lobe, probably as a form of compensation.

Researchers have examined the effects of intensive intervention on the brain pathways involved in reading in dyslexia using fMRI. Before treatment, the dyslexic children prefer the right brain, normal children the left brain, when sounding out words or listening to speech. After treatment, both groups found increased activity in the left brain pathways involved in reading, especially the phonological pathway. Dyslexics also showed increased activity in the right brain after treatment, suggesting that the right brain may play a role in compensation when the left brain cannot support reading fully. Currently, our group at UCLA, along with Dr. Frank Manis at USC, is studying sub-types of dyslexia using fMRI. At least three sub-types of dyslexia have been identified, and it is quite likely that different brain regions are affected in these subtypes. Hopefully, by learning more about brain function in each group we can suggest different approaches to treatment depending upon the specific brain pathway underlying each sub-type.

In autism, far less is known about the underlying brain mechanisms, but several groups are working hard to learn more about this challenging problem. Our group, as well as centers at Yale University and University of Pittsburgh, have focused on understanding the basis of social communication and emotion. One area that has been studied extensively involves learning how the brains of children with autism respond to human faces. In typically developing children, even in infants, the brain has a strong affinity for the human face, and we have a special brain region devoted to recognizing faces. In addition, emotion centers of the brain are tightly connected to the face areas, responding very quickly to emotional expressions, especially those involved in fear and surprise. Because children with autism have difficulty interpreting emotional expressions, this has been a keen area of interest in fMRI research.

Several fMRI studies have found abnormal activity in both the emotion and the face areas in children with autism. Most (but not all) studies find that children with autism have reduced activity in the face area of the brain; rather than showing a clear specializing for faces in comparison to objects, the brains of children with autism appear not to differentiate between faces and objects. Other studies show that children with autism use their left brain to process faces, while most typically developing children use their right brain more. This is significant because the left brain tends to see the details of objects and faces rather than the "whole," and reliance on the left hemisphere may make it less likely that children will see the "big picture" or the significance of a face and what it is conveying, focusing instead on small and perhaps irrelevant details. A second common finding is that the emotion center (the amygdala) appears less responsive to faces in children with autism, Other areas under study include the interpretation of emotion in autism, and processing emotional intonations in language.

By analyzing patterns of brain activity, researchers can learn more about the root causes of developmental disorders and about individual differences or sub-types of these disorders. While we clearly have much to learn about brain function in autism, dyslexia and other developmental differences, it is very exciting to know we now have tools to help us study how the brain is working in these children. Ultimately, we may be able to see how interventions affect brain function and hopefully, help us to design interventions that affect the core symptoms of the disorders. UCLA will continue to work closely with the HELP group to make the latest research opportunities and knowledge available to our children.

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