FACT SHEET

2006

NEUROBIOLOGICAL BASIS OF LEARNING DISABILITIES

Learning disabilities (LD) are neurobiological in nature. How do we know this? Over the last decade, compelling scientific evidence from genetic research and studies of the brain has clearly demonstrated the neurobiological basis of learning disabilities (LD).

Early Brain Development

Compared to other organs, the human brain develops over a long period of time - beginning in the first weeks after conception with most of the basic brain structure laid down before birth. Fetal brain development is complex; cells grow, multiply, migrate, and establish interconnections and a communication system.

Cells in the early stage reproduce at an astonishing rate of 250,000 a minute. The human brain has approximately 100 billion neurons and one trillion glial cells (supporting cells). The cells assemble themselves in a series of tightly choreographed steps, with clockwork precision. The cells migrate to distant locations. "Wiring" the brain involves trillions of connections between neurons linking one part of the brain to another. These connections control various functions from speech, memory, attention, processing, etc. Therefore, deviations in these connections can result in LD.

There is a brain growth spurt from the third trimester of pregnancy which continues over a prolonged period of time, and the first three years of brain development are critical.

Research shows that brain development continues during the early years, some systems maturing at puberty and beyond.

The brain, central nervous system and other organs are most susceptible to damage at conception and during fetal development because it is a time of rapid growth.

The developing human brain is much more vulnerable to toxic insult than the mature brain in most cases, and this insult will not only affect those processes undergoing development, but some processes programmed to come after.

Toxins/Contaminants

Normal brain development can be disrupted by a wide variety of factors. There is a growing body of research on the association between prenatal exposure to environment contaminants and negative effects on the brain development including: prenatal factors; toxic and teratogenic agents; poor nutrition; very low birth weight; gestational age; oxygen deprivation; early oxygen dependence; neonatal seizures; hemorrhages; resistance to thyroid hormones; PCBs and other dioxins; pesticides use; alcohol, cigarettes, marijuana, and cocaine; lead and cadmium; and iron and chloride deficiencies. As a result, early development in the child as well as later cognitive and behavioural development can be affected.

Research on the role of neurotoxicants as factors in developmental delays or disabilities is growing. As Yvonne Brackbill, a renowned researcher noted in 1987, "This field of science can help us resist the tendency to attribute all educational ills to social and home-environment antecedents." We must feed the brain and protect the brain in order to achieve full potential for our children.

Nutrition also plays a part in brain development. Studies of malnourished rats show reduced numbers of cells (neurons) at birth, as well as reductions in the numbers of cell types. Studies of children with iron deficiency provide evidence of important behavioural effects. Some of these negative effects on development, IQ and achievement test scores have been seen to persist into childhood, even after supplementation with iron.

Brain Structure

A variety of methods are now available to measure the physical structure as well as the function of the brain. Techniques include autopsy studies; neuro-imaging techniques include computed tomography (CT) scan, Magnetic resonance imaging (MRI), positron emission tomography (PET), regional cerebral blood flow (rCCBF) and single photon emission computed tomography (SPECT); electrophysiological measures include Electroencephalograms (EEC), event related potentials (ERP) and averaged evoked potentials (AEP); and neuropsycological assessments evaluate brain/behaviour relationships.

A number of studies of brain structure and function have been carried out on subjects with LD. Postmortem findings have indicated that the normal brain has asymmetries. For example, one side of the brain is not exactly the same as the other. These asymmetries are expected and considered normal (just as it is quite ordinary or typical for one foot to be longer than the other).

Studies have shown that brains of subjects with reading disabilities have no asymmetry in brain structures where there should be asymmetry, that is, there is an absence of ordinary asymmetry. For example, the temporal lobe in the left hemisphere has been found to be typically larger than the temporal lobe in the right hemisphere in subjects without LD (asymmetrical), whereas, this area in the left hemisphere has been found to be the same size as in the right hemisphere in subjects with LD.

Another technique for studying the brain is the CT scan (computed tomography. With this technique, a beam of x-rays is shot through the brain, identifying bone, grey matter, and fluid. A computer then reconstructs an image of each slice or brain section, allowing abnormalities in structure to be detected. CT scans have shown asymmetry in certain parts of the brain in subjects without LD and symmetry in subjects with LD.

MRI is a technique that involves picking up the electromagnetic energy of brain protons and constructing an image by superimposing magnetic fields. MRI research has shown that subjects without LD showed asymmetry in certain parts of the brain whereas subjects with LD did not show the expected asymmetry.

It has been demonstrated through autopsy, CT Scan, and MRI studies, that there are structural differences in the brains of subjects with LD in comparison to subjects without LD. It has also been demonstrated that there are differences in brain function in the subjects with LD, that is, how the brain works. Functional neuroimaging techniques, including PET, rCBF, fMRI and SPECT are used to measure brain activity while subjects are engaged in a task such as reading. An fMRI and rCBF are non-invasive methods that measures blood flow, while PET and SPECT methods involve the injection of radioactive materials. SPECT scan results have indicated that subjects with LD show under functioning in certain parts of the brain while reading, in comparison to subjects without LD.

EEGs, ERPs, and AEPs record electrical activity of the brain through electrodes. Research has shown that subjects with LD (dyslexia) showed less electrical activity in certain parts of the brain, in comparison to subjects without LD.