



## Brain Development

### *Recent Research Sheds Light On This Incredible Phenomenon*

**R**ecent research on the development of the brain suggests that stimulation infants and children receive plays a larger role than previously thought in the development of characteristics that define success and fulfillment.

In the extreme, these findings suggest brain development occurs through a sequence of critical periods, each offering a “window of opportunity” during which proper stimulation can support and enhance development, and lack of stimulation can result in the dulling of aspects important to learning, thinking, feeling, and loving.

Such claims hold great potential for shaping policies and programs for children. The benefits of early stimulation, for example, support the expansion of high quality early childhood development and education, an issue gaining recognition among educators and policymakers.

But it is important to understand the findings, their limitations, and some lingering questions.

This report is a summary of the basics of brain development. In a separate report, *Brain Development: The Role Experience Plays In Shaping Children*, **background** examines what new research demonstrates and the implications.

#### Fundamental Principles

Two fundamental principles are important to the understanding brain development.

1. Except for minor reflexes, essentially all human behavior – looking, listening, speaking, thinking, loving, worshipping, imagining, and socializing – is largely governed by the brain. Persistent changes in the behavior of an infant, child, or adult are accompanied by changes in the brain of that person, and finding such changes in the brain does not make the behaviors special.

Most of the recent research confirms the importance of good parenting and child care.

2. Recent research shows the terrible consequences of extremely poor and atypical stimulation and environments on the brain development. But research does not show that extreme stimulation or super rich environments produce a superior brain or child.

For example, abusive and neglectful treatment of infants and young children produce serious and sometimes permanent deficits in the brains and behavior of these children.

But bombarding infants and children with sights, sounds, language, flashcards, music, games, and other experi-

*For more on what is known about brain development and function see **background Report #11, Spring 1998***

ences does not produce a super child. In fact, too much stimulation that isn't developmentally appropriate may hinder infant development or turn off a child to learning.

#### Incredible Phenomenon

The neurological process of brain development is an incredible phenomenon.

The brain of every human, for example, has approximately one billion nerves, each formed between the sixth week and the fifth month of prenatal life. These nerves are wired in ways that enable us to learn, imagine, and love.

Research is beginning to reveal the secrets of how that takes place.

#### Neural Proliferation

First, it is important to understand that brain development occurs in overlapping stages.

The first stage is neural proliferation, during which those one billion nerve cells, called neurons, are created by the end of the fifth prenatal month.

Barring extremely unfavorable conditions, neurons are produced in every in-

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fant according to biological instructions.

### Neural Migration

The second stage, neural migration, is largely completed during prenatal life. By a process not yet fully understood, nerves literally grow and send long arms through the brain to different areas and make contact with one another.

This migration is like the laying of telephone "trunk lines" that allow calls to be made between cities but not to any specific phone.

### Synaptogenesis

During and after neural migration, neural synaptogenesis and differentiation occurs.

Synaptogenesis is the connecting of different nerve cells at places called synapses. These connections form a network of linkages. Using the telephone trunk line analogy, synaptogenesis allows for "calls" to be made to specific "phones."

As a result of these connections, neurons that start out essentially the same become differentiated to perform one function instead of another – hearing, for example, rather than seeing.

These activities do not occur simultaneously throughout the brain, so different functions develop at different times. In the region associated with hearing, the peak activity of such development occurs during the first postnatal months; in the region associated with vision, during the first 3-4 months of postnatal life; and in areas responsible for cognition and intelligence, 12 months through adolescence.

This sequencing is part of the basis for "developmentally appropriate practices," or providing stimulation and experiences for different skills and func-

tions at the appropriate times.

### Neural Overproduction

In the process of making all of these connections, the brain makes more connections than it needs.

An infant in the first few months of life, for example, is capable of distinguishing between every pair of sounds that occurs in any language in the world.

### Myelination

A late stage of brain development is myelination, the process by which nerve cells become coated with a layer of fatty cells (myelin) that insulates them and speeds neural conduction.

Myelination contributes speed and efficiency to the functioning of the brain.

### Selective Elimination

Most of brain growth is governed by biology. But experience, or stimulation, is needed. Experience enhances both connections between neurons and selective elimination and degeneration of connections, in what is sometimes called a "use or lose it" developmental process.

The connections in the brain that help the infant distinguish the sounds (phonemes) of various languages are used when an infant hears those sounds.

But if infants are not exposed to sounds unique to a specific language, those neural connections that distinguish them wither and die. For example, all infants are born with the ability to distinguish "r and "l" sounds. But within the first six months of life, infants in Japan can no longer distinguish between "r" and "l" sounds, because those sounds do not exist in the Japanese language.

This is one of the reasons parents are advised to talk to their infants, even if their infants cannot understand words.

Selective elimination may be the first, if not most crucial, component of the ability of human beings to adapt to their environments. It makes us exceedingly flexible.

The fact that nerve connections die if not used is often invoked as the basis for the claim that if certain capabilities not nurtured at particular times in early development, they are lost and cannot be developed later. This is only partly true.

Not every set of connections and every capability is permanently lost if not stimulated early. In fact, very few human functions are lost forever from lack of stimulation.

For most abilities, connections that once degenerated can be recreated when the environment changes.

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## references

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