Understanding Brain Development in Young Children

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This publication is intended to assist parents understand how a child's brain develops and their important role in interacting with children to support brain development.

A child's first words. Grasping a spoon. Babies turning their head in recognition of a mother's voice. What do these things have in common? All of them are examples of a young child's developmental "steps" forward.

Perhaps no aspect of child development is so miraculous and transformative as the development of a child's brain. Brain development allows a child to develop the abilities to crawl, speak, eat, laugh and walk. Healthy development of a child's brain is built on the small moments that parents and caregivers experience as they interact with a child.

Think of some recent memories when you have watched a baby or toddler.

• As a mother feeds her child, she gazes lovingly into his eyes.

• A father talks gently to his daughter as she snuggles on his lap and he reads her a book.

• A caregiver sings a child to sleep.

These everyday moments, these simple loving encounters, provide essential nourishment.

What Do We Know About Brain Development?

As scientists learn more about how the human brain develops, many of our ideas about the brain are being challenged. We are learning that some old ideas actually were myths that are being replaced with new facts and understanding. Consider the following examples:

Brain Development - Myth or Fact?

Myth At birth the brain is fully developed, just like one's heart or stomach.

Fact - Most of the brain's cells are formed before birth, but most of the connections among cells are made during infancy and early childhood.

Myth The brain's development depends entirely on the genes with which you are born.

Fact - Early experience and interaction with the environment are most critical in a child's brain development.

Myth A toddler's brain is less active than the brain of a college student.

Fact - A 3-year-old toddler's brain is twice as active as an adult's brain.

Myth Talking to a baby is not important because he or she can't understand what you are saying.

Fact - Talking to young children establishes foundations for learning language during early critical periods when learning is easiest for a child.

Myth Children need special help and specific educational toys to develop their brainpower.

Fact - What children need most is loving care and new experiences, not special attention or costly toys. Talking, singing, playing and reading are some of the key activities that build a child's brain.

How the Brain Develops

A number of factors influence early brain development. These important factors include genetics, food and nutrition, responsiveness of parents, daily experiences, physical activity and love. In particular, parents should be aware of the importance of furnishing a healthy and nutritious diet, giving love and nurturing, providing interesting and varied everyday experiences, and giving children positive and sensitive feedback.

In the past, some scientists thought the brain's development was determined genetically and brain growth followed a biologically predetermined path. Now we know that early experiences impact the development of the brain and influence the specific way in which the circuits (or pathways) of the brain become "wired." A baby's brain is a work in progress. The outside world shapes its development through experiences that a child's senses — vision, hearing, smell, touch and taste — absorb. For example:

• The scent of the mother's skin (smell)

• The father's voice (hearing)

• Seeing a face or brightly colored toy (vision)

• The feel of a hand gently caressing (touch)

• Drinking milk (taste)

Experiences that the five senses take in help build the connections that guide brain development. Early experiences have a decisive impact on the actual architecture of the brain.

Recent equipment and technological advances have allowed scientists to see the brain working. What scientists have found is that the brain continues to form after birth based on experiences. An infant's mind is primed for learning, but it needs early experiences to wire the neural circuits of the brain that facilitate learning.

Imagine that a child's brain is like a house that has just been built. The walls are up, the doors are hung. Then you go to the store and buy electrical wiring, switches, a fuse box and other electrical supplies. You bring these supplies to the new house and set them on the floor. Will they work? Probably not. You first must string the wiring and hook up all of the connections. This is quite similar to the way our brains are formed. We are born with as many nerve cells as stars in the Milky Way galaxy. But these cells have not yet established a pattern of wiring between them — they haven't made their connections.

What the brain has done is to lay out circuits that are its best guess about what is required for vision, language, etc. Now the sensory experiences must take this rough blueprint and progressively refine it.

Circuits are made into patterns that enable newborn infants to perceive their mother's touch, their father's voice and other aspects of their environment.

Normal sensory experiences direct brain cells to their location and reinforce the connections between brain cells. We are born with more than 100 billion brain cells or neurons; we will not grow more. That's about 10 times the number of stars in the entire Milky Way, and about 20 times the number of people on the planet.

Neurons are the functioning core of the brain. Each cell body is about one-hundredth the size of the period at the end of this sentence. A neuron has branches or *dendrites* emerging from the cell body. These dendrites pick up chemical signals across a *synapse* and the impulse travels the length of the axon. Each axon branch has a sac containing neurotransmitters at its tip. The electrical impulse causes the release of the neurotransmitters, which, in turn, stimulates or inhibits neighboring dendrites, like an on-off switch.

These connections are miracles of the human body. But to understand their power, you have to multiply this miracle by trillions. A single cell can connect with as many as 15,000 other cells.

This incredibly complex network of connections that results often is referred to as the brain's "circuitry" or "wiring." Experience shapes the way circuits are made in the brain.

A remarkable increase in synapses occurs during the first year of life. The brain develops a functional architecture through the development of these synapses or connections.

For example, if a parent repeatedly calls a child a certain name, then connections will form that allow the child to recognize that name over time as referring to him and he will learn to respond. From birth, the brain rapidly is creating these connections that form our habits, thoughts, consciousness, memories and mind.

By the time a child is 3 years old, a baby's brain has formed about 1,000 trillion connections — about twice as many as adults have. A baby's brain is superdense and will stay that way throughout the first decade of life. Beginning at about age 11, a child's brain gets rid of extra connections in a process calling "pruning," gradually making order out of a thick tangle of "wires."

The remaining "wiring" is more powerful and efficient. The increase in synaptic density in a child's brain can be seen in Figure 2. The interactions that parents assist with in a child's environment are what spur the growth and pattern of these connections in the brain.

As the synapses in a child's brain are strengthened through repeated experiences, connections and pathways are formed that structure the way a child learns. If a pathway is not used, it's eliminated based on the "use it or lose it" principle. Things you do a single time, either good or bad, are somewhat less likely to have an effect on brain development.

When a connection is used repeatedly in the early years, it becomes permanent. For example, when adults repeat words and phrases as they talk to babies, babies learn to understand speech and strengthen the language connections in the brain.

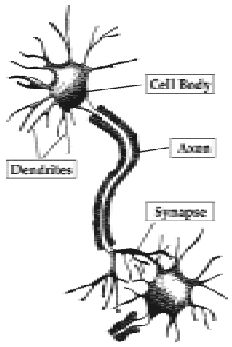

Figure 1. Neurons and connections

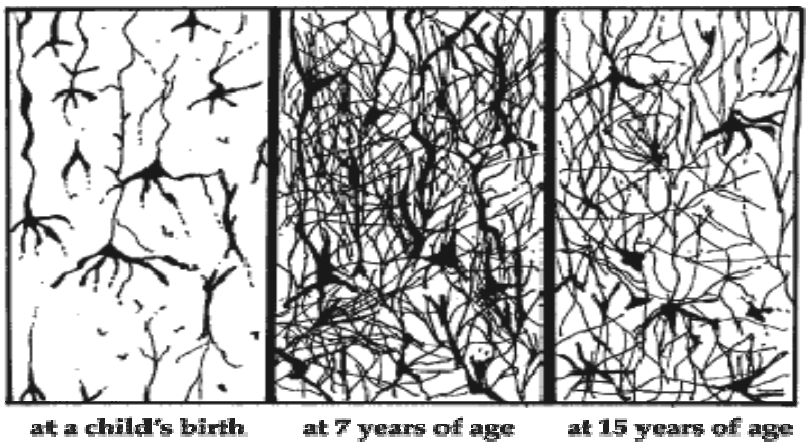

Figure 2. Synaptic density in the human brain

Construction of the Brain

We have explored how the brain develops at the cellular level with neurons and connections. Understanding the different parts of the brain as a whole and how it functions and develops also is useful.

The brain grows in sequential fashion, from bottom to top, or from the least complex part (brain stem) to the more complex area (cortex). If you draw a line from the forehead to the chin and open the brain for a side view, you would see the brain as it is shown in Figure 3.

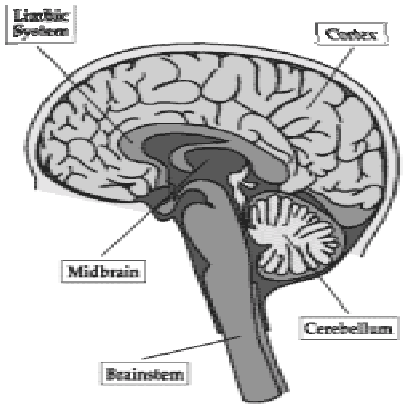

Figure 3.Brain: side view

The basic elements of the human brain include the following:

1. The **brainstem** is at the base of the skull and it controls most basic life activities, including blood pressure and body temperature.

2. The **midbrain** is at the top of the brainstem and it controls motor activity, appetite and sleep.

3. The **cerebellum** is behind the brainstem and it coordinates movement and balance.

4. The **limbic system** is in the central part of the brain and it controls emotions, attachment and memory.

5. The **cortex** is the top layer of the brain and is about the depth of two dimes placed on top of each other. The cortex is the "executive branch" of the brain that regulates decision-making and controls thinking, reasoning and language.

The cerebral cortex contains 80 percent of the neurons in the brain. Because it is the least developed part of the brain at birth and keeps developing until adolescence and even beyond, the cortex is more sensitive to experiences than other parts of the brain.

Construction of the brain is somewhat like the construction of a house. A house is built from the foundation up and different parts of the structure have different functions. Also, like the brain, once the architecture is in place, you can continue learning and "add on" or "decorate." But, if you have to move a wall or add a window, it is more difficult and expensive than if you had done it earlier in the building process.

Critical Periods of Brain Development

Brain development proceeds in waves, with different parts of the brain becoming active "construction sites" at different times. The brain's ability to respond to experience presents exciting opportunities for a child's development.

Learning continues throughout life. However, "prime times" or "windows of opportunity" exist when the brain is a kind of "supersponge," absorbing new information more easily than at other times and developing in major leaps. While this is true especially in the first three years of life, it continues throughout early childhood and adolescence. For example, young children learn the grammar and meaning of their native language with only simple exposure.

While learning later is possible, it usually is slower and more difficult. Some improvement in most skills is possible throughout life. However, providing children with the best opportunity for learning and growth during the periods when their minds are most ready to absorb new information is important.

Visual and auditory development

The "prime time" for visual and auditory development, or a child's capacity for learning to see and hear, is from birth to between 4 and 5 years old. The development of these sensory capacities is very important for allowing children, especially babies, to perceive and interact with the world around them. During the first few months, especially, babies need to see shapes, colors, objects at varying distances and movement for the brain to learn how to see. Babies also need exposure to a variety of sounds so their brain can learn to process that information and allow for responsiveness by hearing something.

Language development

The "prime time" for language development and learning to talk is from birth to 10 years of age. Children are learning language during this entire period. However, the "prime time" for language learning is the first few years of life. Children need to hear you constantly talk, sing and read to them during these early years. Respond to their babbling and language efforts.

Children vary in their language development during these first years, so parents should allow for some variation in children's abilities at different ages. They should encourage language development, be patient and seek assistance from a qualified professional if concerns arise about a child's progress in this area.

Physical and motor development

The "prime time" for physical and motor development in children is from birth to 12 years of age. Children become physically ready for different aspects of motor development at different times. Large motor skills, such as walking, tend to come before the refinement of fine motor skills, such as using a crayon.

A child needs several years to develop the coordination skills to play catch with a ball easily, and even then refinement of such skills continues into a child's early adolescence. Parents should monitor a child's motor development but be patient since children vary in their rates of development.

Emotional and social development

The "prime time" for emotional and social development in children is birth to 12 years of age. Differing aspects of emotional and social development, which incorporate higher capacities, such as awareness of others, empathy and trust, are important at different times. For example, the real "prime time" for emotional attachment to be developed is from birth to 18 months, when a young child is forming attachments with critical caregivers. Such development provides the foundations for other aspects of emotional development that occur as children grow.

Emotional intelligence is critical to life success. The part of the brain that regulates emotion, the amygdala, is shaped early on by experience and forms the brain's emotional wiring. Early nurturing is important to learning empathy, happiness, hopefulness and resiliency.

Social development, which involves both self-awareness and a child's ability to interact with others, also occurs in stages. For example, sharing toys is something that a 2-year old's brain is not fully developed to do well, so this social ability is more common and positive with toddlers who are 3 or older. A parent's efforts to nurture and guide a child will assist in laying healthy foundations for social and emotional development.

Conclusion

The development of a child's brain holds the key to the child's future. Although the "first years last forever" in terms of the rapid development of young children's brains, the actual first years of a child's life go by very quickly. So touch, talk, read, smile, sing, count and play with your children. It does

more than make both of you feel good. It helps a child's brain develop and nourishes the child's potential for a lifetime.

Recommended Resources

Books

Gopnik, A., Meltzoff, A.N., and Kuhl, P.K. (1999). *The Scientist in the Crib: Minds, Brains, and How Children Learn*. New York: William Morrow & Co. Inc.

Babies as scientists — this book summarizes all kinds of amazing research findings with babies.

Healy, J. (1994). *Your Child's Growing Mind: A Practical Guide to Brain Development and Learning from Birth to Adolescence*. New York: Doubleday.

This easy-to-read book is full of practical suggestions for teaching and learning.

Martin, E. (1988). *Baby Games: The Joyful Guide to Child's Play from Birth to Three Years*. Running Press Book Publishers.

This fun book is full of activities, songs and ideas for parents of young children.

Ramey, C.T. and Ramey, S.L. (1999). *Right from Birth: Building Your Child's Foundation for Life*. New York: Goddard Press Inc.

By a leader in the field, this book sets forth seven essential factors to help children grow each day from birth to 18 months.

Shore, R. (1997). *Rethinking the Brain: New Insights into Early Development*. New York: Families and Work Institute.

This well-written and descriptive book is on key aspects of brain development in children and their importance for children and parents.

Siegel, D. J. (1999). *The Developing Mind*. New York: Guilford Press.

This provides profound and interesting insights on how the brain and biology influence who we are and how we develop as human beings.

Videos

The First Years Last Forever.
This video is available from the I Am Your Child Campaign, which the Reiner Foundation sponsors. For ordering information, visit the Web site (see below) or write to: I Am Your Child, PO Box 15605, Beverly Hills, CA 90209.

Web sites

• *The Better Brains for Babies* publication series was done by faculty in the College of Family and Consumer Sciences at the University of Georgia. The Web site is: *www.fcs.uga.edu/pubs* .

• *I Am Your Child* is a national public awareness and engagement campaign, which the Reiner Foundation created, to help people understand the importance of new brain research and its implications for our children's lifelong healthy development. Information can be accessed on the Web site at *www.iamyourchild.org* .

• The Wisconsin Council on Children and Families has educational resources that include *Great Beginnings: The First Years Last Forever* and the *Brain Watch* series. Information can be accessed on the Web site at *www.wccf.org* .

References

Bales, Diane. (1998). *Better Brains for Babies*. Publication Nos. FACS 01-1, 01-2, 01-4, 01-6 and 01-7. College of Family and Consumer Sciences, University of Georgia.

Bower, Don. (1998). *Better Brains for Babies*. Publication Nos. FACS 01-3 and 01-5. College of Family and Consumer Sciences, University of Georgia.

I Am Your Child Campaign. (1999). Web site: *www.iamyourchild.org* . Beverly Hills, Calif.

Gopnik, A., Meltzoff, A.N., and Kuhl, P.K. (1999). *The Scientist in the Crib: Minds, Brains, and How Children Learn*. New York: William Morrow & Co. Inc.

Healy, J. (1994). *Your Child's Growing Mind: A Practical Guide to Brain Development and Learning from Birth to Adolescence*. New York: Doubleday.

Jensen, Eric. (1998). *Teaching with the Brain in Mind*. Association for Supervision and Curriculum Development, Alexandria, Va.

Shore, Rima. (1997). *Rethinking the Brain: New Insights into Early Development*. New York: Families and Work Institute.

Siegel, D. J. (1999). *The Developing Mind*. New York: Guilford Press.

Wisconsin Council on Children and Families. (January 1999). *Brain Watch: The Facts About Baby's Brain*. Web site: *www.wccf.org* .

Just as their bodies need food to grow, science tells us that the experiences children have in their earliest years are equally necessary for growth of a healthy brain.

Children's ability to recognize, think and interact with the world is dependent on the development of their brain.

Science is beginning to unlock new understanding of brain development and how it occurs in young children.

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