Second Edition

Starting Smart

How Early Experiences Affect Brain Development

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Starting Smart

How Early Experiences Affect Brain Development

Michael Stevens is a healthy, beautiful newborn baby. As his parents admire him, they wonder, "What will Michael be like when he grows up? Will he do well in school? Will he get along with other kids and be happy?" Scientists now believe that the answers to these questions depend in large part on how young Michael's brain develops, and that this development in turn depends largely on the nutritional, medical, emotional, and intellectual support his parents, extended family, and community provide for him during his childhood.

Recent advances in brain research have provided great insight into how the brain, the most immature of all organs at birth, continues to grow and develop after birth. Whereas this growth had been thought to be determined primarily by genetics, scientists now believe that it is also highly dependent upon the child's experiences. Research shows that, like protein, fat, and vitamins, interactions with other people and objects are vital nutrients for the growing and developing brain, and different experiences can cause the brain to develop in different ways. It is this "plasticity" of the brain, its ability to develop and change in response to the demands of the environment, that will enable Michael to learn how to use computers as successfully as his ancestors learned how to hunt animals in the wild.

As he grows, Michael's ability to understand language, solve problems, and get along with other people will be influenced by what he experiences as an infant and young child. This is not to say that individual genetic differences have no influence on how a child develops; they do. But there is mounting evidence that experiences affect the way genes are expressed (i.e., turned on and off) in the developing brain. While good early experiences help the brain to develop well, experiences of neglect and abuse can literally cause some genetically normal children to become mentally retarded or to develop serious emotional difficulties.

Understanding How the Brain Develops

To understand how this happens, we need to understand a bit about how the brain works. The brain is comprised of many regions that perform specific functions, such as identifying what we see, processing spoken language, or assessing whether we are in danger. Within each of these brain areas are millions of neurons, or nerve cells, which send messages to each other across synapses. These trillions of nerves and synapses and the pathways they form make up the "wiring" of the brain; they allow all of the various areas to communicate and function together in a coordinated way. The number and organization of connections in the brain influence everything from the ability to recognize letters of the alphabet to facility at managing complex social relationships.

In most regions of the brain, no new neurons are formed after birth. Instead, brain development consists of an ongoing process of wiring and re-wiring the connections among neurons. New synapses between cells are constantly being formed, while others are broken or pruned away. This happens throughout life. However, in early childhood the brain is genetically programmed to produce more synapses than it will ultimately use. Indeed, by 8 months of age a baby may have an astounding 1,000 trillion synapses in his brain! This blooming of synapses happens at different times in different areas of the brain. Development then proceeds by keeping the synapses that are used and pruning away those that aren't. The pruning of synapses happens over the childhood years as the different areas of the brain develop(Huttenlocher & Dabholkar, 1997).

Pruning allows the brain to keep the connections that have a purpose, while eliminating those that aren't doing anything. In short, pruning increases the efficiency with which the brain can do what it needs to do. But, because the brain operates on the "use it or lose it" rule, an "over-pruning" of these connections can occur when a child is deprived of normally expected experiences in the early years. This leaves the child struggling to do what would have come more naturally otherwise.

Some areas of the brain, such as those which help us see clearly, become less "plastic" or changeable when the pruning is over. This has led to tremendous concern about providing what the brain needs to prune and organize itself correctly before the "windows of opportunity" close. For example, surgeons now remove congenital cataracts as early in infancy as possible, because they know that if they wait until the child is older, the neural connections between his eyes and his brain will fail to develop properly, and he will never be able to see. Brain scientists are also working diligently to unlock the secrets of how the brain turns on and off its ability to change itself. There is real hope that if we can understand the ways this happens, we can create therapies, both those that use drugs and those that use carefully structured experiences and training exercises, that can open up windows and re-wire brains that were deprived of normally expected experiences early in life or those that get damaged later in life.

The Power of Early Experiences

Our brains shape and reshape themselves in ways that depend on what we use them for throughout our lives. Learning language is a nice example of how experiences contribute to each person's unique pattern of brain development. The ability to speak and to understand other's speech requires only the minimal opportunity to communicate that almost all children experience. However, *which* language a child learns to speak depends on the language he experiences, and his brain will adapt to this specific language. When an infant is 3 months old, his brain can distinguish several hundred different spoken sounds, many more than are present in his native language. Over the next several months, however, his brain will organize itself more efficiently so that it only recognizes those spoken sounds that are part of the language that he regularly hears. For example, a one-year-old Japanese baby will not recognize that "la" is different from "ra," because the former sound is never used in his language. During early childhood, the brain retains the ability to re-learn sounds it has discarded, so young children typically learn new languages easily and without an accent. After about age 10, however, plasticity for this function is greatly diminished; therefore, most people find it difficult to learn to speak a foreign language as well as a native speaker if they only begin to learn it in adolescence or adulthood.

More importantly, early experiences can determine how proficient a child becomes in his or her native language. Researchers found that when mothers frequently spoke to their infants, their children learned almost 300 more words by age 2 than did their peers whose mothers rarely spoke to them (Huttenlocher et al., 1991; also, Hart & Risley, 1995). Furthermore, studies have suggested that mere exposure to language such as listening to the television or to adults talking amongst themselves provides little benefit. Rather infants need to interact directly with other human beings, to hear people talking about what they are seeing and experiencing, in order for them to develop optimal language skills. Unfortunately, many parents are under the mistaken impression that talking to babies is not very important because they are too young to understand what is being said.

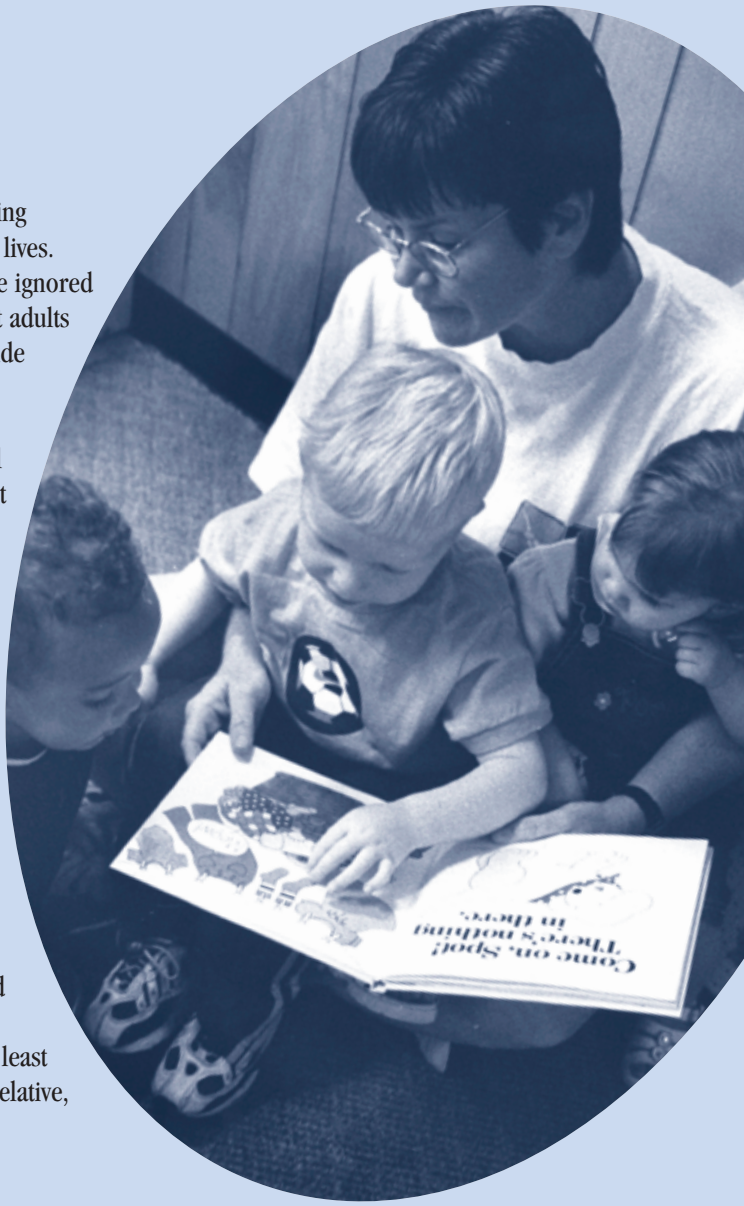
A new consensus is emerging about the importance of intervening with families of disadvantaged children in the first months and years of life to ensure they provide the kinds of experiences that support optimal development. Psychologists have long known that children of poorly educated, low-income parents often don't reach the same intellectual levels as children of well-educated, wealthy parents. The recent developments in brain research have provided new insights into why this is so. Parents who are preoccupied with a daily struggle to ensure that their children have enough to eat and are safe from harm may not have the resources, information, or time they need to provide the stimulating experiences that foster optimal brain development. Infants and children who are rarely spoken to, who are exposed to few toys, and who have little opportunity to explore and experiment with their environment may fail to fully develop the neural connections and pathways that facilitate later learning. Despite their normal genetic endowment, these children are at a significant intellectual disadvantage and are likely to require costly special education or other remedial services when they enter school. Fortunately, intervention programs that start working with children and their families at birth or even prenatally can help prevent this tragic loss of potential (*see box below*).

Intervention Can Help Kids Who Are at Risk

Through the University of North Carolina's "Abecedarian Project," Craig Ramey and his colleagues demonstrated that intensive early intervention could greatly enhance the development of children whose mothers have low income and education levels. The children in the project were randomly assigned to receive either an intensive 5-year program of full-day, full-year child care and parent involvement activities beginning in the first few months after the child's birth, or to receive only free formula and diapers. After just 3 years, dramatic results were evident: the program children had an average IQ score of 105, while the control group children averaged only 85. And unlike many programs which began intervention at age 4, the effects of the program on IQ held over time. The program children were less likely to repeat a grade in school and demonstrated better achievement in reading and mathematics throughout elementary and high school. At age 21, the children who participated in the 5-year program still displayed a significant intellectual advantage over the control children. Clearly this intensive, early intervention had a long-lasting impact on these children's lives (Ramey, Campbell, & Blair, 1998).

Emotional Development and the Infant Brain

One of the most fundamental tasks an infant undertakes is determining whether and how he can get his needs met in the world in which he lives. He is constantly assessing whether his cries for food and comfort are ignored or lovingly answered, whether he is powerless or can influence what adults do. If the adults in his life respond predictably to his cries and provide for his needs, the infant will be more likely to use these adults as sources of safety and security. With his safety taken care of, he then can focus his attention on exploring, allowing his brain to take in all the wonders of the world around him. If, however, his needs are met only sporadically and pleas for comfort are usually ignored or met with harsh words and rough handling, the infant will focus his energies on ensuring that his needs are met. He will have more and more difficulty interacting with people and objects in his environment, and his brain will shut out the stimulation it needs to develop healthy cognitive and social skills (Lieberman & Zeanah, 1995).



Children who receive sensitive, responsive care from their parents and other caregivers in the first years of life enjoy an important head start toward success in their lives. The secure relationships they develop with the important adults in their lives lay the foundation for emotional development and help protect them from the many stresses they may face as they grow. Researchers who have examined the life histories of children who have succeeded despite many challenges in their lives consistently found that these people have had at least one stable, supportive relationship with an adult (usually a parent, relative, or teacher) beginning early in life (Werner & Smith, 1992).

The Effects of Trauma and Chronic Stress

Negative early experiences can also profoundly affect the development of the brain. Unfortunately, child abuse and neglect are pervasive social problems. Each year in the United States there are more than a million substantiated cases – and many more than that probably never come to light. Maltreatment increases a child's risk of developing depression, self-destructive behavior, eating disorders, attention deficit disorders, drug and alcohol problems, sexual promiscuity, and delinquency. Many researchers believe that these effects can be partly explained by understanding how chaotic, stressful, and traumatic experiences affect brain development. However, this is a new area of study, with much more that we need to learn.

At the moment, we know the most about how traumatic experiences affect the brains of children who develop Post-Traumatic Stress Disorder (PTSD) (*see box below*). Similar to adults with PTSD, these children have trouble sleeping, can't control their memories of the trauma, and seem to be on constant alert (Kaufman & Charney, 1999). Estimates vary from as low as 30% to as high as 90% for the likelihood of developing PTSD for some period following sexual and physical abuse in childhood – and it can have long-lasting effects (Fletcher, 1996). While experiencing the symptoms of PTSD, children have difficulty learning and maintaining positive relationships with family and peers. Although the ability of the brain to put abused children on constant alert may help them to survive in traumatic environments (for example, the battered child may be able to better avoid the abusive father when he is in a bad mood) it exacts a cost, for the child and for society.

It is important that we not assume that a poorly parented or traumatized child is incapable of healthy functioning later in childhood or adolescence. Research on the developing brain suggests continuing opportunity for change into adulthood and provides no evidence that there is some age beyond which intervention will fail to make a difference. In fact, this research provides exciting new clues as to what kinds of therapy might be most helpful for children who have experienced difficult lives (DeBellis, Baum et al., 1999; DeBellis, Keshaven, et al., 1999). Clearly, however, the costs (in human suffering, loss of potential, and real money) of trying to repair, remediate, or heal these children is far greater than the costs of preventing these problems by promoting healthy development of the brain during the first few years of life.

The Impact of Neglect and Trauma on the Developing Brain: *How Nurture Becomes Nature*

At the Developmental Traumatology Laboratory at Western Psychiatric Institute and Clinics in Pittsburgh, Pennsylvania, researchers are conducting studies in traumatized children using the most up-to-date methods to study their stress circuits and brain development. In a recent report, they described their findings on maltreated children with PTSD who they compared to healthy, normal children and to children with clinical anxiety disorders who had not been maltreated. Many of the maltreated children had been sexually abused beginning between the ages of 18 months and 7 years. They had also witnessed domestic violence beginning early in life, and some had been battered by family members. For most of the children with PTSD, the trauma was chronic, lasting for several years before the children were rescued.

Unlike non-maltreated comparison children, the children with PTSD had elevated levels of the stress hormones adrenaline and cortisol, even on a normal day when nothing especially stressful was happening (DeBellis, Baum, et al., 1999). Thus, these children's stress systems seemed to be turned on even when they didn't need to be. Especially high stress hormone levels were found among the children who had been abused for longer and/or had more severe PTSD. Very similar results have been found for children rescued from Romanian orphanages, even though for the most part these children had been severely neglected rather than physically or sexually abused.

The Pittsburgh group also scanned the brains of maltreated children with PTSD. Even after they accounted for many things that could produce mistaken results, they found striking evidence of smaller brain volumes, with larger effects the earlier the abuse began and the longer it lasted before the children were rescued (De Bellis, Keshaven, et al., 1999). Similar results have been found at the CIVITAS Child Trauma Programs at Baylor College of Medicine. Did the abuse cause the brains of these children to be smaller? We can't be certain. Would the brains of abused children who did not develop chronic PTSD also show some reduction in size? We don't know. But these data and other studies currently underway certainly encourage concern about the impact that maltreatment may have on the child's developing nervous system.

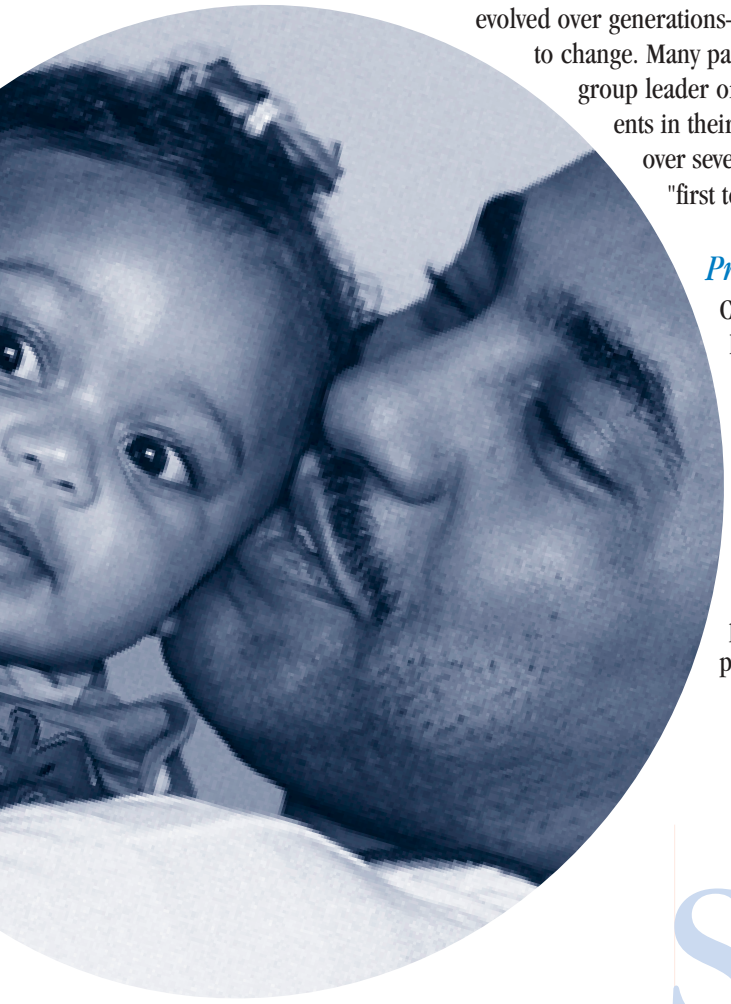
Helping Families Support Healthy Brain Development

It is now clear that what a child experiences in the first years of life profoundly influences how his brain will develop and how he will interact with the world throughout his life. Parents play the most important role in providing the nurturing and stimulation that children require, but they need information and support to develop good parenting skills. In the past, extended family members were often close by, offering good advice and acting as role models for inexperienced parents. Young families today often live far away from grandparents and other family and rely more on community resources for information and support in parenting. There is much that communities can do to help families promote their children's healthy brain development.

Educate parents about the importance of early experiences for their children's development.

Often parents don't know about the many little things they can do to foster their children's healthy cognitive and emotional development, like talking to the children beginning in infancy, reading to them from a very early age, and helping them play simple games. Parents, especially new or young parents, may also need help learning to recognize their children's cues that they are hungry for stimulation or have had enough.

In some cases written materials or a few sessions of parenting education classes may be all that a parent needs to learn how to provide his or her child with appropriate stimulation. However, parenting styles and beliefs that have evolved over generations—such as rarely talking to babies—can be difficult for parents to change. Many parents benefit from community-based programs in which a parent group leader or a home visitor acts as a role model and coach, supporting parents in their relationships with their children. Programs that work with parents over several years can be very successful in helping them become effective "first teachers" of their children (Olds et al, 1993).



Prevent abuse and neglect.

Children who are abused or severely neglected are at extremely high risk of developing emotional, behavioral, social, and intellectual disabilities. By the time a child is identified as having been neglected or abused, these problems have already begun to develop. Greater attention must be given to preventing maltreatment before it starts. High-quality home visiting programs that start working with families as soon as the child is born have proven to be effective in preventing abuse and neglect (MacMillan et al., 1994). The key to these programs' success is that they help parents manage the stresses of raising children before unhealthy patterns develop and things get out of control.

Provide accessible, quality mental health services for parents.

Research has shown that parents suffering from untreated depression often fail to respond sensitively to their children's cries and bids for attention, and that they are unlikely to provide the child with the kind of cognitive stimulation that promotes healthy brain development (Field, 1995). Other mental illnesses, such as schizophrenia, can also dramatically affect a parent's ability to interact appropriately with his or her child. Proper mental health treatment for these parents can make a real difference in their ability to raise a competent, well-adjusted child.

Ensure adequate nutrition prenatally and in the first years after birth.

Numerous studies have shown the devastating effects on intelligence and brain development of a lack of basic nutrients in the prenatal period, in infancy and in early childhood. Programs such as the Special Supplemental Program for Women, Infants, and Children (WIC) can be effective in ensuring that babies receive the kinds of foods they need to thrive (Yip et al., 1987). Educational and outreach campaigns to alert women to the importance of nutrition in the first trimester of pregnancy would also be helpful in preventing problems that can arise in this critical period when brain cells begin to form.

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The Importance of Quality in Infant-Toddler Child Care

Increasing numbers of U.S. infants and toddlers spend hours each day in various child care arrangements because their parents work or attend school. It is critical that the care that these children receive promotes their healthy growth and development. Too often, however, child care providers are poorly trained and do not provide children with appropriate stimulation. Research has shown that in the majority of infant care arrangements in the U.S., children are not talked to and played with enough, and they do not have the opportunity to form the kind of comfortable, secure relationships with a caregiver who will promote their healthy emotional development (The Cost, Quality and Child Care Outcomes Study Team, 1995; National Center for Early Development and Learning, 1999).

Parents should be given information about how to choose quality care for their children. In addition, special attention must be given to the development and enforcement of child care licensing standards that promote high-quality care: adequate pre-service and inservice training for caregivers; low child-to-teacher ratios, and small group sizes. Finally, child care reimbursement rates for families moving from welfare to work must be high enough to fund well-trained teachers who can deliver developmentally appropriate care and education.

Conclusion

Like most children, Michael Stevens has a family who will provide the stimulation and nurturing that he needs to grow and develop to his potential. Unfortunately, high rates of child abuse and neglect across the country as well as persistently high rates of school failure in some communities indicate that far too many children do not receive what they need during their first few years for healthy brain growth and development. As our society becomes even more technically and socially complex, we cannot afford to continue to allow large numbers of children to miss out on the positive experiences they need in infancy and early childhood; the costs, in terms of lost intellectual potential and increased rates of emotional and behavioral problems, are too high. The new developments in brain research show us what children need; our challenge is to ensure that every child receives it.

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