DOCUMENT RESUME

ED 427 845 PS 027 325

AUTHOR Frost, Joe L.
TITLE Neuroscience, Play, and Child Development.
PUB DATE 1998-06-00
NOTE 18p.; Paper presented at the IPA/USA Triennial National Conference (Longmont, CO, June 18-21, 1998).
PUB TYPE Information Analyses (070) -- Opinion Papers (120) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Child Development; *Cognitive Development; Early Childhood Education; *Early Experience; Emotional Development; Language Acquisition; *Neuropsychology; *Play; Social Development

ABSTRACT

This paper presents a brief overview of the array of neuroscience research as it applies to play and child development. The paper discusses research showing the importance of play for brain growth and child development, and recommends that families, schools and other social and corporate institutions rearrange their attitudes and priorities about play, recess, physical education, music, games, art, and personal interactions between caregivers and children. Also discussed are connections between brain development and play in early childhood; the role of play in cognitive, language, social, emotional, and physical development, and bridging the gap between neuroscience and educational practice. The paper lists 15 implications of brain research for education and child development, including recommendations for parents and teachers. (Contains 42 references.) (JPB)

NEUROSCIENCE, PLAY, AND CHILD DEVELOPMENT*

Joe L. Frost
Parker Centennial Professor
University of Texas at Austin

1

"Zap: neurons in the brain's amydala send pulses of electricity through the circuits that control emotion. You hold him on your lap and talk...and neurons from his ears start hard-wiring connections to the auditory cortex. And you thought you were just playing with your kid." (Begley, 1996, p. 55)

The purpose of this paper is to present a modest overview of the exploding array of neuroscience research as it applies to play and child development.

With the aid of high-tech brain imaging technology, scientists around the world are making unprecedented inroads into understanding the role of experience in human development. As early as 1996 the United States had over 3,000 brain researchers with research resources of over one billion dollars and the Japanese had drafted a plan to invest 18 billion U.S. dollars in brain science over the next two decades and about one billion in a state-of-the-art nuclear resonance (NMR) center for structural biology (Barker, 1996). Because of this unprecedented interest in neuroscience, the 1990's is now called the "decade of the brain." Neuroscience appears to be the new frontier for revolutionary research into the structure and function of the brain, the prevention and treatment of neurological disorders, and virtual replication or mimicking the brain's information processing functions.

Neuroscientists are seeing both planned and unanticipated results that are relevant to education and child development. Play, the frivolous, unimportant, behavior with no apparent purpose has earned new respect as biologists, neuroscientists, psychologists, and others see that play is indeed serious business and is perhaps equally important as other basic drives of sleep, rest, and food. In the scientific community, if not in social institutions, play and the people who study it are no longer seen as strange and immature. Hopefully, this unprecedented explosion of information about the importance of play for brain growth and child development will influence families, schools and other social and corporate institutions to rearrange their attitudes and priorities about play, recess, physical education, music, games, art, and rich, personal interactions between caregivers and children.

* c 1998, Joe L. Frost. Prepared for presentation at the IPA/USA Triennial National Conference, Longmont, Colorado. June 18-21, 1998.

Emergence of Neuroscience

Studies of the role of the human brain in child development gained considerable momentum during the 1960's. A number of professionals (Frost, 1968, 1975; Hess, 1968; Hunt, 1961) concluded from both animal and human studies that infancy and early childhood were optimum periods for development and that the brain is most plastic during these periods and highly influenced by environmental stimulation. Animals (dogs) raised in isolation from birth were unable to avoid pain (Melzack and Scott, 1957), acquire normal social interactions (Melzack and Thompson, 1956), or perform well on problem-solving tasks (Thompson and Heron, 1954). Similarly, children raised in orphanages with minimal on-going stimulation suffered emotional deprivation resulting in apathetic, immature behavior during adolescence (Goldfarb, 1953) and in cases of most severe deprivation, two- to -four -year- olds could not sit alone or walk alone (Dennis, 1960).

In his classic work, Intelligence and Experience (1961), J. McVicker Hunt, as early as 1961, garnered extensive evidence to conclude that the concept of fixed intelligence was no longer tenable. He viewed intelligence as problem- solving capacity based on hierarchical organization of symbolic representations and information processing strategies of the brain derived to a considerable degree from past experiences. The child's intelligence (IQ) may vary as much as 20 to 40 points as a result of environmental stimulation or lack of environmental stimulation.

Consequently, views of the brain and its function in development gradually shifted from a mechanical, telephone switchboard model where a stimulus could be connected with a variety of responses to a electronic computer model. The computer model was characterized by information or memories coded and stored, logical operations that act on these memories, and hierarchically arranged programs of these operations for various purposes. Experience was regarded as programming the intrinsic portions of the cerebrum for learning and problem-solving, and intellectual capacity at any given time was considered to be a function of the nature and quality of the programming.

Although the work of Piaget is presently drawn into question regarding its authenticity and currency, the serious scholar must acknowledge his brilliant insights into cognition, play, early development, and, in a more remote sense, brain science. Analysis of Piaget's work (1951, 1952) on cognitive structures which he called schemata, reveals a number of principles relevant to this context. First, the formation of cognitive structures (schemata) depends upon opportunities for use of action sequences. Second, there is continuous development of schemata through use and stimulation. Third, accommodation by the child depends upon a proper match between existing mental structure and objects and events encountered. Fourth, the greater the variety of situations to which the child must accommodate his behavioral structures, the more differentiated they become, and the more rapid his rate of intellectual development. Fifth, the rate of development appears to be the result of a variety of stimulation during infancy and early childhood.

Thus, we see that research of the 1960's and earlier established the early years as optimum times for intervention and supported a plastic view as opposed to a fixed view of the brain and cognitive development. The early observational studies lacked the sophistication of current studies which utilize remarkable, brain-imaging technology yet they were sufficiently compelling to influence the development of a range of federally sponsored early childhood intervention programs such as Operation Head Start and the High Scope Project.

While the generalized view of infant plasticity and importance of early intervention were widely recognized, questions as to the nature and intensity of intervention were still very much open issues. The plasticity of the infant brain does not appear to be an advantage in all situations. In 1974, the President's Committee on Mental Retardation sponsored the National Conference on Early Intervention with High Risk Infants and Young Children at the university of North Carolina in Chapel Hill. Here, the early plasticity theories were documented with physical evidence (Frost, 1975). A relatively small amount of damage to the infant brain results in a reduction in volume of the entire hemisphere of over 30 percent while similar damage to the adult brain results in a reduction of only 20 to 30 percent (Isaacson, 1974).

Albert Einstein College of Medicine physicians presented evidence at the North Carolina Conference that there can be too much stimulation, or too little. Lipton (1974) believes that no stimulation leads to no elaboration of neurological structure and processes, while pushing brain maturation (overstimulation) leads to overdevelopment and later deficits in behavior. Photographs of brain tissue from infants who died several weeks after premature birth (Purpura, 1974) revealed remarkably abnormal brain development, apparently resulting from a few weeks of survival in an isolet. Isolation or lack of stimulation did not stop development but resulted in an extraordinary amount of extra development. The implications of such findings are now being examined critically, using brain imaging technology that provides visible, concrete, quantifiable evidence that is more convincing than earlier anecdotal evidence.

High-Tech Brain Imaging

During the past quarter century, neuroscience has become a major field of research. Neuroscientists study the basic units of the brain - the extremely small but highly interconnected cells. Such study now relies on sophisticated brain-imaging technology, made possible by advances in computer science. This technology takes scientists well beyond earlier observation, autopsies, two-dimensional X-rays, and EEG results to a world of three-dimensional color TV graphics with high spatial and temporal resolution. Sylwester (1995) and Thatcher, et al, (1996) describe the technology in detail. The new-brain imaging technology focuses on three elements of brain organization and operation: (1) chemical composition, (2) electrical transmission and magnetic fields, and (3) distribution of blood through the brain.

Two types of imaging technology are used to study chemical composition, the CAT scan (computerized axial tomography) and MRI (magnetic resonance imaging). These create graphic, three-dimensional images of the anatomy of the brain (or other body parts). The CAT scan uses multiple X-rays that respond to the density of areas scanned, dark gray for denser elements (e.g., bones, tumors, and dense tissue) and lighter shades of gray for soft tissue. The MRI provides an image of the chemical composition of the brain by focusing on chemical differences in soft tissue. Fast MRI allows researchers to observe brain activity on television during a subject's cognitive activity.

PET (positron emission tomography) traces sequential changes in brain energy by monitoring chemical functions, including blood flow, through the brain and other body organs (Chugani, 1994; Sylwester, 1995). This noninvasive technique allows the tracing of brain energy as parts of the brain are activated. The past decade has already produced more knowledge about brain development than did previous centuries. Scientists are already learning how normal brains develop during the early years. As brain-imaging technology becomes more sophisticated and less expensive, it will be increasingly used in schools and other contexts to diagnose and treat learning disabilities such as ADHD (attention deficit hyperactive disability).

Organization of the Brain

The human brain is an organ of extraordinary complexity and sophistication. Simply stated, its function is based on activities of several billion brain cells or **neurons** and trillions of connections or **synapses** that transmit (receive and send) electrochemical signals (messages). Each single neuron has an **axon** which sends electrochemical signals to other neurons and contains many small, hairlike structures or **dendrites** which receive the signals. When the axon of one neuron connects with the dendrite of another neuron, a **synapse** (connection) is formed. Electrochemical transmission across these structures requires **neurotransmitters** (chemical catalysts) such as dopamine, serotonin, or endorphins. Neural development, then, is (includes) the proliferation or growth of these key brain elements. For elaboration see Begley (1996), Healy (1997), Shore (1997), and Thompson (1997).

Before a baby is born, considerably more neurons and synapses are developed than the child will need but most of the surplus neurons have disappeared by the time of birth. As neurons expand the brain grows in volume and weight. Although the number of synapses increases at a remarkable rate during the first three years, the number of neurons remains stable (Shore, 1997). Normal early development is so rapid that the PET scan of a one-year-old more closely resembles and adult's brain than a newborn's. By age two the number of synapses reaches adult levels. By age three the child's brain has about 1,000 trillion synapses or about twice the number of an adult's brain and is two and a half times more active (Shore, 1997). The density of synapses remains super-saturated through the first decade of life, followed by a decline in density. By late adolescence about half of the brain's synapses have been discarded.

This discarding of synapses is a lifelong process of refining or **pruning** to eliminate those that are not used in favor of those that are used through everyday experiences. The early experiences of children play a critical role in determining the wiring of the brain, and, it is hypothesized, the range and quality of the child's intellectual abilities. As the child grows, a complex system of synapses or neural pathways is formed. The pathways that are repeatedly activated or used are protected and retained into adulthood.

Effects of Deprivation on Brain Development

When a child is born the brain is a mass of neurons, ready to be wired or programmed through use and experience. Some hard-wiring is already present to produce breathing and reflexes, regulate body temperature, and control heartbeat. Billions of other neurons are ready to be connected to other neurons but they must be used in order for connections to be made and circuitry to be formed. Unused, neurons do not survive, the potential trillions of synapses or connections are not formed, and the child never reaches his potential. Brain development is truly a "use or lose it" process. Early experiences determine which neurons are to be used and which are to die, and consequently, whether the child will be brilliant or dull, confident or fearful, articulate or tongue-tied (Begley, 1996).

Much of the violence in the United States may be related to the lack of appropriate attachments of young children to adults. Inappropriate attachments associated with neglect and traumatic stress result in overdevelopment of the brainstem and midbrain, areas that are primitive and "hardwired" and not very susceptible to external influence (Perry, 1996). The long-term research of Stroufe and his colleagues (Renken, et. al., 1989) confirms the link between attachment and violence. Children with primary caregivers who are emotionally unavailable during the early years are more aggressive in later childhood and adolescence. Even lingering depression of mothers has adverse effects on young children, particularly six to eighteen month olds, when mothers fail to provide cognitive stimulation that promotes healthy brain growth (Ounce of Prevention Fund, 1996).

The traditional view that neural development and intelligence are pfixed by the genes is no longer tenable. Genetics and experience work together to form the child. The effects of sensory and motor experience on brain development begins before birth. Ultrasound recordings show that the neurons that develop in utero begin driving the infant's limbs as early as seven weeks of gestation (Shore, 1997). Brain development is adversely influenced by environmental influences on the mother - drugs, stress, malnutrition, illness, trauma, abuse - which are passed on to the fetus. Trauma and abuse in the fetus and during infancy continue to have a devastating effect on brain development throughout childhood. Neglect by parents, social deprivation, stressful living conditions, and lack of appropriate stimulation jeopardize early brain development and may result in immature social and emotional behavior, impulsivity, violence, and dramatic reduction in capacity for later learning. These negative influences are often associated with living in poverty (Ramey and Ramey, 1996) and living in institutions such as orphanages (Frank, et. al., 1996).

We do not deliberately subject children to extreme conditions of deprivation for purposes of research but ample cases exist, particularly in orphanages around the world. Perhaps the most poignant and revealing institutional condition exists in the orphanages of Romania where about 100,000 children live under cruel and debilitating conditions (ABC News, 1996). According to ABC News, this condition resulted from a dictator's plan to double the Romanian population. He outlawed birth control and demanded that women have children, resulting in thousands being placed in institutions. The children were reared under conditions of almost total neglect - some penned in cages, others confined to cribs with little or no stimulation from caretakers. Between 1960 and 1996, more than 3,000 were adopted by Americans.

Many of these adopted children, particularly those confined to orphanages over extended periods, failed to develop emotionally and intellectually, some so severe that one mother described hers as the "child from hell." Some never learned to talk, read, accept love, or even to feel pain. Some were violent. After several years of pain and frustration, a support group of American parents of these orphans organized and sought specialized assistance. Scientists at the Denver Children's Hospital conducted PET scans and learned that the children's brains were remarkably different from those of normal children. Although measurable progress resulted from therapy, including play therapy, they never developed like normal children.

For many, the therapy came too late. The window of opportunity is open during infancy but narrows with each passing year and appears to close between ages 8 and 10.

Neuroscience and Play: Connections

What are the linkages between brain development and play during the early childhood years? Let us begin with a few fundamental principles that have considerable support from neuro-scientists and play scholars:

First, all healthy young mammals play. Beginning shortly after birth, using the built-in neural mechanisms, infant animals and humans engage in their first playful games. Animal infants tend to initiate the early games. Early frivolity is encouraged and mediated by adults, usually the parents or other primary caregivers. Since the human infant's period of helplessness and motor immaturity is relatively long; parents of human infants "...must both initiate and give structure and direction to play....That structure acts as a scaffolding for development" (Fagen in Angier 1992, p. B-8).

Second, the range and complexity of play quickly increase as neurons start hardwiring connections at a remarkable rate. Simply put, play programs neural structures and resulting, increasingly complex, neural structures influence ever more complex play. "...an animal plays most vigorously at precisely the time when its brain cells are frenetically forming synaptic connections, creating a dense array of neural links that can pass on electrochemical messages from one neighborhood of the brain to the next" (Angier, 1992, p. B-8).

Third, the early games and frivolity of animals and humans equip them for the skills they will need in later life. Angier (1992) and Brownlee (1997) describe these games. Games are "tailor made" to fit the very different tasks animals and humans will face. Animals practice those skills that assist survival in a dangerous world - less defensible animals practicing escape games such as mock flight and the stronger carnivores playing stalking, pouncing, capturing games. In-so-doing, they learn flexibility, inventiveness, and versatility (Brown, 1994). Human infants and young children practice motor, language and negotiation skills. Across cultures boys and girls play differently, with boys more likely to engage in rough and tumble and organized games of physical contact and war using miniature war figures and toy weapons. Girls tend to engage in such games of chase, tag, jump rope, and hopskotch, and rehearse motherhood and housekeeping roles with dolls and utensils. Both boys and girls engage in socially and culturally mediated task analysis, problem solving, negotiation, and discourse during their play (Frost, 1992).

Fourth, play is essential for healthy development. The links between neuroscience and development are not clearly established but there is substantial evidence about how the brain develops and the linkages with language, emotions, movement, socialization, and cognition are becoming clearer. What is presently known is that early childhood experiences exert a dramatic, precise impact on the wiring of the neural circuits and that the formation and selecting out (pruning) of synapses coincides with the emergence of various developmental abilities (Begley, 1997). During the first years of life, it is playful activity, not direct instruction, seclusion, deprivation, or abuse that makes a positive difference in brain development and subsequent human functioning. Nash 1997) reported from research at Baylor College of Medicine that "...children who don't play much or are rearely touched develop brains 20% to 30% smaller than normal for their age (p.51).

Fifth, play deprivation results in aberrant behavior. Anecdotal evidence about the effects of play deprivation (see Frost & Jacobs, 1997; Brown, 1994) continues to mount and supports the findings of recent brain research. Stuart Brown, a physician, psychiatrist, and play researcher, presented one of the most compelling studies (1994) to date about the effects of play and play deprivation. Having long studied the development of abused children who became violent adults, he was charged by Governor John Connally of Texas to investigate the behavioral characteristics of Charles Whitman, who barricaded himself on top of the university's 27 story tower in 1966 and shot 44 people. The author (Frost) of this paper was at the scene throughout this massacre.

Brown found that Whitman had a history of violence and brutality at the hands of his father and was absent a normal play pattern as a child. He secluded himself on the playground and his father did not allow him to play at home. Following this investigation, Brown helped conduct a study of 26 convicted Texas murderers. He found that 90 per cent showed either the absence of childhood play or abnormal play such as bullying, sadism, cruelty to animals, or extreme teasing. In yet another study of mostly drunk drivers who killed themselves or others while driving, Brown found that 75 per cent had play abnormalities.

Neuroscience, Play and Child Development

Cognitive Development. Most of the brain's billions of neurons are dedicated to the analysis and solution of problems (Sylwester, 1995). They interpret sensory information, compare it with recalled information and determine how to respond. Only a relatively small number of neurons are involved in direct sensory interactions with the environment or with regulating basic body processes. Brain development and cognitive achievements of very young children are well disguised in the seemingly innocuous cloak of play. Essentially, only neuroscientists see physical evidence (brain scans) that reveal the relative consequences of environmental stimulation or neglect. The casual observer does not grasp the profound relationships between achievement and the endless games that the very young play - the patty-cake, peek-a-boo and sing-song rhythms that are in reality storehouses or machines for programming the brain for language, art, music, math, science, kinesthetic, and interpersonal abilities and intelligence.

Many key brain areas are formed and dedicated before birth to general problem solving areas. Although these systems are interrelated, a distinct brain area is dedicated to processing each function. Gardner (1983) proposes that there are seven distinct forms or systems of intelligence: linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, intrapersonal, and interpersonal. An individual can perform exceptionally in one system and poorly in another, depending upon complex interactions between genetics and experience. The implications of multiple intelligences are profound. Should we focus on optimizing strengths or remediating weaknesses? Should we value social, cooperative behavior or solitary, competitive behavior? What are the proper roles of parents, of teachers, and social institutions in optimizing intelligences?

Language Development. The brains of normal children are wired at birth to allow them to learn any language. Language learning begins long before babies are able to speak first words. As early as six months infants develop "language magnets" that attune their ears to the sounds of their native language (Kuhl in Education Commission of the States, 1996); they have learned the basic phonetic elements of their native language (Blakeslee, 1997). As early as eleven months infants are losing the ability to distinguish between phonetic sounds not spoken in their presence (Long, 1997). A growing body of evidence indicates that languages should be taught in preschool or in families before entry to school. Vocabulary development is strongly correlated with parent's talking with their babies. Through reciprocal talk (parents talking, babies listening and making primitive reactions) parents strengthen the neural pathways essential to language development.

Some researchers at the 1997 White House Conference on Early Child Development concluded that, "...the number of words an infant hears each day is the single most important predictor of later intelligence, school success and social competence (Blakeslee, 1997)." However, recent brain research supports earlier studies concluding that there can be too much stimulation and too little stimulation. Merely filling the child with information or scheduling too many activities may lead to overstimulation Live language in a warm, emotional context with a caring adult, not endless, mindless television or video games, boosts language development. Information received in an emotional context is more powerful in stimulating neural development than information alone. Even the tone of voice makes a difference.

Social Development. Before the availability of high-tech brain imaging research, the importance of young children's socialization with adults and older children was highlighted by the work of Vygotsky (1976) who proposed that play, and consequently the higher mental functions, evolve from interactions between the child and her caregiver and socialization with older children. Interaction or socialization with others is essential for healthy development. "...the single best childhood predictor of adult adaptation is not IQ, not school grades, and not classroom behavior but, rather the adequacy with which the child gets along with other children (Hartup, 1992)."

Children and animals learn social skills through socialization. Animals learn to interpret signals and actions of other animals and to respond appropriately (Brownlee, 1997). Through negotiation during play they develop mental and emotional mastery and learn cooperation and leadership skills. Children's imaginative or make-believe play is a powerful medium for socialization, allowing them to simplify a complicated world and make otherwise complex and frightening events manageable and comprehensible. Such play also assists the development of cooperation, sharing, negotiating and problem solving skills, and helps the child to get along in an increasingly complex world.

Emotional Development. The basic wiring that controls emotions develops before birth. After birth parents play a significant role by playing back the child's emotions - his squeals of delight - with hugs and supporting words. Such experiences reinforce the brain's chemical and electrical signals and "wire the brain's calm down circuit (Begley, 1996)." Stress also has its effects. Extreme or continuous trauma floods the brains circuits with neurochemicals such as cortisol and the more frequent they are stimulated, the easier it is to react. Indeed, repeated stress changes the structure of the brain (Begley, 1997). Merely thinking about traumatic experiences or seeing signs related to the incident - abuse by a parent or experiencing a natural disaster, can trigger the flood of neurochemicals and condition the brain to a pattern of high alert. Texas children who experienced a devastating tornado which killed many relatives and friends and destroyed dozens of homes in 1997 still sleep in their clothes without covers one year later so they can be ready to seek cover. Their drawings and paintings still reflect those harrowing experiences and the mere memory or reminder (clouds and wind) of a storm induces fear. Calm, soothing touch and language by the parent calms these emotions and appears to allow emotion and reason to connect.

Play is the language of children. While adults talk out their fears and traumatic experiences, children play theirs out. They may lack the words or the cognitive abilities to understand what has happened to them or to resolve their conflicts, but play has therapeutic qualities that allow children to play out their conflicts and to deal with them. "Play gives concrete form and expression to children's inner world....A major function of play is the changing of what may be unmanageable in reality to manageable situations through symbolic representation... (Landreth, 1991, pp. 9-10)."

Physical Development. At birth infants are awkward and have little control over their limbs. They cannot sit, stand, crawl or walk but rely upon primitive reflexes such as sucking and grasping. These reflexes are rapidly replaced by increasingly complex neural pathways as various regions of the brain develop to accommodate different abilities. Intense sensory and physical stimulation is critical to the growth of synapses in the cerebellum, a region that regulates coordination and muscle control (Angier, 1992). The development of fine and gross motor skills develop independently but both require the formation and **mylenation** (nerve cell coating that insulates against loss of electrical signals) of synapses. The neural circuits that connect the motor cortex of the brain and the muscles are strengthened by repeated motor activities.

If the child's motor neurons are not trained early for a particular athletic skill, there is little chance that the child will be outstanding in that skill. "No world champion skater or golfer took up the sport after 12 (Underwood and Plagens, 1997)." Adult neurons do not appear to be "plastic" enough to allow the required wiring. Tiger Woods started playing with a golf club at ten months. However, related factors are influential in achieving high levels of motor ability, for example, toughness, concentration, motivation, and ambition. Practicing related skills also appears to carry over to developing new skills. The great football player, Walter Payton, was in ballet classes as a child. The bottom line is that adults must provide experiences that program the neural structures for the skills to be achieved and they must do so in a caring, supportive context.

Neuroscience and Educational Practice: Bridging the Gap

Whenever scientific breakthroughs occur, there are always critics to question their validity and to warn against overgeneralization and speculation. Bruer (1997), for example, proposes that: "Neuroscience has discovered a great deal about neurons and synapses, but not nearly enough to guide educational practice" (p. 15). Scientists at the "Bridging the Gap Between Neuroscience and Education" Workshop, sponsored by the Education Commission of the States (1996), urged the educators at that workshop "not to attempt to apply new research findings until further studies confirm and expand them (p. vi)." Such cautions should, of course, be carefully considered.

Although researchers themselves are often reluctant to draw implications for the appropriate roles of adults in stimulating healthy development, the collective evidence about effects of experience on brain development is now (June, 1998) sufficiently compelling to warrant the formulation of tentative implications for child development and education. These professions have never waited for absolutes to guide practice, for absolutes are few and far between. The prevailing power of argument based on scope and clarity of evidence is sufficient to warrant the formulation of tentative implications for parent and educator practice, yet open-mindedness and attention to future research are essential. Just as medicine is now beginning to reap practical benefits from neuroscience, professionals should also look to brain research for practical applications in child development and education.

Implications of Brain Research for Education and Child Development

Neuroscientists are only beginning to learn which experiences wire the brain in which ways so drawing implications from brain research for education and child development is not an exact science. However, some general conclusions emerging from laboratories across the nation are gaining support. The resulting pattern of intervention is remarkably consistent with what "good" parents have always known and done. Unfortunately, during the past three decades, a growing number of parents have abdicated these roles or delegated them to others.

1. Start early. The proper starting time is conception, involving two healthy adults. If you wait until your child is in preschool or Head Start to begin you have already missed the most formative period for brain development.

2. Spend lots of time playing with your kid. She needs secure attachment or bonding with the parents. Disavow the misguided contention that a little "quality time" compensates for extended absence of parents. Healthy brain development does not take vacations or keep a calendar. There is no down time. Both dads and moms are needed.

3. Be positive, playful, warm and nurturing. Activity is essential but there is good activity and bad activity. Good activity supports healthy brain development. Bad activity programs unhealthy brain development, resulting in ability deficits and behavioral abberations.

4. Pay attention to your child's moral development. Even simple games carry moral overtones such as taking turns, sharing objects and listening to others. Meeting your child's physical and emotional needs does not mean that you cater to her every whim. Parents should have clear moral expectations from the beginning and these should be modeled and enforced.

Ensure that your toddler has opportunities to play with other toddlers. This is important for developing social skills - friendships, sharing, negotiating, problem solving, concern for others - and morals. Some morals may be hard-wired at birth but patterns of brain chemistry, emerging in early childhood appear to influence later moral behavior.

5. Challenge your child, but not beyond his range of abilities. Your expectations should be difficult but do-able. Infants and toddlers are far more capable than commonly realized and adults, especially parents, are far more important in their development than generally acknowledged, even by leading professional groups.

6. Hug your infant. Touching has health and therapeutic results. Touch, caress, pat, cuddle, and gently rock back and forth. Later, engage in gentle wrestling, tugging, tossing, chasing games. Such activities are essential in programming motor abilities and emotional behavior and in reinforcing related thinking abilities. Adults should be cautious not to shake infant's or toddler's heads too vigorously for shaken-baby syndrome may result in brain damage, developmental delays or other injury.

7. Talk to your child. Respond to his cooing and babbling. Use "parentese" with your baby. Expand your vocabulary as the child develops. Listen to your child. Early language must be personal - between child and adult - and related to ongoing activity to best stimulate neural development. For positive results language needs to be in a positive emotional context.

8. Introduce music and art early. Play soft, soothing classical music. Introduce your child to sing-song games during infancy. Introduce musical instruments early. Make simple art materials and simple tools available. Cultivate art through simple manipulative activities and expand to art appreciation activities.

9. Substitute play, art, music, and family outings for television. Control television viewing. Select programs wisely. Do not use television as a baby-sitter or as a substitute for family interaction. Play, art, and music produce long-term changes in neural structures that influence thinking and reasoning abilities.

10. Make your home and your personal life drug free, beginning with conception. Model drug-free behavior for your children. Drugs, including tobacco, alcohol, and misuse of prescription drugs can have a devastating effect on your child's development, en utero and later. Pieces of your child may be permanently lost.

11. Provide blocks, beads, sand, water, simple tools, pots and pans, dress-up clothes and other simple and raw materials at age-appropriate times.

No child care setting need be devoid of stimulating materials for the very young child does not discriminate between simple, inexpensive, natural materials and toys and manufactured, expensive ones. Free, cheap and natural are good enough, assuming the toys are safe.

10. Protect your child from stress and trauma including scolding, loud persistent noise, isolation, and physical and emotional abuse. The brain is acutely vulnerable to stress and trauma and the consequences of extended exposure on brain development are permanent.

11. Don't overstimulate your child with too many toys, too much meaningless talk, too much noise, or too much activity. Do provide plenty of time and interesting, safe places and materials to explore. Special toys or high-tech materials are unlikely to be more effective than talking with the child and making simple toys available. Very young children don't need flash card drills, incessant babbling by a parent or constant noise to get adequate stimulation for development. Indeed, overstimulation appears to have negative effects on brain development.

12. Read to your child, sing with your child, and play simple games with your child. Do this every day.

13. Extend your interest in healthy development to wherever your child goes. Ensure that your child has good nutrition at home, child care center and school. Don't accept the growing pattern of deleting recess, physical education, art and music (the "frills") from the school day. Consider another school for your child if such conditions exist.

14. If your child has a birth defect, developmental disorder, or has suffered a disabling injury, don't give up. The human brain has an amazing capacity to compensate, and to some degree, regenerate, given proper care and therapy.

15. Children are primed by biology to acquire certain basic skills of language and thinking which are intricately wired in early childhood. This wiring is the basis for later, complex, technical problem solving (e.g., mathematics, computer sciences) which will depend on strong cultural and social support for realization. The earliest years (0 -3) are critical periods for ensuring later success in a technological society.

References

ABC News. (1996). Romania: What happened to the children (videotape)? Turning Point. American Broadcasting Co., Inc.

Angier, N. (1992). The purpose of playful frolics: Training for adulthood. The New York Times, Oct. 20, B5-B6.

Barker, S. Brain science benefits from budget plan. Nature, 382, 105.

Begley, S. (1997). How to build a baby's brain. Newsweek Special Edition, Spring-Summer, 28-32.

Begley, S. (1996). Your child's brain. Newsweek. Feb. 29, 55-58.

Blakeslee, S. (1997). Studies show talking with infants shapes basis of ability to think. The New York Times, April 17, A-14.

Brownlee, S. (1997). The case for frivolity. U. S. News and World Report, Feb. 3, 45-49.

Education Commission of the States and the Charles A., Dana Foundation. (1996). Bridging the Gap Between Neuroscience and Education. Denver, CO: Education Commission of the States.

Brown, S. L. (1994). Animals at play. National Geographic. December, 2 - 35.

Bruer, J. T. (1997). Education and the brain: A bridge too far. Educational Researcher, 26, 4-16.

Chugani, H. T. (1994). Development of regional brain glucose metabolism in relation to behavior and plasticity. In G. Dawson, & K. W. Fischer, Human Behavior and the Developing Brain. New York: Guilford Press.

Frank, D. A., Klass, P. E., Earls, F., and Eisenberg, L. (1996). Infants and young children in orphanages: One view from pediatrics and child psychiatry. Pediatrics, 97, 573 - 580.

Fagen, R. M. (1992). In Angier, N. The purpose of playful frolics: Training for adulthood. The New York Times, Tuesday, October 20, B5, B-8.

Frost, J. L. (1975). At risk! Childhood Education, 51, 298-304.

Frost, J. L. (1968). Early Childhood Education Rediscovered. New York: Holt, Rinehart & Winston.

Frost, J. L. and Jacobs, P. (1997). Play deprivation and juvenile violence. Dimensions, Spring, 23, 14 - 20, 39.

Frost, J. L. (1992). Play and Playscapes. Albany, NY: Delmar.

Gardner, H. (1993). Multiple Intelligences: The Theory in Practice. New York: Basic Books.

Hartup, W. W. (1992). Having Friends, Making Friends, and Keeping Friends: Relationships as Educational Contexts. Urbana, IL: ERIC Clearinghouse on Elementary and Early Childhood Education, ED 345 854.

Healy, J. (1997). Current brain research. Scholastic Early Childhood Today. Aug., Sept. 42-43.

Hunt, J. McV. (1961). Intelligence and Experience. New York: The Ronald Press.

Isaacson, R. L. (1954). Recovery "?" from Early Brain Damage. Paper presented at the National Conference on Early Intervention with High Risk Infants and Young Children, University of North Carolina at Chapel Hill.

Landreth, G. (1991). Play Therapy: The Art of the Relationship. Bristol, PA: Accelerated Development.

Lipton, M. A. (1974). Early Experience and Plasticity of the Central Nervous System. Paper presented at the National Conference on Early Intervention with High Risk Infants and Young Children, University of North Carolina at Chapel Hill.

Long, K. (1997). Baby's brain begins distinguishing life experiences very early. Austin American-Statesman, June 4, E-4, E-6.

Melzack. R., & Scott, T. H. (1957). The effects of early experience on the response to pain. Journal of Comparative and Physiological Psychology, 50, 155-161.

Melzack, R., & Thompson, W. R. (1956). Effects of early experience on social behavior. Canadian Journal of psychology, 10, 82-90.

Nash, J. M. (1997). Fertile minds. Time: Special Report. February, 49 - 56.

Ounce of Prevention Fund. (1996). Starting Smart: How Early Experiences Affect Brain Development. Chicago: Ounce of Prevention Fund.

Perry, B. D. (1996). Incubated in terror: Neurodevelopmental factors in the "cycle of violence." In J. D. Osofsky, ed. Children, Youth and Violence: Searching for Solutions. New York: Guilford Press.

Piaget, J. (1951). Play, Dreams, and Imitation in Childhood. First ed., 1945. Translated by C. Gattegno and F. M. Hodgson. New York: International Universities Press.

Piaget, J. (1952). The origins of Intelligence in Children. First ed., 1936. translated by Margaret Cook. New York: International Universities Press.

Purpura, D. P. (1954). Neurological Effects of Early Isolation. Paper presented at the National Conference on Early Intervention with High Risk Infant and Young Children, University of North Carolina at Chapel Hill.

Ramey, C. T., and Ramey, S. L. (1996). Prevention of Intellectual disabilities: Early Interventions to Improve Cognitive Development. Birmingham: University of Alabama Civitan International Research Center.

Renken, B., Egeland, B., Marvinney, S., Mangelsdorf, S., and Stroufe, L. A. (1989). Early childhood antecedents of aggression and passive-withdrawal in early elementary school. Journal of Personality, 57, 257-281.

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

Sylwester, R. (1995). A Celebration of Neurons: An Educator's Guide to the Human Brain. Alexandria, VA: Association for Supervision and Curriculum Development.

Thatcher, R. W., Lyon, G. R., Rumsey, J., and Krasnegor, N. (Eds.) (1996). Developmental Neuroimaging: Mapping the Development of Brain and Behavior. New York: Academic Press.

Thompson, R. A. (1997). Early Brain Development and Early Intervention. Lincoln, NE: University of Nebraska.

Thompson, W. R., & Heron, W. (1954). The effects of restricting early experience on the problem-solving capacity of dogs. Canadian Journal of psychology, 8, 17-31.

Underwood, A., & Plagens, P. (1997). Little artists and athletes. Newsweek Special Issue, Spring-Summer, 14-15.

Vygotsky, L. S. (1976). Play and its role in the mental development of the child. In J. Bruner, A. Jolly, & K. Sylva (Eds.). Play - Its Role in Development and Evolution. New York: Basic Books. (Original written in 1933).

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

ERIC®

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: NEUROSCIENCE, PLAY AND CHILD DEVELOPMENT	
Author(s): JOE L. FROST	
Corporate Source:	Publication Date:

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1 [✓]	Level 2A [ ]	Level 2B [ ]
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature: Joe L. Frost	Printed Name/Position/Title: JOE L. FROST PROFESSOR	
Organization/Address: SZB 244 University of Texas, Austin, TX 78712	Telephone: 512-471-4089	FAX: 512-471-8460
	E-Mail Address: JFROST@mail.utexas.edu	Date: 2-9-99

(over)

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

ERIC Clearinghouse on Elementary and Early Childhood Education
and the National Parent Information Network
13 Children's Research Center
51 Gerty Drive
Champaign, IL 61820-7469
USA

October 15, 1998

Dear Colleague:

It has come to our attention that you will be giving a presentation at the ***1999 Annual International Conference "CLAIMING OUR FUTURE"*** of the ***Association for Childhood Education International*** be held in San Antonio, Texas, from April 7-10th. We would like you to consider submitting your presentation, or any other recently written education-related papers or reports, for possible inclusion in the **ERIC** database. As you may know, **ERIC (the Educational Resources Information Center)** is a federally-sponsored information system for the field of education. Its main product is the **ERIC** database, the world's largest source of education information. **The Clearinghouse on Elementary and Early Childhood Education** is one of sixteen subject-specialized clearinghouses making up the **ERIC** system. We collect and disseminate information relating to all aspects of children's development, care, and education.

Ideally, your paper should be at least eight pages long and not have been published elsewhere at the time of submission. ***Announcement in ERIC does not prevent you from publishing your paper elsewhere*** because you still retain complete copyright. Your paper will be reviewed and we will let you know within six weeks if it has been accepted.

Please sign and complete the reproduction release on the back of this letter, and return it with an abstract and two copies of your presentation to **ERIC/EECE**. If you have any questions, please contact me by phone at (800) 583-4135 or by email at (ksmith5@uiuc.edu). I look forward to receiving your paper.

Best wishes,

Karen E. Smith
Acquisitions Coordinator

Phone: 217-333-1386
800-583-4135 Voice/TTY
Fax: 217-333-3767

ERIC

E-Mail: ericeece@uiuc.org
http://ericeece.org
http://npni.org