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Work and Families Institute Conference Background-Brain Development in Young Children, June 1996 [1]

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Early Childhood Development Continued

FILES
Development- Work and Families Institute Conference Background 6/1996
Development- Home Visiting Issues
Development- HIPPY Event
Development- ELMIRA Study
Development- Home Visiting #2
Development- UNESCO Publication- HRC Piece
Development- Harvard/MIT Learning and the Brain Conference
Development- Title XX
Development- Early Childhood Development Studies
Development- Early Childhood Initiative Children 1997
Development- Reiner Foundation
Development- Prescription for Reading (PFR) - 1999
Development- PFR- Read Across America Initiative
Development- PFR- Events
Development- PFR- Easter Egg Roll 1999
Development- Reach Out and Read Background
Development- Kansas City Children's Conference 6/14/96

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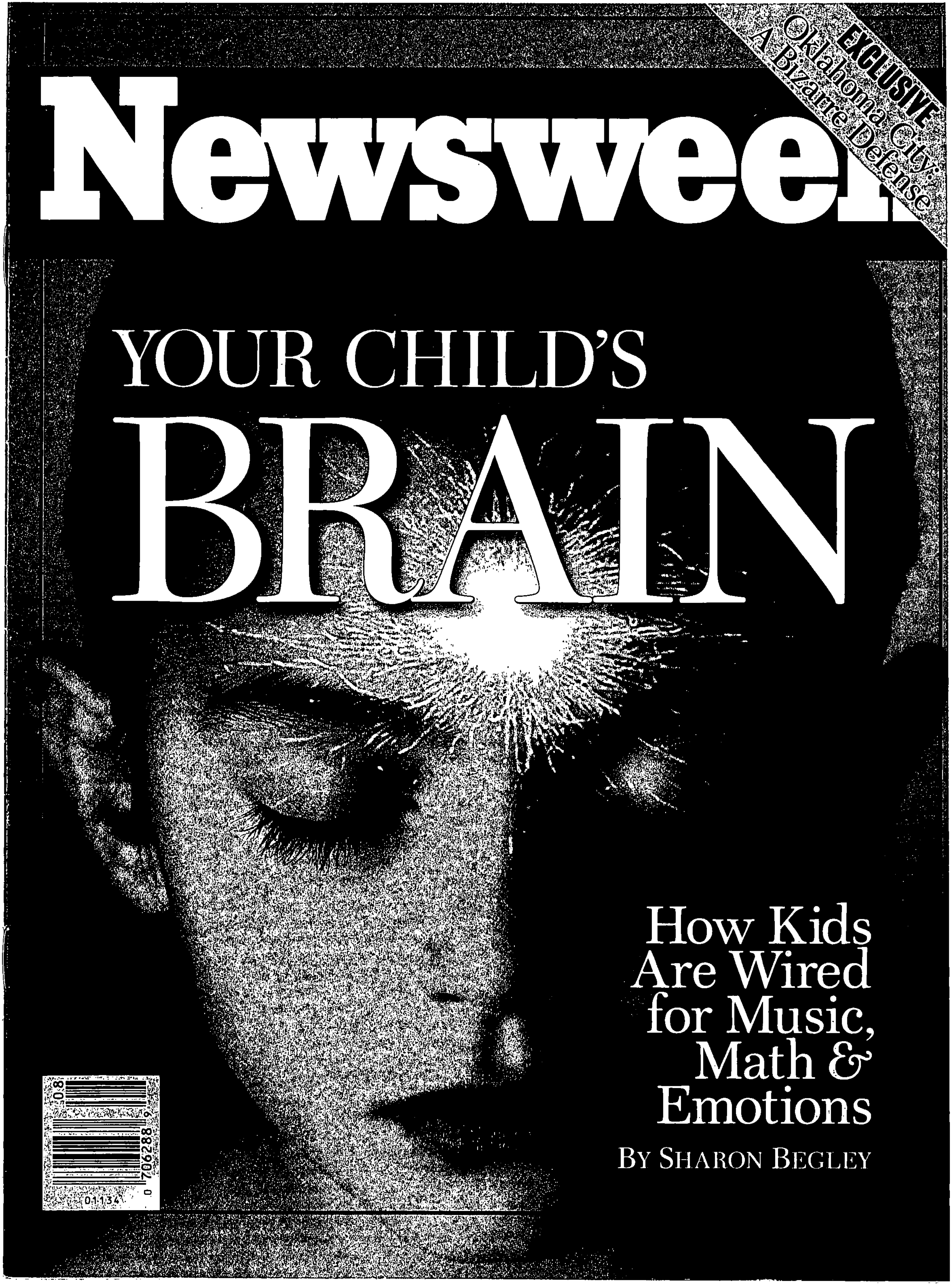
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BY SHARON BEGLEY

SPECIAL REPORT

FERTILE MINDS

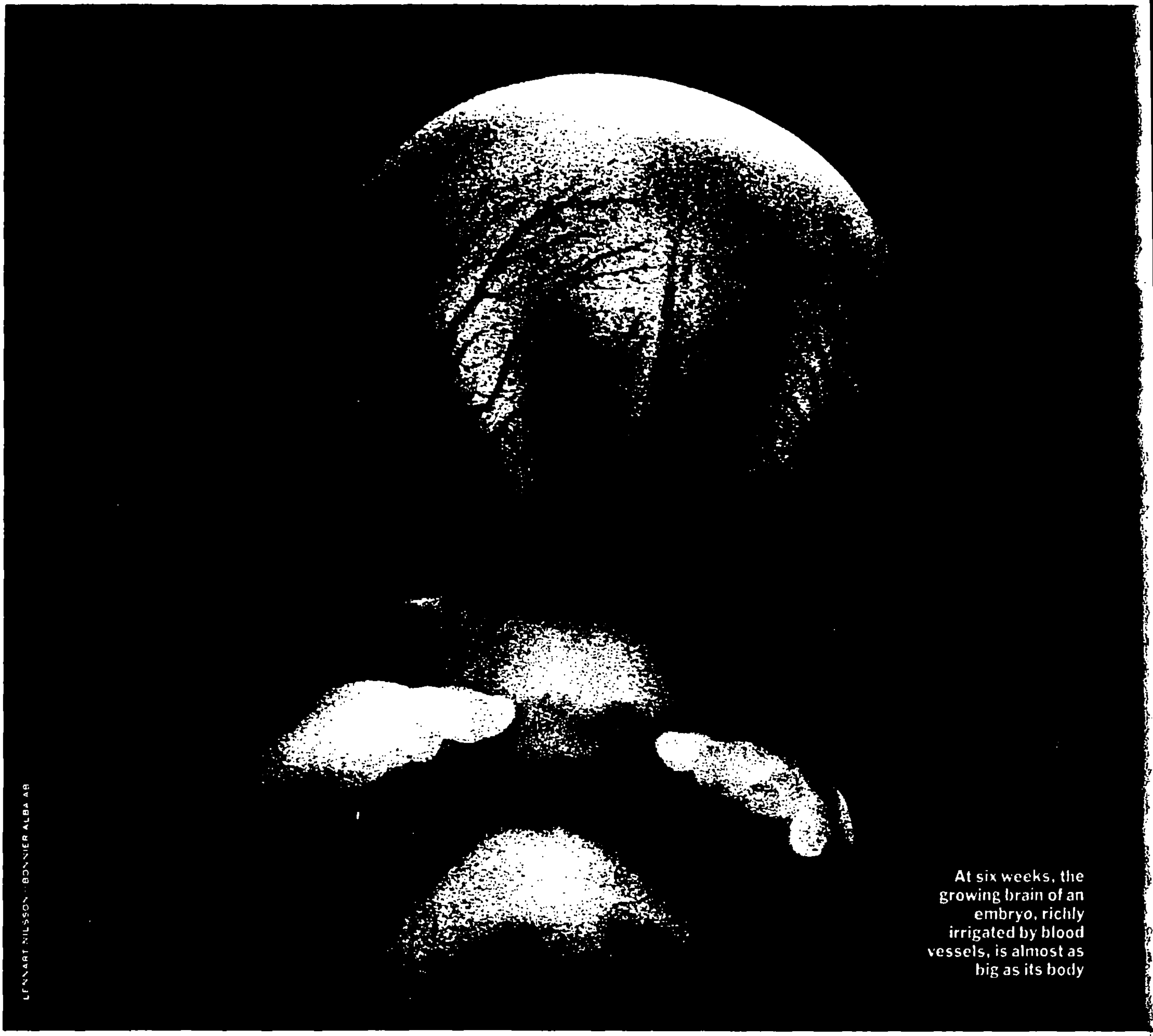
From birth, a baby's brain cells proliferate wildly, making connections that may shape a lifetime of experience. The first three years are critical

By J. MADELEINE NASH

RAT-A-TAT-TAT. RAT-A-TAT-TAT. RAT-A-TAT-tat. If scientists could eavesdrop on the brain of a human embryo 10, maybe 12 weeks after conception, they would hear an astonishing racket. Inside the womb, long before light first strikes the retina of the eye or the earliest dreamy images flicker through the cortex, nerve cells in the developing brain crackle with purposeful activity. Like teenagers with telephones, cells in one neighborhood of the brain are calling friends in another, and these cells are calling their friends, and they keep calling one another over and over again, "almost," says neurobiologist Carla Shatz of the University of California, Berkeley, "as if they were autodialing."

But these neurons—as the long, wiry cells that carry electrical messages through the nervous system and the brain are called—are not transmitting signals in scattershot fashion. That would produce a featureless static, the sort of noise picked up by a radio tuned between stations. On the contrary, evidence is growing that the staccato bursts of electricity that form those distinctive rat-a-tat-tats arise from coordinated waves of neural activity, and that those pulsing waves, like currents shifting sand on the ocean

Photograph by Anne Geddes



LENNART NILSSON · BONNIER ALBA AB

At six weeks, the growing brain of an embryo, richly irrigated by blood vessels, is almost as big as its body

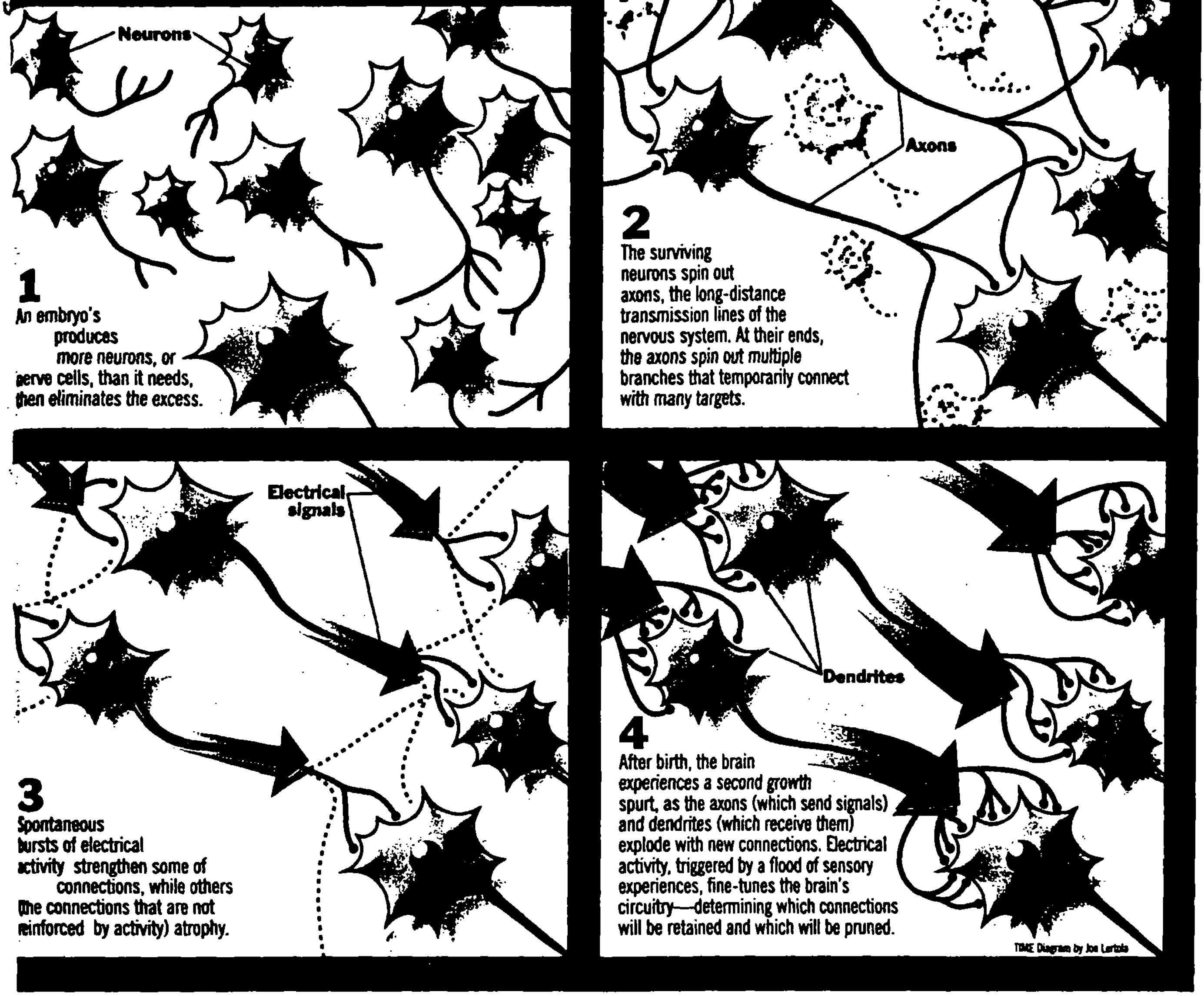
floor, actually change the shape of the brain, carving mental circuits into patterns that over time will enable the newborn infant to perceive a father's voice, a mother's touch, a shiny mobile twirling over the crib.

Of all the discoveries that have poured out of neuroscience labs in recent years, the finding that the electrical activity of brain cells changes the physical structure of the brain is perhaps the most breathtaking. For the rhythmic firing of neurons is no longer assumed to be a by-product of building the brain but essential to the process, and it begins, scientists have established, well before birth. A brain is not a computer. Nature does not cobble it together, then turn it on. No, the brain begins working long before it is finished. And the same processes that wire the brain before birth, neuroscientists are finding, also drive the explosion of learning that occurs immediately afterward.

At birth a baby's brain contains 100 billion neurons, roughly as many nerve cells as there are stars in the Milky Way. Also in place are a trillion glial cells, named after the Greek word for glue, which form a kind of honeycomb that protects and nourishes the neurons. But while the brain contains virtually all the nerve cells it will ever have, the pattern of wiring between them has yet to stabilize. Up to this point, says Shatz, "what the brain has done is lay out circuits that are its best guess about what's required for vision, for language, for whatever." And now it is up to neural activity—no longer spontaneous, but driven by a flood of sensory experiences—to take this rough blueprint and progressively refine it.

During the first years of life, the brain undergoes a series of extraordinary changes. Starting shortly after birth, a baby's brain, in a display of biological exuberance, produces trillions more connections between neurons than it can possibly use. Then, through a process that resembles Darwinian competition, the brain eliminates connections, or synapses, that are seldom or never used. The excess synapses in a child's brain undergo a draconian pruning, starting around the age of 10 or earlier, leaving behind a mind whose patterns of emotion and thought are, for better or worse, unique.

Wiring the Brain



Deprived of a stimulating environment, a child's brain suffers. Researchers at Baylor College of Medicine, for example, have found that children who don't play much or are rarely touched develop brains 20% to 30% smaller than normal for their age. Laboratory animals provide another provocative parallel. Not only do young rats reared in toy-strewn cages exhibit more complex behavior than rats confined to sterile, uninteresting boxes, researchers at the University of Illinois at Urbana-Champaign have found, but the brains of these rats contain as many as 25% more synapses per neuron. Rich experiences, in other words, really do produce rich brains.

The new insights into brain development are more than just interesting science. They have profound implications for parents and policymakers. In an age when mothers and fathers are increasingly pressed for time—and may already be feeling guilty about how many hours they spend away from their children—the results coming out of the labs are likely to increase concerns about leaving very young children in the care of others. For the data underscore the importance of hands-on parenting, of finding the time to cuddle a baby, talk with a toddler and provide infants with stimulating experiences.

The new insights have begun to infuse new passion into the political debate over early education and day care. There is an urgent need, say child-development experts, for preschool programs designed to boost the brain power of youngsters born into impoverished rural and inner-city households. Without such programs, they warn, the current drive to curtail welfare costs by pushing mothers with infants and toddlers into the work force may well backfire. "There is a time scale to brain development, and the most important year is the first," notes Frank Newman, president of the Education Commission of the States. By the age of three, a child who is neglected or abused bears marks that, if not indelible, are exceedingly difficult to erase.

But the new research offers hope as well. Scientists have found that the brain during the first years of life is so malleable that very young children who suffer strokes or injuries that wipe out an entire hemisphere can still mature into highly functional adults. Moreover, it is becoming increasingly clear that well-designed preschool programs can help many children overcome glaring deficits in their home environment. With appropriate therapy, say researchers, even serious disorders like dyslexia may be treatable. While inherited problems may place certain children at greater risk than others, says Dr. Harry Chugani, a pediatric neurologist at Wayne State University in Detroit, that is no excuse for ignoring the environment's power to remodel the brain. "We may not do much to change what happens before birth, but we can change what happens after a baby is born," he observes.

Strong evidence that activity changes the brain began accumulating in the 1970s. But only recently have researchers had tools powerful enough to reveal the precise mechanisms by which those changes are brought about. Neural activity triggers a biochemical cascade that reaches all the way to the nucleus of cells and the coils of DNA that encode specific genes. In fact, two of the genes affected by neural activity in embryonic fruit flies, neurobiologist Corey Goodman and his colleagues at Berkeley reported late last year, are identical to those that other studies have linked to learning and memory. How thrilling, exclaims Goodman, how intellectually satisfying that the snippets of DNA that embryos use to build their brains are the very same ones that will later allow adult organisms to process and store new information.

As researchers explore the once hidden links between brain activity and brain structure, they are beginning to construct a sturdy bridge over the chasm that previously separated genes from the environment. Experts now agree that a baby does not come into the world as a genetically preprogrammed automaton or a blank slate at the mercy of the environment, but arrives as something much more interesting. For this reason the debate that engaged countless generations of philosophers—whether nature or nurture calls the shots—no longer interests most scientists. They are much too busy chronicling the myriad ways in which genes and the environment interact. "It's not a competition," says Dr. Stanley Greenspan, a psychiatrist at George Washington University. "It's a dance."

THE IMPORTANCE OF GENES

THAT DANCE BEGINS AT AROUND THE THIRD week of gestation, when a thin layer of cells in the developing embryo performs an origami-like trick, folding inward to give rise to a fluid-filled cylinder known as the neural tube. As cells in the neural tube proliferate at the astonishing rate of 250,000 a minute, the brain and spinal cord assemble themselves in a series of tightly choreographed steps. Nature is the dominant partner during this phase of development, but nurture plays a vital supportive role. Changes in the environment of the womb—whether caused by maternal malnutrition, drug abuse or a viral infection—can wreck the clockwork precision of the neural assembly line. Some forms of epilepsy, mental retardation, autism and schizophrenia appear to be the results of developmental processes gone awry.

But what awes scientists who study the brain, what still stuns them, is not that things occasionally go wrong in the developing brain but that so much of the time they go right. This is all the more remarkable, says Berkeley's Shatz, as the central nervous system of an embryo is not a miniature of the adult system but more like a tadpole that gives rise to a frog. Among other things, the cells produced in the neural tube must migrate to distant locations and accurately lay down the connections that link one part of the brain to another. In addition, the embryonic brain must construct a variety of temporary structures, including the neural tube, that will, like a tadpole's tail, eventually disappear.

What biochemical magic underlies this incredible metamorphosis? The instructions programmed into the genes, of course. Scientists have recently discovered, for instance, that a gene nicknamed "sonic hedgehog" (after the popular video game Sonic the Hedgehog) determines the fate of neurons in the spinal cord and the brain. Like a strong scent carried by the wind, the protein encoded by the hedgehog gene (so called because in its absence, fruit-fly embryos sprout a coat of prickles) diffuses outward from the cells that produce it, becoming fainter and fainter. Columbia University neurobiologist Thomas Jessell has found that it takes middling concentrations of this potent morphing factor to produce a motor neuron and lower concentrations to make an interneuron (a cell that relays signals to other neurons, instead of to muscle fibers, as motor neurons do).

Scientists are also beginning to identify some of the genes that guide neurons in their long migrations. Consider the problem faced by neurons destined to become part of the cerebral cortex. Because they

Wiring Vision

PENNY GENTIEU

WHAT'S GOING ON Babies can see at birth, but not in fine-grained detail. They have not yet acquired the knack of focusing both eyes on a single object or developed more sophisticated visual skills like depth perception. They also lack hand-eye coordination.

WHAT PARENTS CAN DO There is no need to buy high-contrast black-and-white toys to stimulate vision. But regular eye exams, starting as early as two weeks of age, can detect problems that, if left uncorrected, can cause a weak or unused eye to lose its functional connections to the brain.

WINDOW OF LEARNING Unless it is exercised early on, the visual system will not develop.

AGE (in years) Birth 1 2 3 4 5 6 7 8 9 10

Visual acuity

Binocular vision

arise relatively late in the development of the mammalian brain, billions of these cells must push and shove their way through dense colonies established by earlier migrants. "It's as if the entire population of the East Coast decided to move en masse to the West Coast," marvels Yale University neuroscientist Dr. Pasko Rakic, and marched through Cleveland, Chicago and Denver to get there.

But of all the problems the growing nervous system must solve, the most daunting is posed by the wiring itself. After birth, when the number of connections explodes, each of the brain's billions of neurons will forge links to thousands of others. First they must spin out a web of wirelike fibers known as axons (which transmit signals) and dendrites (which receive them). The objective is to form a synapse, the gaplike structure over which the axon of one neuron beams a signal to the dendrites of another. Before this can happen, axons and dendrites must almost touch. And while the short, bushy dendrites don't have to travel very far, axons—the heavy-duty cables of the nervous system—must traverse distances that are the microscopic equivalent of miles.

What guides an axon on its incredible voyage is a "growth cone," a creepy, crawly sprout that looks something like an amoeba. Scientists have known about growth cones since the turn of the century. What they didn't know until recently was that growth cones come equipped with the molecular equivalent of sonar and radar. Just as instruments in a submarine or airplane scan the environment for signals, so molecules arrayed on the surface of growth cones search their surroundings for the presence of certain proteins. Some of these proteins, it turns out, are attractants that pull the growth cones toward them, while others are repellents that push them away.

THE FIRST STIRRINGS

UP TO THIS POINT, GENES HAVE CONtrolled the unfolding of the brain. As soon as axons make their first connections, however, the nerves begin to fire, and what they do starts to matter more and more. In essence, say scientists, the developing nervous system has strung the equivalent of telephone trunk lines between the right neighborhoods in the right cities. Now it has to sort out which wires belong to which house, a problem that cannot be solved by genes alone for reasons that boil down to simple arithmetic. Eventually, Berkeley's Goodman estimates, a human brain must forge quadrillions of connections. But there are only 100,000 genes in human DNA. Even though half these genes—some 50,000—appear to be dedicated to constructing and maintaining the nervous system, he observes, that's not enough to specify more than a tiny fraction of the connections required by a fully functioning brain.

In adult mammals, for example, the axons that connect the brain's visual system arrange themselves in striking layers and columns that reflect the division between the left eye and the right. But these axons start out as scrambled as a bowl of spaghetti, according to Michael Stryker, chairman of the physiology department at the University of California at San Francisco. What sorts out the mess, scientists have established, is neural activity. In a series of experiments viewed as classics by scientists in the field, Berkeley's Shatz chemically blocked neural activity in embryonic cats. The result? The axons that connect neurons in the retina of the eye to the brain never formed the left eye–right eye geometry needed to support vision.

But no recent finding has intrigued researchers more than the results reported in October by Corey Goodman and his Berkeley colleagues. In studying a deceptively simple problem—how axons from motor neurons in the fly's central nerve cord establish connections with muscle cells in its limbs—the Berkeley researchers made an unexpected discovery. They knew there was a gene that keeps bundles of axons together as they race toward their muscle-cell targets. What they discovered was that the electrical activity produced by neurons inhibited this gene, dramatically increasing the number of connections the axons made. Even more intriguing, the signals amplified the activity of a second gene—a gene called CREB.

The discovery of the CREB amplifier, more than any other, links the developmental processes that occur before birth to those that continue long after. For the twin processes of memory and learning in adult animals, Columbia University neurophysiologist Eric Kandel has shown, rely on the CREB molecule. When Kandel blocked the activity of CREB in giant snails, their brains changed in ways that suggested that they could still learn but could remember what they learned for only a short period of time. Without CREB, it seems, snails—and by extension, more developed animals like hu-

Wiring Feelings

WHAT'S GOING ON Among the first circuits the brain constructs are those that govern the emotions. Beginning around two months of age, the distress and contentment experienced by newborns start to evolve into more complex feelings: joy and sadness, envy and empathy, pride and shame.

WHAT PARENTS CAN DO Loving care provides a baby's brain with the right kind of emotional stimulation. Neglecting a baby can produce brain-wave patterns that dampen happy feelings. Abuse can produce heightened anxiety and abnormal stress responses.

WINDOW OF LEARNING Emotions develop in layers, each more complex than the last.

AGE (in years) Birth 1 2 3 4 5 6 7 8 9 10
Stress Response
Empathy, Envy

mans—can form no long-term memories. And without long-term memories, it is hard to imagine that infant brains could ever master more than rudimentary skills. "Nurture is important," says Kandel. "But nurture works through nature."

EXPERIENCE KICKS IN

WHEN A BABY IS BORN, IT CAN SEE and hear and smell and respond to touch, but only dimly. The brain stem, a primitive region that controls vital functions like heartbeat and breathing, has completed its wiring. Elsewhere the connections between neurons are wispy and weak. But over the first few months of life, the brain's higher centers explode with new synapses. And as dendrites and axons swell with buds and branches like trees in spring, metabolism soars. By the age of two, a child's brain contains twice as many synapses and consumes twice as much energy as the brain of a normal adult.

University of Chicago pediatric neurologist Dr. Peter Huttenlocher has chronicled this extraordinary epoch in brain development by autopsying the brains of infants and young children who have died unexpectedly. The number of synapses in one layer of the visual cortex, Huttenlocher reports, rises from around 2,500 per neuron at birth to as many as 18,000 about six months later. Other regions of the cortex score similarly spectacular increases but on slightly different schedules. And while these microscopic connections between nerve fibers continue to form throughout life, they reach their highest average densities (15,000 synapses per neuron) at around the age of two and remain at that level until the age of 10 or 11.

This profusion of connections lends the growing brain exceptional flexibility and resilience. Consider the case of 13-year-old Brandi Binder, who developed such severe epilepsy that surgeons at UCLA had to remove the entire right side of her cortex when she was six. Binder lost virtually all the control she had established over muscles on the left side of her body, the side controlled by the right side of the brain. Yet today, after years of therapy ranging from leg lifts to math and music drills, Binder is an A student at the Holmes Middle School in Colorado Springs, Colorado. She loves music, math and art—skills usually associated with the right half of the brain. And while Binder's recuperation is not 100%—for example, she has never regained the use of her left arm—it comes close. Says UCLA pediatric neurologist Dr. Donald Shields: "If there's a way to compensate, the developing brain will find it."

What wires a child's brain, say neuroscientists—or rewires it after physical trauma—is repeated experience. Each time a baby tries to touch a tantalizing object or gazes intently at a face or listens to a lullaby, tiny bursts of electricity shoot through the brain, knitting neurons into circuits as well defined as those etched onto silicon chips. The results are those behavioral mileposts that never cease to delight and awe parents. Around the age of two months, for example, the motor-control centers of the brain develop to the point that infants can suddenly reach out and grab a nearby object. Around the age of four months, the cortex begins to refine the connections needed for depth perception and binocular vision. And around the age of 12 months, the speech centers of the brain are poised to produce what is perhaps the most magical moment of childhood: the first word that marks the flowering of language.

When the brain does not receive the right information—or shuts it out—the result can be devastating. Some children who display early signs of autism, for example, retreat from the world because they are hypersensitive to sensory stimulation, others because their senses are underactive and provide them with too little information. To be effective, then, says George Washington University's Greenspan, treatment must target the underlying condition, protecting some children from disorienting noises and lights, providing others with attention-grabbing stimulation. But when parents and therapists collaborate in an intensive effort to reach these abnormal brains, writes Greenspan in a new book, *The Growth of the Mind* (Addison-Wesley, 1997), three-year-olds who begin the descent into the autistic's limited universe can sometimes be snatched back.

Indeed, parents are the brain's first and most important teachers. Among other things, they appear to help babies learn by adopting the rhythmic, high-pitched speaking style known as Parentese. When speaking to babies, Stanford University psychologist Anne Fernald has found, mothers and fathers from many cultures change their speech patterns in the same peculiar ways. "They put their faces very close to the child," she reports. "They use shorter utterances, and they speak in an unusually melodious fashion." The heart rate of infants increases while listening to Parentese, even Parentese delivered in a

Wiring Language

WHAT'S GOING ON Even before birth, an infant is tuning into the melody of its mother's voice. Over the next six years, its brain will set up the circuitry needed to decipher—and reproduce—the lyrics. A six-month-old can recognize the vowel sounds that are the basic building blocks of speech.

WHAT PARENTS CAN DO Talking to a baby a lot, researchers have found, significantly speeds up the process of learning new words. The high-pitched, singsong speech style known as Parentese helps babies connect objects with words.

WINDOW OF LEARNING Language skills are sharpest early on but grow throughout life.

AGE (in years) Birth 1 2 3 4 5 6 7 8 9 10

Recognition of speech

Vocabulary

foreign language. Moreover, Fernald says, Parentese appears to hasten the process of connecting words to the objects they denote. Twelve-month-olds, directed to "look at the ball" in Parentese, direct their eyes to the correct picture more frequently than when the instruction is delivered in normal English.

In some ways the exaggerated, vowel-rich sounds of Parentese appear to resemble the choice morsels fed to hatchlings by adult birds. The University of Washington's Patricia Kuhl and her colleagues have conditioned dozens of newborns to turn their heads when they detect the *ee* sound emitted by American parents, vs. the *eu* favored by doting Swedes. Very young babies, says Kuhl, invariably perceive slight variations in pronunciation as totally different sounds. But by the age of six months, American babies no longer react when they hear variants of *ee*, and Swedish babies have become impervious to differences in *eu*. "It's as though their brains have formed little magnets," says Kuhl, "and all the sounds in the vicinity are swept in."

TUNED TO DANGER

EVEN MORE FUNDAMENTAL, SAYS Dr. Bruce Perry of Baylor College of Medicine in Houston, is the role parents play in setting up the neural circuitry that helps children regulate their responses to stress. Children who are physically abused early in life, he observes, develop brains that are exquisitely tuned to danger. At the slightest threat, their hearts race, their stress hormones surge and their brains anxiously track the nonverbal cues that might signal the next attack. Because the brain develops in sequence, with more primitive structures stabilizing their connections first, early abuse is particularly damaging. Says Perry: "Experience is the chief architect of the brain." And because these early experiences of stress form a kind of template around which later brain development is organized, the changes they create are all the more pervasive.

Emotional deprivation early in life has a similar effect. For six years University of Washington psychologist Geraldine Dawson and her colleagues have monitored the brain-wave patterns of children born to mothers who were diagnosed as suffering from depression. As infants, these children showed markedly reduced activity in the left frontal lobe, an area of the brain that serves as a center for joy and other lighthearted emotions. Even more telling, the patterns of brain activity displayed by these children closely tracked the ups and downs of their mother's depression. At the age of three, children whose mothers were more severely depressed or whose depression lasted longer continued to show abnormally low readings.

Strikingly, not all the children born to depressed mothers develop these aberrant brain-wave patterns, Dawson has found. What accounts for the difference appears to be the emotional tone of the exchanges between mother and child. By scrutinizing hours of videotape that show depressed mothers interacting with their babies, Dawson has attempted to identify the links between maternal behavior and children's brains. She found that mothers who were disengaged, irritable or impatient had babies with sad brains. But depressed mothers who managed to rise above their melancholy, lavishing their babies with attention and indulging in playful games, had children with brain activity of a considerably more cheerful cast.

When is it too late to repair the damage wrought by physical and emotional abuse or neglect? For a time, at least, a child's brain is extremely forgiving. If a mother snaps out of her depression before her child is a year old, Dawson has found, brain activity in the left frontal lobe quickly picks up. However, the ability to rebound declines markedly as a child grows older. Many scientists believe that in the first few years of childhood there are a number of critical or sensitive periods, or "windows," when the brain demands certain types of input in order to create or stabilize certain long-lasting structures.

For example, children who are born with a cataract will become permanently blind in that eye if the clouded lens is not promptly removed. Why? The brain's visual centers require sensory stimulus—in this case the stimulus provided by light hitting the retina of the eye—to maintain their still tentative connections. More controversially, many linguists believe that language skills unfold according to a strict, biologically defined timetable. Children, in their view, resemble certain species of birds that cannot master their song unless they hear it sung at an early age. In zebra finches the window for acquiring the appropriate song opens 25 to 30 days after hatching and shuts some 50 days later.

WINDOWS OF OPPORTUNITY

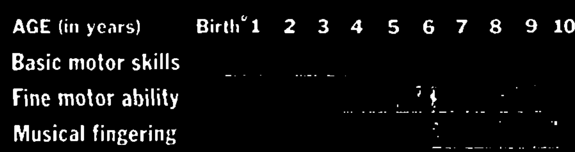
WITH A FEW EXCEPTIONS, THE WINDOWS OF opportunity in the human brain do not close quite so abruptly. There appears to be a series of windows for developing lan-

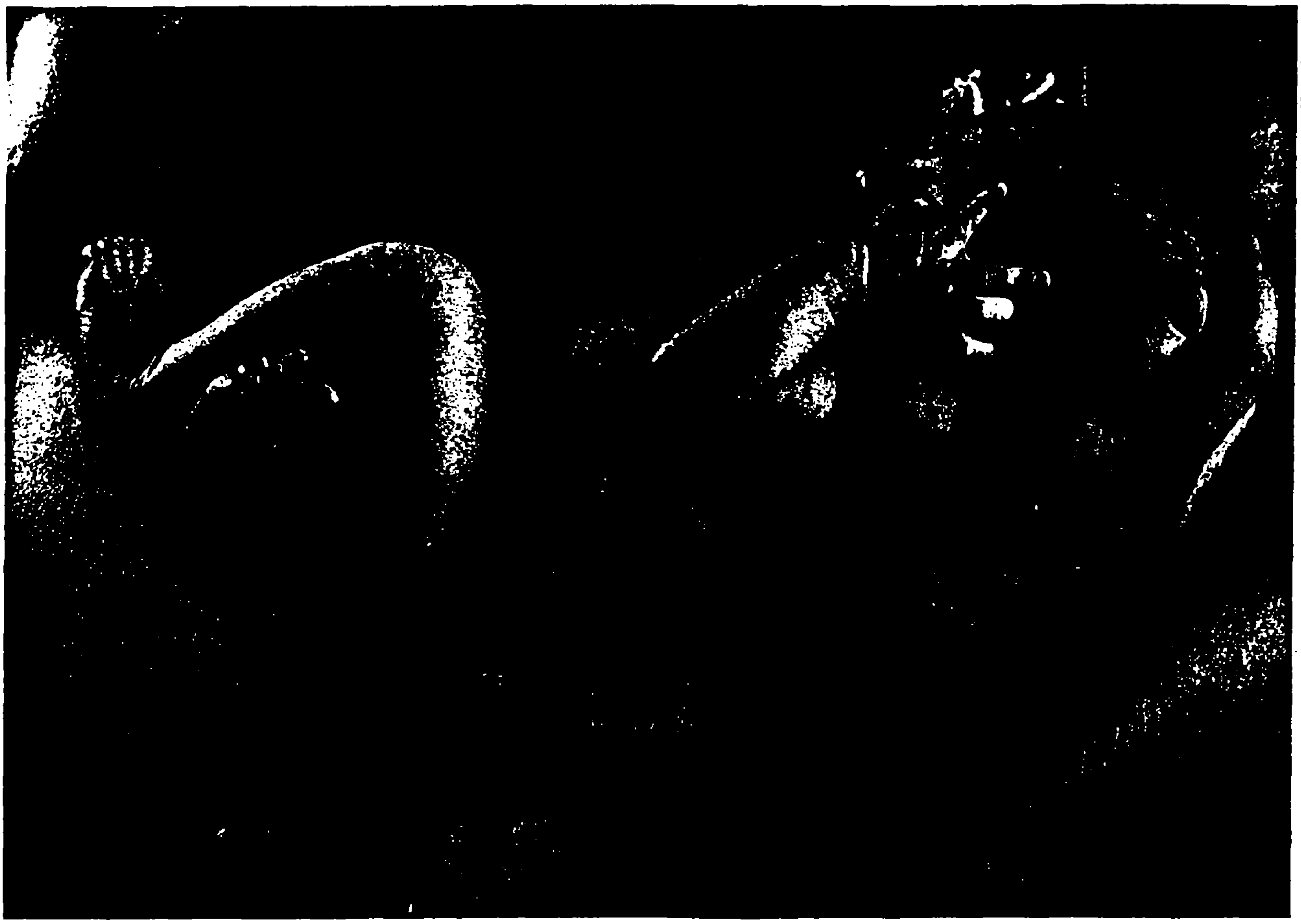
Wiring Movement

WHAT'S GOING ON At birth babies can move their limbs, but in a jerky, uncontrolled fashion. Over the next four years, the brain progressively refines the circuits for reaching, grabbing, sitting, crawling, walking and running.

WHAT PARENTS CAN DO Give babies as much freedom to explore as safety permits. Just reaching for an object helps the brain develop hand-eye coordination. As soon as children are ready for them, activities like drawing and playing a violin or piano encourage the development of fine motor skills.

WINDOW OF LEARNING Motor-skill development moves from gross to increasingly fine.





ANNE GEDDES

guage. The window for acquiring syntax may close as early as five or six years of age, while the window for adding new words may never close. The ability to learn a second language is highest between birth and the age of six, then undergoes a steady and inexorable decline. Many adults still manage to learn new languages, but usually only after great struggle.

The brain's greatest growth spurt, neuroscientists have now confirmed, draws to a close around the age of 10, when the balance between synapse creation and atrophy abruptly shifts. Over the next several years, the brain will ruthlessly destroy its weakest synapses, preserving only those that have been magically transformed by experience. This magic, once again, seems to be encoded in the genes. The ephemeral bursts of electricity that travel through the brain, creating everything from visual images and pleasurable sensations to dark dreams and wild thoughts, ensure the survival of synapses by stimulating genes that promote the release of powerful growth factors and suppressing genes that encode for synapse-destroying enzymes.

By the end of adolescence, around the age of 18, the brain has declined in plasticity but increased in power. Talents and latent tendencies that have been nurtured are ready to blossom. The experiences that drive neural activity, says Yale's Rakic, are like a sculptor's chisel or a dressmaker's shears, conjuring up form from a lump of stone or a length of cloth. The presence of extra material expands the range of possibilities, but cutting away the extraneous is what makes art. "It is the overproduction of synaptic connections followed by their loss that leads to patterns in the brain," says neuroscientist William Greenough of the University of Illinois at Urbana-Champaign. Potential for greatness may be encoded in the genes, but whether that potential is realized as a gift for mathematics, say, or a brilliant criminal mind depends on patterns etched by experience in those critical early years.

Psychiatrists and educators have long recognized the value of early experience. But their observations have until now been largely anecdotal. What's so exciting, says Matthew Melmed, executive director of Zero to Three, a nonprofit organization devoted to highlighting the importance of the first three years of life, is that modern neuroscience is providing the hard, quantifiable evidence that was missing earlier. "Because you can see the results under a microscope or in a PET scan," he observes, "it's become that much more convincing."

What lessons can be drawn from the new findings? Among other things, it is clear that foreign languages should be taught in elementary school, if not before. That remedial education may be more effective at the age of three or four than at nine or 10. That good, affordable day care is not a luxury or a fringe benefit for welfare mothers and working parents but essential brain food for the next generation. For while new synapses continue to form throughout life, and even adults continually refurbish their minds through reading and learning, never again will the brain be able to master new skills so readily or rebound from setbacks so easily.

Rat-a-tat-tat. Rat-a-tat-tat. Rat-a-tat-tat. Just last week, in the U.S. alone, some 77,000 newborns began the miraculous process of wiring their brains for a lifetime of learning. If parents and policymakers don't pay attention to the conditions under which this delicate process takes place, we will all suffer the consequences—starting around the year 2010. ■

THE DAY-CARE

By JAMES COLLINS

ENVIRONMENT MATTERS. FOR ANYone wondering how the latest brain research applies to the care of infants and toddlers, that is the crucial finding. Yes, proper brain development is a matter of genetics and nutrition and whether a mother-to-be drinks or smokes, but it also depends on the stimuli, as the scientists call them, that a baby receives. It depends on what the baby sees, hears and touches and on the emotions he or she repeatedly experiences. But if environment matters, we are faced with a question: At a time when children suffer from perhaps the gravest social problems of any group in the U.S., how do we ensure that they grow up in the best environment possible?

In many ways, children are better off today than they were in previous decades. They are healthier, their families have a higher income, the level of their mother's education (the most important determinant of a child's intelligence) has risen. But 1 out of every 10 children three years old and younger lives in "extreme poverty"—at or below 50% of the federal poverty level. And the well-being of many others is threatened by such social changes as the rise of single-parent households, the uneven quality of day care, the decline of communities and, some would argue, the push to reform the welfare system.

Social policy cannot ameliorate all these conditions. A change in attitude toward parenting and marriage would do children far more good than any government program. Over the past few years, however, there has been a movement in Washington and the state capitals to address the problems of children, from newborn to the age of three. Now neuroscientists, by confirming much of what social scientists had already surmised about early development, are giving that movement added momentum.

The recent concern about infants and toddlers has been inspired in part by *Starting Points*, a landmark report published by the Carnegie Corporation in 1994, which identified a "quiet crisis" in the lives of the youngest children. Hillary Clinton has begun to speak out on the importance of a child's earliest years, and several Governors have forcefully taken up the issue. The size of the programs in place is quite modest. But to their advocates they hold out promise not only

DILEMMA

Too many children today live in conditions that threaten their brain development. What can we do?

of helping children fulfill their potential but also of saving society the costs incurred when intellectually and socially impaired children grow up to be intellectually and socially impaired adults.

Government policy in any number of areas—health care, taxes, the economy, crime—touches children. But the initiative that will have the most particular and powerful effect on them is welfare reform. If, as some predict, the incomes of poor mothers are drastically reduced as a result of the new system, children will be harmed.

But let's assume that the reforms work as intended and mothers get jobs that pay them more than paupers' wages. What effect may the changes have on childhood development?

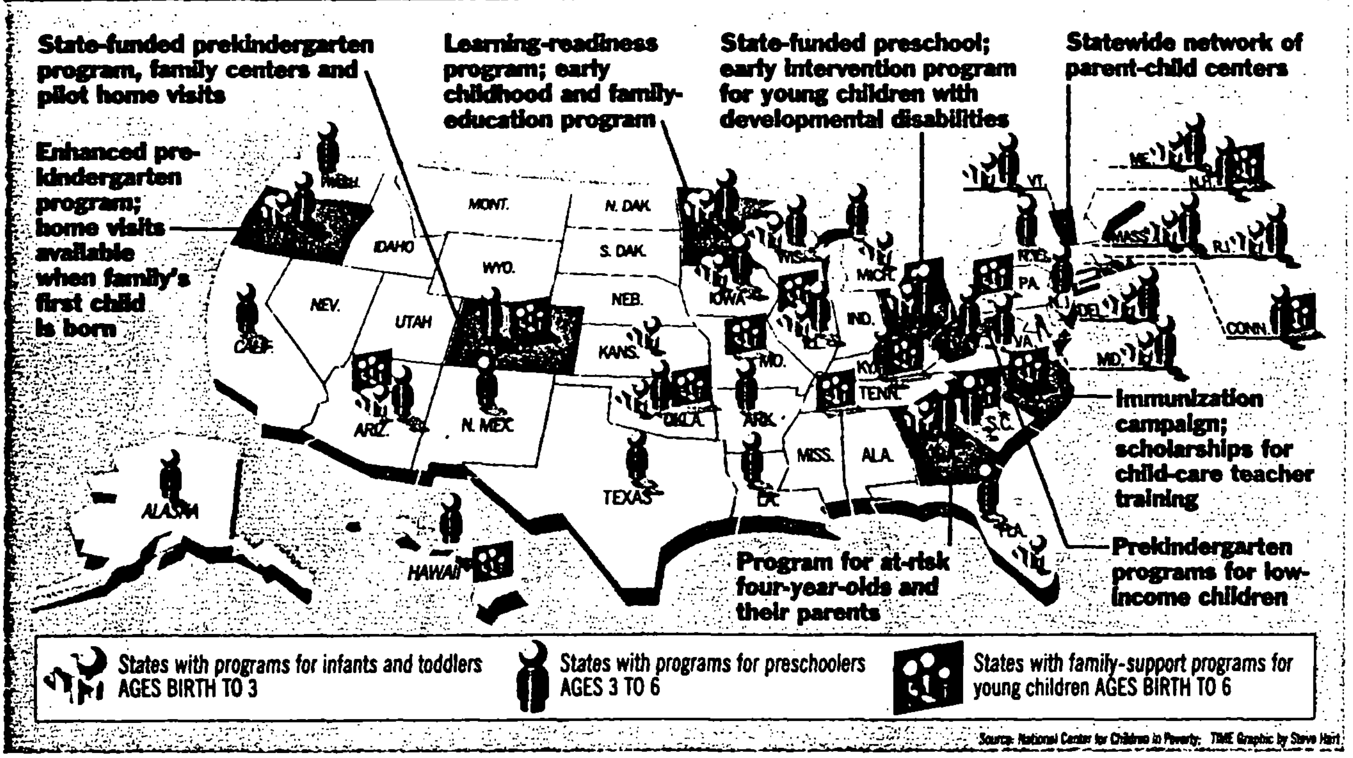
There is some evidence that children benefit if their mothers stay home with them until they are one year old, and the welfare law allows states to exempt new mothers from work requirements for a year. But so far, states do not seem to be taking advantage of the provision. For example, in Wisconsin, which is a leader in welfare reform, mothers must start looking for work when their baby is 12 weeks old. Those who favor these reforms say a mother who has a job will be a prouder and more responsible parent, and some studies suggest that children do benefit if their mother receives earned income rather than a government check for the same amount.

If mothers are out working, however, the quality of child care provided by others will largely determine how well the children fare under the states' new plans. To care for their children, many mothers will rely on relatives and friends, some of whom will be loving and attentive and some of whom will not. Also, the strain on the day-care system is a matter of grave concern to child-development and child-care experts. A recent study found that 40% of day-care centers for infants and toddlers gave less than the minimal standard of care. Problems ranged from safety hazards to unresponsive caregivers to a lack of toys. If a caregiver spoons food from one bowl into the mouths of half a dozen toddlers lined up in high chairs, as has been known to happen, not only is the health of the children at risk but they are surely not receiving the kind of attention that promotes healthy brain development.

"If you push more children into this system through welfare reform," says Ellen Galinsky, co-president of the Families and Work Institute, "and you are saying to these families, 'Just get any child care you can find and can pay for,' there's a real danger."

The challenge for the states is to regulate and subsidize child care in such a way

What States Are Doing



as to increase the likelihood of good outcomes for children. This is true regardless of welfare reform, of course. Bad day-care can harm the development of any child. Research has shown that children benefit when caregivers are trained and the ratio of staff to children is high. Several states license centers accordingly, requiring a minimum amount of training and setting ratios for different age groups. Welfare mothers themselves are not necessarily the best caregivers, and it is possible that in some instances welfare reform will actually improve the care of children. But high-quality care is expensive, and states do not have adequate budgets to subsidize it.

The Federal Government and the states do have programs specifically aimed at helping the development of infants and toddlers, although as social policy they are nowhere near as sweeping as an overhaul of welfare. The most notable federal initiative is Early Head Start, which was created in 1994 when Congress reauthorized funding for Head Start, the 32-year-old program that brings three-, four- and five- year-olds into classroom settings in part to prepare them for school. Mary Jo Bane was working at the time at the Department of Health and Human Services (she quit over welfare reform), and she led a task force charged with finding ways to improve Head Start. Child-development experts, she says, "pointed the group toward the importance of interventions earlier than age four."

In 1996, the budget for Early Head Start was $146 million, and HHS awarded grants to 143 sites. The money is used to provide a variety of services to poor families with children under the age of four and to poor pregnant women. How the funds are spent is determined to some extent by the communities that receive them. Some communities are experimenting with family interventions that include grandparents; others are trying to address the special health needs of newborns or to provide extra help to teen parents with a history of drug abuse.

SMART START, HEALTHY START

NORTH CAROLINA HAS INSTITUTED A FLEXIble program called Smart Start. Under it, parents, teachers, doctors and nurses, child-care providers, ministers and businesspeople form partnerships at the county level that set goals for the education and health care of children under six. These partnerships then administer private and public funds as they see fit. In one county, for example, administrators chose to give subsidies to new parents so that mothers could stay home from work during a baby's first year. More than half of North Carolina's 100 counties are participating in the program, at a cost to the state of $68 million.

Governor James Hunt hopes that by adding hard science to his arguments, he will strengthen his position when battling for increases in Smart Start funding. "This is revolutionary information," he says of studies demonstrating the sensitivity of babies' brains in the first years of life. "Now that we can measure it and prove it, and if it can be made known widely so people understand this, then they'll understand why their schools aren't going to work for them, their technical training isn't going to work, other things we do later on aren't going to work fully unless we do this part right and do this at the appropriate time."

Some states have found that a very simple but powerful way to help parents is simply to coordinate the various services that they already offer. In West Virginia, for example, single sites that provide more than a dozen services have been established in seven communities. "Parents typically get a runaround and may only get a long list of phone numbers," says Kimberly Veraas, chairwoman of the state's Early Childhood Implementation Commission. "If they're really motivated, they can get information. But now we're rolling out the red carpet to parents. They only have to tell their story once."

As developmental experts often point out, child rearing is not an innate skill, and several states are trying to help educate parents about parenting. Home visits by social workers or nurses are among the most promising methods. In Oregon such visits occur under a program called Healthy Start. Sandra Daus, 22, a single mother of an 18-month-old girl, recalls the help she received from Mellissa Magill. "She encouraged me to read books, a lot of books," says Daus. "I thought when Sydney got older, maybe two or three, we'd start reading. Mellissa said no, start reading to her now. Sydney was a month old."

In Vermont someone from the state's Success by Six program first visits a home within two weeks of a baby's birth. "That gets us in the door at age zero instead of age five, so we can assess what families need," Governor Howard Dean points out. Visits may continue for up to three years. "It is so inexpensive," says Dean, "to take care of children relative to the other things we do, such as build jails and put up expensive social-service networks for runaway youth."

With the new scientific evidence to bolster it, the logic for spending money on early-childhood development programs may seem incontrovertible. But not everyone is convinced. The question of what approaches have worked and will work has not been resolved. Research supports the long-term benefits of older programs that are used as models today, but those studies are criticized because they look at very small samples of children who were given special attention and care.

"We have seen over and over and over that even if you can produce good results with small programs, when you expand to a national level, the effect often disappears," says Ronald Haskins, a top Republican staff member of the House Ways and Means Committee. "That is the case with Head Start. We still do not have evidence that Head Start produces any long-term effects."

Social science, however, is an imperfect discipline. Referring to programs for young children, Isabel Sawhill, a scholar at the Urban Institute and former official in the Clinton Administration, has written, "The evidence is always mixed. We simply do not know whether they work. In these cases, one must weigh the risk of doing something and having it not work against the risk of doing nothing and missing an opportunity to improve lives. It can be just as costly to not fund a potentially successful program as it is to fund a potentially unsuccessful one."

Right now, the total public expenditure on early-childhood development is tiny. Given the potential rewards, how risky is a bigger investment? *—Reported by Ann Blackman/Washington, Wendy Cole/Chicago, Rita Healy/Denver, Melissa Ludtke/Cambridge and Lisa H. Towle/Raleigh*

ROBERT DE MICHIELL FOR TIME

HOLLYWOOD GOES GAGA

Whoopi, Robin, Rob and friends have found a new cause

CELEBRITIES WHO PUBLICLY EMBRACE worthy causes sometimes seem to be auditioning less for *Sense and Sensibility* than for *Clueless*. Stars have dangled from bridges to protest logging practices, hawked clothes made in sweatshops while promoting moral values and slugged pesky photographers even as they were begging for kindness to animals. A recent surge of show-biz interest in children, however, seems to be as well aimed as it is high profile. More than half a dozen organizations founded or funded by Hollywood celebrities are zeroing in on kids' issues. And early childhood development is one of their top concerns.

In April, ABC-TV will air a prime-time special on brain development, directed by Rob Reiner and featuring such A-list stars as Tom Hanks and Robin Williams. It's the opening shot of an elaborate multimedia blitz that is coordinated by Families and Work Institute, based in New York City, and includes public-service announcements, magazine specials, home videos, online sites and CD-ROMS. "I couldn't create a big, federally funded program," says Reiner. "But I certainly can put on a show to raise awareness about how the first three years critically impact the way a child later deals with society."

Reiner says he became interested in baby brain activity three years ago during his own analysis. Now he is taking his case directly to the top. He has been urging President Clinton to host a Washington summit on the subject, and last month sat beside Hillary Clinton at a White Ho arts-award dinner. The next day she gave a speech that included a long section on early-childhood learning. "It's an important issue for the President to get on," says Reiner. "You talk about trying to fix the welfare situation. This is a way to do it."

Reiner is one of dozens of celebrities who have joined Hollywood's latest children's crusade. Whoopi Goldberg, Barbra Streisand, Whitney Houston and Henry Winkler have all donated their names, their time and even their money to various kids' causes. Not only did Steven Spielberg and his wife Kate Capshaw cofound the Children's Action Network, which makes educational films and sponsors immunization campaigns, but Spielberg also chairs the Starbright Foundation, an innovative charity group that deploys entertainment technologies to help the suffering of sick children.

Hollywood's interest in a cause often means Big Money. A benefit movie premiere can raise up to $350,000 in a single night. Still, as Starbright managing director Chris Garvey notes, "Our board members give more than their money and Rolodexes. They relish the hands-on experience of dealing with children in hospitals."

But not too hands on. Celebrity sightings at clinics and youth shelters are, for the most part, rare. "We try to provide children with a calm, soothing place, not chaotic, star-studded events," says Leslie Johnson of the Westside Children's Center in Culver City, California. "Besides, children under three have different about celebrity. When Barney came to our Christmas party, Jim Carrey could have been standing there and no one would have noticed him." *—By Jeffrey Ressner/Los Angeles*

Hillary Rodham Clinton

Comfort and Joy

The First Mom suggests reading as an easy way to help a baby's brain grow

THE NIGHT AFTER THE INAUGURAL, BILL AND I GATHERED with our family in the solarium on the third floor of the White House. After dinner our toddler nephews Tyler and Zachary climbed up on the couch with their Uncle Bill to hear him read a story. They accompanied him with words, sounds, pointed fingers and a few tussles over who would hold the book. As I watched them, I thought of all the times Bill and I used to take turns reading stories to Chelsea. Every night one of us (and occasionally both) would stretch out on her bed, hold her in our arms, and either read or make up new tales about imaginary characters who embarked on improbable but breathtaking adventures.

Bill and I did not know about brain cells or synapses or the newest discoveries in neuroscience. Reading to Chelsea became a daily ritual because it's what our own parents and grandparents had done with us, and because we wanted to spend quiet time with her every day. Bill's grandmother thought that reading to him would help him develop a strong vocabulary and the language skills he would need later on in school. My mother and father placed a similar premium on reading, and to this day I remember the feelings of security and comfort that I felt sitting in my grandfather's lap when he read stories to my brothers and me.

Mrs. Clinton with her daughter in the crucial first three years

Today, thanks to advances in brain research, we know that reading with a child has intellectual, emotional and physical benefits that can enhance the child's development. The intimacy of sharing books and stories strengthens the emotional bonds between a parent and child, helps a child learn words and concepts, and actually stimulates the growth of a baby's brain.

As I discussed in my book, *It Takes a Village*, scientists have discovered that children whose parents read and talk to them during the first three years of life create a stronger foundation for future reading success. In other words, what our parents and grandparents knew instinctively is now backed up by hard scientific evidence.

That's why doctors and nurses are starting to *prescribe* reading to babies along with regular checkups and vaccinations. Recently I went to Georgetown University's Medical Center with Maurice Sendak, the renowned children's author and illustrator. His book *Where the Wild Things Are* was one of Chelsea's—and Bill's—favorites. Mr. Sendak read the story to children, and I announced, along with representatives of the American Academy of Pediatrics, the American Booksellers Association and the American Library Association, a national campaign to put books in the hands of parents who bring their young children to the doctor, and to get doctors to prescribe daily reading. My husband and I will be discussing this and other activities to follow up on the latest findings about the brain at a White House conference in the spring.

It's important that we take to heart what the neuroscientists are telling us—without losing the heart of the reading experience. In today's high-tech world of E-mail and microchips, it is easy to forget the importance of human connections in our daily activities. Technology has brought many welcome conveniences to our lives. But it has the potential to create feelings of distance, detachment and isolation among us.

Reading to a child while touching, hugging and holding him or her can be a wonderful antidote to the impersonal tendencies of the information age—for both the adult and the child. While critical to building brains, reading is equally important to building trusting and close relationships. That's why many of us remember the warm embrace or the comfortable lap that cradled us when we read books as children. And that's why reading should not be viewed solely as an intellectual proposition, particularly in the era in which we now live.

If Americans take away only one lesson from these exciting scientific discoveries, I hope it's that reading to children is easy, affordable and feasible for parents no matter what their level of education or economic station in life. Children's books are available for free at public libraries in every community and can be found at reasonable prices in many bookstores. Doctors, librarians, teachers, book publishers, business leaders and the news media can help make books available to families and educate parents about the vital role that reading plays in our children's lives.

It isn't very often that we have before us such a simple, inexpensive and pleasurable way to improve our children's health and development and raise their prospects for a brighter future. Whether you lie down together on the rug, sit together in an old rocking chair or cuddle on your child's bed the way Bill and I used to with Chelsea, there is no better way to spend time than reading to your child.

And now we also know that there are few better ways to help your baby's brain grow. ■

Families and Work Institute

BRAIN DEVELOPMENT IN YOUNG CHILDREN: NEW FRONTIERS FOR RESEARCH, POLICY AND PRACTICE

An Invitational Conference

Thursday and Friday
June 13th and 14th 1996
The Conference Center
at The University of Chicago
450 North Cityfront Plaza Drive
Chicago, Illinois

330 Seventh Avenue, New York, New York 10001 (212) 465.2044 Fax (212) 465.8637

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Early Childhood Public Engagement Campaign Description

Prominent entertainers, national media experts, leading foundations and early childhood experts and organizations are launching an unprecedented public awareness and engagement campaign to focus on the importance of the first three years of life and on what families and communities can do to promote young children's healthy development and school readiness. This campaign is designed to help and inform families, to build the capacity of the fields that serve young children and their families, and to bring about change through a powerful mix of public education and community mobilization activities. Our intention is to establish an enduring collection of resources to help parents nurture their children.

The campaign builds on *Starting Points,* the seminal 1994 report by the Carnegie Corporation of New York that documents the substantial body of literature on young children's emotional, social, physical, intellectual, and brain development and concludes that "how children function from the preschool years all the way through adolescence, and even adulthood, hinges in large part on their experiences before the age of three."

Campaign founders represent an unusual collaboration that includes entertainment talent, spearheaded by Rob Reiner and Michele Singer Reiner, and by Ellen Gilbert from International Creative Management (ICM) and a broad range of experts from the early childhood field—including child development, early childhood care and education, parent education and family support, and children's health, coordinated by the Families and Work Institute. Our work together is designed to tie a media call for action with actual action at the national, state, and community levels. The campaign is supported by the AT&T Foundation, the Carnegie Corporation of New York, and the Teresa and H. John Heinz III Family Foundation.

The objectives of the campaign are to:

- increase public awareness of the importance of the first three years of life;
- increase family and community involvement in young children's development and education;
- motivate family and community action to ensure young children's healthy development; and
- stimulate school readiness.

Current campaign components include:

An Hour-Long ABC Prime Time Special will be produced by Rob Reiner, Michele Singer Reiner and their team, and is scheduled to air sometime between January and March 1997. It will feature music, comedy and several documentaries. Performers will include Robin Williams, Billy Crystal, and other stars. The documentaries, created by New Screen Concepts, will cover such topics as fetal development, brain development, and the importance of community supports for families. An estimated 20 to 30 million viewers will watch this show, which will be heavily promoted in the media. In discussion are a week-long series on *Good Morning America,* features on all other ABC shows such as *Nightline,* and print ads.

ABC may also produce generic footage to feed to ABC affiliates across the country to use as a wrap-around for local stories about their community's issues and solutions. The TV special will include information about an 800 number for viewers to call to obtain fulfillment materials.

Newsweek Special Edition: *Newsweek* magazine will publish a special edition which will be a status report on young children and their families, which will also provide practical information.

Public Service Announcements (PSAs): Print and broadcast public service announcements (PSAs) will be produced with the Ad Council with funding from the AT&T Foundation. The PSAs will focus on the importance of family involvement in early childhood development and school readiness. They are part of the Ad Council's current campaign focusing on children. The PSAs will contain the same 800 number as the TV special that viewers can call for fulfillment materials. United Airlines has agreed to run the PSAs on all of their flights for a one-month period around the time that the Prime Time Special is aired.

800 Number and Fulfillment Materials (Written Fulfillment Materials Developed for the General Public): The Prime Time television special and the PSAs will include an 800 number that viewers can call to obtain written fulfillment materials. Production and dissemination of the fulfillment materials are being coordinated by the Families and Work Institute. The materials will include tips on how to promote young children's school readiness and healthy development. Separate tip sheets will be developed for multiple audiences—families, businesses, child care providers, schools, communities, pediatricians, social service organizations, churches, government, media, and others. These tip sheets will be prepared by a number of national organizations and will also contain listings of resources. Space will be reserved on these materials for state and local organizations to add their own logos, 800 numbers, or resources.

A Video for New Parents will provide "how to" information to help families promote their children's healthy development. It will describe child development milestones from birth to age three, with information on how families can encourage children's healthy development at each stage. Funding is being provided by Johnson & Johnson. The video may be distributed free of charge through hospitals, video stores, clinics, child care centers, schools, employers, non-profits, and early childhood state and community mobilization efforts. In addition, the Marriott Corporation has offered to show the film on its hotel television channel.

CD-ROM/On-Line Information is planned to address the burning questions that parents have, beginning in the prenatal period and extending through the first three years of life. Funding is being provided by IBM and the CD-ROM will be created by Evolutionary Publishing, Inc.

A Conference on Brain Development will be held in June 1996 in Chicago, with funding from the Carnegie Corporation of New York, the Charles A. Dana Foundation, the Harris Foundation and the Robert R. McCormick Tribune Foundation. This invitational conference will share key findings from leading researchers who are investigating prenatal and early childhood brain development. Panels of early childhood experts, the media, business and public policy leaders will respond to the findings by discussing their implications. The press will be invited to this conference, which will serve as an introduction to the larger media campaign. Proceedings of the conference will be written up and disseminated widely.

One of the hallmarks of this public engagement campaign will be its connection to action at a state and local level.

We are also working with national, state and local organizations to promote state and local action on behalf of young children and families in several ways:

Interviews and Meeting with National Organizations: We began the campaign by interviewing over 150 leaders from early childhood organizations. We distributed a survey to more than 1,000 others to ascertain ways we could work together to further the messages of the campaign. Later this year, we will convene a meeting with leaders from national organizations to plan for how we will all work together.

Meeting with Representatives from Starting Points, Danforth-Carnegie, and EQUIP (Early Education Quality Improvement Project) States and Communities: On March 21-22, 1996 there was a Technical Assistance Institute for state and community partnerships for families with young children. Convened by Carnegie Corporation of New York for its *Starting Points* states and communities, with additional funding from the Danforth Foundation for its state mobilization efforts, and the AT&T Foundation for its EQUIP sites, the Institute brought together 18 state and community partnership teams. The public awareness/public engagement campaign was discussed with the intention of developing targeted, enhanced campaigns in certain sites. All of these sites are receiving an invitation to participate, followed by a series of conference calls with site leadership teams.

Linkages to Business Leaders: With funding from The Commonwealth Fund, a symposium will be conducted in collaboration with the Committee for Economic Development in September, 1996 to focus on what large companies are doing to support new and expectant parents. We expect that this event will stimulate additional strategies to engage the business community in our campaign.

Guide to Working with the Media: We expect ABC to develop generic footage from the Prime Time show that can be fed to local ABC stations. Local programming can then be developed as a wrap-around, featuring local problems, solutions, and stories. With national organizations that have an expertise in working with the media, we will develop a guide to working with the media on the campaign's themes. This guide, funded by the AT&T Foundation, will be widely disseminated to national early childhood organizations that can, in turn, disseminate the guide to its local affiliates.

Challenge Grants to States and Communities: We hope to stimulate the provision of challenge grants in communities to support local activities that follow the television show. We will ask members of the Coalition of Community Foundations for Youth and other grantmakers to provide small grants for follow-up action. At the same time, we will notify state and local early childhood leaders, suggesting that they follow-up with local funders.

Action Pack for Follow-Up Activities: We will develop an action pack that includes a menu of possible follow-up activities, such as town meetings, surveys to assess the family-friendliness of the community, etc. It will be funded by the AT&T Foundation and distributed widely.

A small **Expert Advisory Board** has been selected to ensure that the content of this campaign is guided by accurate scientific knowledge. Expert Advisors represent national organizations reflecting the major domains specified in the *Starting Points* report: health, parent education and family support, early childhood education and care, and child development. They include:

Judy Langford Carter, MA, Executive Director of Family Resource Coalition;

Jerlean Daniel, PhD, President, National Association for the Education of Young Children;

Emily Fenichel, MSW, Associate Director of ZERO TO THREE: National Center for Infants, Toddlers, and Families (formerly National Center for Clinical Infant Programs); editor, *Zero to Three;*

Deborah A. Phillips, PhD, Director, Board on Children and Families, National Research Council's Commission on Social and Behavioral Sciences and the Institute of Medicine; and

Barry Zuckerman, MD, Chairman, Department of Pediatrics, Boston University School of Medicine.

Separate review committees will be established for other materials developed in this campaign because different materials require different types of expertise.

For further information please contact Families and Work Institute: Ellen Galinsky at (212) 465-2044 or Nina Sazer O'Donnell at (919) 477-7137.

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Advanced Study in Child Development

BARBARA T. BOWMAN
President
Erikson Institute
For Advanced Study in Child Development

Barbara Bowman is one of three faculty members who founded the Erikson Institute in 1966. She is an authority on early education and a nationally recognized advocate for improved and expanded training for practitioners who work with children and families.

Mrs. Bowman, a past president of the National Association for the Education of Young Children (NAEYC), combines advocacy at the national level with a strong commitment to leadership and teaching in Chicago. At Erikson, she teaches courses in early education and administration. She also has taught courses at universities in China and Iran. She has directed training projects for Head Start teachers, caregivers of infants at risk for morbidity or mortality, and teachers in mathematics and computer education. Her research has most recently focused on the public schools, specifically to introduce developmentally appropriate practices and authentic assessment in the early grades. She is a frequent consultant on parent support programs.

Mrs. Bowman has served on numerous national and state commissions, including the Corporate/Community Schools of America; the Early Childhood Education Task Force of the National Association of State Boards of Education; and the Panel on Day Care Policy, National Research Council, National Academy of Sciences. She currently is an advisor to the National Black Child Development Institute and the Chicago Community Trust Community Initiatives Program. She serves on the Early Childhood Panel of the National Board for Professional Teaching Standards and the Advisory Council on Early Childhood Education of the Illinois State Board of Education. She also is on the board of the Great Books Foundation and the Family Resource Coalition and serves on the Advisory Committee to Teachers College Press Early Childhood Series.

Mrs. Bowman earned her B.A. from Sarah Lawrence College and her M.A. in education from the University of Chicago. Honors include a D.H.L. from Bank Street College of Education, the Outstanding Women in Education award from the YWCA of Chicago, and the Oliver Greenfelder Memorial Award from the Day Care Action Council.

8/14/94

Marie M. Bristol, Ph.D.

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National Institute of Child Health and Human Development (NICHD)

At the conference on brain development in young children, Dr. Bristol is representing Dr. Duane Alexander, Director of the National Institute of Child Health and Human Development (NICHD) at the National Institutes of Health (NIH) in Bethesda, Maryland. The NICHD is the component of the NIH that conducts, fosters, supports, and disseminates the results of biomedical and behavioral research on the underlying causal structure and system dynamics of human development from preconception to adulthood. The Institute initiates and supports a range of scientific studies of change over time in the interactions and interrelationships among genetic endowment, social milieu, behavior and physical environment in order to identify, understand, and prevent conditions that produce acquired and developmental diseases and disabilities.

The Institute supports and conducts research that helps inform biomedical, social, and behavioral choices that improve the health of children and their families, help those with congenital and acquired disabilities realize their full potential in life by achieving full participation in society, have a positive influence on the course of human development, and contribute to the quality of human life. The NICHD has been a leader in research on the effects of early intervention on later child development and in research on the development of the brain and the central nervous system.

Biographical Sketch

Dr. Bristol recently joined NICHD from the University of North Carolina Medical School where she is a tenured Associate Professor in the Department of Psychiatry and Director of Family and Preschool Research and Services in Division TEACCH, an internationally recognized research, clinical, and training program for children with autism and related developmental disorders. Dr. Bristol holds an M.A. degree from the University of Utah, and a Ph.D. from the University of North Carolina at Chapel Hill where she was a fellow in an NICHD-supported multidisciplinary research training program in child development.

At NICHD, Dr. Bristol is responsible for managing, developing, and disseminating results of behavioral and biobehavioral research, including research on cognitive neuroscience and developmental disorders, and on early intervention. Within the past year, she has chaired an NICHD conference on "Cognitive Neuroscience and Neurodevelopmental Disorders: Conceptual and Methodological Challenges," an inter-institute "NIH Autism State-of-the-Science Conference", and a conference for clinicians on "Autism: the State of the Art Informed by the State of the Science". Dr. Bristol's publications are in the areas of autism, family research, and early intervention. She has lectured throughout the United States, in Europe, Korea, and Japan.

Gaston Caperton
Governor
State of West Virginia

Gaston Caperton had a remarkable business career before becoming governor of West Virginia in 1989, and his innate understanding of business and deep commitment to education have permeated his improvements throughout state government. The results have been revolutionary in West Virginia.

Because of his leadership, West Virginia is a national leader in education technology and has launched a landmark *Jobs Through Education* initiative that links the world of work and the classrooms of learning.

Caperton's progressive 10-year, $70 million program to place computers in every classroom established West Virginia at the nation's leading edge. More than 17,500 computers have been placed in kindergarten through sixth grade classrooms. The effort is complemented by funding for computers and software to help students in grades 7-12 convert basic skills into marketable, job-related skills. The goal of *Jobs Through Education* is to make each high school graduate fully prepared for college, other postsecondary education and gainful employment.

Caperton's aggressive school building program has prompted $800 million in investment for 61 new schools and 780 school renovations to benefit two-thirds of West Virginia's students. Caperton raised teachers' salaries from 49th to 31st and trained more than 16,000 educators through a statewide Center for Professional Development to ensure technology's best use in West Virginia classrooms.

West Virginia has gained 75,000 new jobs since Caperton took office, thanks to this dedication to education and one of his most successful initiatives: establishing the West Virginia Trade Office in Nagoya, Japan. The result has been hundreds of millions of dollars in investment in West Virginia through new Japanese companies. The state's "cottage industry" is organized as never before through Tamarack: The Best of West Virginia. This facility establishes an integrated distribution and marketing network that fosters the cottage industry involving 1,000 West Virginia artists. It is a world-class showcase for West Virginia products.

Caperton's success stems from his focus on specific goals for West Virginia: education, jobs, infrastructure, health care, public safety, environment, communication and government management.

His accomplishments for the state also include 12,000 miles of highway improvements, an innovative public-private partnership for economic development, the lowest crime rate in the nation, and historic environmental legislation. Caperton also is replacing 55 county jails with a nationally lauded regional jail system. *The Wall Street Journal* has touted West Virginia as a model for rural areas following a Rural Health Initiative Act that promotes accessible and affordable health care to West Virginians.

In April, Caperton received the Zenith Data Systems Information Technology Leadership Award for Education from the Computerworld Smithsonian Awards Program and Zenith Data Systems. As the winner, information about him and his work will be included in the Smithsonian's Permanent Research Collection. Award sponsors called Caperton a "visionary" who "fundamentally changed the education system in America" by using technological innovation.

Caperton is the 1996 chair of the Democratic Governors' Association, serves on the National Governors' Association executive committee and is a member of the Intergovernmental Policy Advisory Committee on U.S. Trade. He is chairman of the Appalachian Regional Commission and heads the National Council for Accreditation of Teacher Education's Distinguished Visitors Panel. The governor has chaired the Southern Regional Education Board and the Southern Growth Policy Board.

Caperton, 56, earned a bachelor's degree in business from the University of North Carolina and holds four honorary doctorates. He is married to Maestra Rachael Worby, well-known conductor and music director of the Wheeling Symphony Orchestra, and has two sons, Gat and John.

BIOGRAPHY

MARIA D. CHAVEZ

Dr. María Chávez is the Executive Director of the University of New Mexico's Family Development Program. María has given numerous presentations and written several publications relating to bilingual education and to parental involvement of low-income parents in preschool education programs. She is an educator who has devoted more than 20 years of her life to serving minority and underprivileged children in New Mexico.

The Family Development Program is a comprehensive continuum of services for low income families and their children 0-12 years old in Albuquerque, New Mexico. The Family Development Program focuses on building positive relationships with families and schools in order to create an environment where families can recognize their strengths, set their own agendas and make constructive changes in their lives.

Dr. Chávez has served on the New Mexico State School Board for eight years and as State Library Commissioner. She has also served as a board member on the National Association of State School Boards. Currently Dr. Chávez serves on two national boards, the Family Resource Coalition based in Chicago, Illinois, with an emphasis on family support and Zero to Three, based in Washington, D.C., with an emphasis on the first 3 years of life.

As a hobby she co-managed, JPC General Contractors Construction Company with her husband and they recently designed and built their own home. What she is most proud of is being a mother to three lovely children who now have rewarded her with four fantastic grandchildren.

FF Principal Investigator/Program Director *(Last, first, middle)*: Chugani, Harry T.

BIOGRAPHICAL SKETCH

Provide the following information for the key personnel in the order listed on Form Page 2.
Photocopy this page or follow this format for each person.

NAME	POSITION TITLE
Harry T. Chugani, M.D.	Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
Georgetown Univ. School of Medicine	M.D.	1976	Medicine
Georgetown Univ. Hosp., Wash. D.C.	Resident	1978	Pediatrics
Georgetown Univ. Hosp., Wash. D.C.	Resident	1980	Neurology
Georgetown Univ. Hosp., Wash.D.C.	Fellow	1981	Ped Neurol
UCLA, Los Angeles, California	Fellow	1992	Nucl Med

RESEARCH AND PROFESSIONAL EXPERIENCE: Concluding with present position, list, in chronological order, previous employment, experience, and honors. Include present membership on any Federal Government public advisory committee. List, in chronological order, the titles, all authors, and complete references to all publications during the past three years and to representative earlier publications pertinent to this application. If the list of publications in the last three years exceeds two pages, select the most pertinent publications. DO NOT EXCEED TWO PAGES.

PROFESSIONAL EXPERIENCE:

1981 - 1988	Assistant Professor, Departments of Neurology and Pediatrics, UCLA School of Medicine
1988 - 1993	Associate Professor, Departments of Neurology and Pediatrics, UCLA School of Medicine
1981 - 1991	Consultant in Pediatric Neurology, Olive View Medical Center
1990 - 1992	Instructor, Division of Nuclear Medicine and Biophysics
1993 - present	Professor, Departments of Pediatrics, Neurology and Radiology; Director, Positron Emission Tomography Center - Children's Hospital of Michigan, Wayne State University

HONORS AND AWARDS:

1984 - 1989	Teacher Investigator Developmental Award
1986 - 1987	UCLA Pediatrics Faculty Scholar Award
1986 - 1987	Young Investigator Award, Association of Indian Neuroscientists
1986	Acknowledgement in the President's Report to the Regents of the University of California, March 21, 1986
1987	Best Abstract: XIII International Symposium on Cerebral Blood Flow and Metabolism
1987	Certificate of Merit: Scientific Exhibit Award, Radiological Society of North America, Chicago
1992	Distinguished Scientist Award: Crump Institute, UCLA

SELECTED PUBLICATIONS (only refereed publications included)

Chugani HT, Phelps ME: Maturational changes of cerebral function in the infant determined by FDG positron emission tomography. Science 231: 840-843, 1986.

Chugani HT, Mazziotta JC, Engel J Jr., Phelps ME: Lennox-Gastaut syndrome: Metabolic subtypes determined by 18FDG positron emission tomography. Ann Neurol 21: 4-13, 1987.

Chugani HT, Phelps ME, Mazziotta JC: Positron emission tomography study of human brain functional development. Ann Neurol 22: 487-497, 1987.

Chugani HT, Shewmon DA, Peacock WJ, Shields WD, Mazziotta JC, Phelps ME: Surgical treatment of intractable neonatal-onset seizures: The role of positron emission tomography. Neurol 38: 1178-1188, 1988.

Chugani HT, Mazziotta JC, Phelps ME: Sturge-Weber syndrome: A study of cerebral glucose utilization with positron emission tomography. J Pediatrics 114: 244-253,1989.

Olson DM, Chugani HT, Shewmon DA, Phelps ME, Peacock WJ: Electrocorticographic confirmation of focal positron emission tomographic abnormalities in children with intractable epilepsy. Epilepsia 31: 731-739, 1990.

Chugani HT, Shewmon DA, Shields WD, Peacock WJ, Phelps ME: Pediatric Epilepsy surgery: Pre-and post-operative evaluation with PET. J. Epilepsy 3 (Suppl): 75-82, 1990.

Chugani HT, Shields WD, Shewmon DA, Olson DM, Phelps ME,Peacock WJ: Infantile spasms: PET identifies focal cortical dysgenesis in cryptogenic cases for surgical treatment. Ann Neurol, 27: 406-413, 1990.

Chugani HT, Hovda DA, Villablanca JR, Phelps ME, Xu WF: Metabolic maturation of the brain: A study of local cerebral glucose utilization in the cat. J. Cereb Blood Flow Metab, 11: 35-47, 1991.

Kerrigan JF, Chugani HT, Phelps ME: Regional cerebral glucose metabolism in clinical subtypes of cerebral palsy. Ped Neurol, 7: 415-425, 1991.

Chugani HT, Shewmon DA, Sankar R, Chen BC, Phelps ME: Infantile spasms: II. Lenticular nuclei and brainstem activatic on positron emission tomography. Ann Neurol 31: 212-219, 1992.

Jacobs B, Harris GC, Allada V, Chugani HT, Pollack DB, Raleigh MJ: Midazolam as an effective intravenous adjuvant to prolonged ketamine sedation in young rhesus (Macaca mulatta) and vervet (Cercopithecus aethiops sabeaus) monkeys: A preliminary report. Am J Primat 29: 291-298, 1993.

Rintahaka PJ, Chugani HT, Messa C, Phelps ME: Hemimegalencephaly: Evaluation with positron emission tomography. Ped Neurol 9: 21-28, 1993.

Chugani HT, Shewmon DA, Khanna S, Phelps ME: Interictal and postictal focal hypermetabolism on positron emission tomography. Ped Neurol 9: 10-15, 1993.

Chugani HT, Shewmon DA, Shields WD, Sankar R, Comair Y, Vinters HV, Peacock WJ: Surgery for intractable infantile spasms: Neuroimaging perspectives. Epilepsia 34: 764-771, 1993.

Caplan R, Chugani HT, Messa C, Guthrie D, Sigman M, de Traversay J, Mundy P: Hemispherectomy for intractable seizures: Presurgical cerebral glucose metabolism and postsurgical non-verbal communication. Dev Med Child Neurol 35: 582-592, 1993.

Rocha L, Ackermann RF, Nassir Y, Chugani HT, Engel J Jr.: Characterization of mu opioid receptor binding during amygdala kindling in rats and effects of chronic naloxone pretreatment: An autoradiographic study. Epilepsy Res 14: 195-208, 1993.

Rocha L, Tatsukawa K, Chugani HT, Engel J Jr.: Benzodiazepine receptor binding following chronic treatment with naloxone, morphine and met-enkephalin in normal rats. Brain Res 612: 247-252, 1993.

Kornblum HI, Chugani HT, Tatsukawa K, Gall CM: Cerebral hemidecortication alters expression of transforming growth factor alpha mRNA in the neostriatum ofdeveloping rats. Mol Brain Res 21: 107-114, 1994.

Chugani HT, Rintahaka PJ, Shewmon DA: Ictal patterns of cerebral glucose utilization in children with epilepsy. Epilepsia 35: 813-822, 1994.

Chugani HT, Jacobs B: Metabolic recovery in caudate nucleus of children following cerebral hemispherectomy. Ann Neurol 36: 794-797, 1994.

Khanna S, Chugani HT, Messa C, Curran JG: Corpus callosum agenesis and epilepsy: PET findings. Pediatr Neurol 10: 221-227, 1994.

Philippart M, Messa C, Chugani HT: Spielmeyer-Vogt (Batten, Spielmeyer-Sjogren) disease: Distinctive patterns of cerebral glucose utilization. Brain 117: 1085-1092, 1994.

Chugani HT: The role of PET in childhood epilepsy. J Child Neurol 9 (Suppl) S82-S88, 1994.

Jacobs B, Chugani HT, Allada V, Chen S, Phelps ME, Pollack DB, Raleigh MJ: Developmental changes in brain metabolism in sedated rhesus macaques and vervet monkeys revealed by positron emission tomography. Cerebral Cortex May/Jun 1995;3:222-233.

Philippart M, Chugani HT, Bateman JB: A new Spielmeyer-Vogt variant with granular inclusions and early brain atrophy. Am J of Med Genetics, 1995; 57:160-164.

Rocha L, Ackermann RF, Chugani HT, Engel J Jr.: Chronic pretreatment with naloxone modifies benzodiazepine receptor binding in amygdaloid kindled rats. Epilepsy Res 17: 135-142, 1994.

Rintahaka PJ, Chugani HT, Sankar R: Landau-Kleffner syndrome with continuous spikes and waves during slow-wave sleep. J Child Neurol 10: 127-133, 1995.

Gaily EK, Shewmon DA, Chugani HT, Curran JG: Asymmetric and asynchronous infantile spasms. Epilepsia 1995; 36:873-882.

Chugani HT, Conti JR: Etiological classification of infantile spasms in 140 cases: Role of Positron emission tomography. J Child Neurol 11: 44-48, 1996.

Elliott TK, Watkins JM, Messa C, Lippe B, Chugani HC: Positron emission tomography and neuropsychological correlations in Turner Syndrome. Developmental Neuropsychology, in press.

Chugani HT, da Silva E, Chugani DC. Infantile spasms: III. Prognostic implications of bilateral hypometabolism on positron emission tomography. Annals of Neurology 39: 643-649, 1996.

Hovda DA, Villablanca JR, Chugani HT, Phelps ME: Cerebral metabolism following neonatal or adult hemineodecortication in cats: I. Effects on glucose [14-C]2-Deoxy-D-Glucose autoradiography. Journal of Cerebral Blood Flow and Metabolism 16: 134-136, 1996.

Shamoto H, Chugani HC, Chugani DC: Glucose metabolism in the human cerebellum. 1: Anatomical-functional correlations, in press.

BOOK:

Dulac O, Chugani HT, Dalla Bernardina B (Eds): Infantile Spasms and West Syndrome. Saunders, London, 1994.

BIOGRAPHICAL SKETCH

Provide the following information for the key personnel in the order listed on Form Page 2.
Photocopy this page or follow this format for each person

NAME	POSITION TITLE
Geraldine Dawson	Professor

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)

INSTITUTION AND LOCATION	DEGREE (if applicable)	YEAR(s)	FIELD OF STUDY
University of Washington, Seattle	B.S.	1974	Psychology
University of Washington, Seattle	Ph.D.	1979	Developmental Psych.
UCLA Neuropsychiatric Institute	Intern	1980	Child Clinical Psych

RESEARCH AND PROFESSIONAL EXPERIENCE: Concluding with present position, list, in chronological order, previous employment, experience, and honors. Include present membership on any Federal Government public advisory committee. List, in chronological order, the titles, all authors, and complete references to all publications during the past three years and to representative earlier publications pertinent to this application. If the list of publications in the last three years exceeds two pages, select the most pertinent publications. DO NOT EXCEED TWO PAGES.

EMPLOYMENT

1990 - present Professor of Psychology, Univ. of Washington
1985 - 1990 Associate Professor of Psychology, Univ. of Washington
1985 - 1991 Director, Child Clinical Psychology Program, Univ. of Washington
1985 - present Licensed Practicing Psychologist, Washington State
1980 - 1985 Assistant Professor of Psychology, Univ. of North Carolina at Chapel Hill

OTHER PROFESSIONAL ACTIVITIES

Member: NIMH Child Psychopathology & Treatment Review Committee (91 - 93)
NIMH Small Grants Review Committee (89 - 91)
ADAMHA Reviewers Reserve (92 - present)
NIMH B-START Grants Review Committee (94 - present)
Associate Editor: Journal of Autism and Developmental Disorders
Editorial Board: Development and Psychopathology
Consultant: MacArthur Foundation Group on Psychopathology and Development

PUBLICATIONS (selected)

Dawson, G., Warrenburg, S., & Fuller, P. (1982). Cerebral lateralization in individuals diagnosed as autistic in early childhood. Brain and Language, 15, 353-368.

Dawson, G. (1983). Lateralized brain dysfunction in autism: Evidence from the Halstead-Reitan Neuropsychological Battery. Journal of Autism and Developmental Disorders, 13, 269-286.

Dawson, G., Warrenburg, S. & Fuller, P. (1983. Hemisphere functioning and motor imitation in autistic persons. Brain and Cognition, 2, 346-354.

Dawson, G., & Adams, A. (1984). Imitation and social responsiveness in autistic children. Journal of Abnormal Child Psychology, 12, 209-225.

Dawson, G. & McKissick, F.C. (1984). Self-recognition in autistic children. Journal of Autism and Developmental Disorders, 14, 383-394.

Dawson, G. Warrenburg, S. & Fuller, P. (1985). Left hemisphere specialization for facial and manual imitation in children and adults. Psychophysiology, 22, 237-243.

Dawson, G., Finley, C., Phillips, S., & Galpert, L. (1985). Cognitive processing of verbal and musical stimuli in autistic children as indexed by P300. J. of Exper. and Clinical Neuropsychology, 7, 626.

Dawson, G., & Galpert, L. (1986). A developmental model for facilitating the social behavior of autistic children. In E. Schopler & G. Mesibov (Eds.). Social Behavior in autism, New York: Plenum.

Dawson, G., Finley, C., Phillips, S. & Galpert, L. (1986). Hemispheric specialization and the language abilities of autistic children. Child Development, 57, 1440 - 1453.

Dawson, G. & Fernald, M. (1987). Perspective-taking ability and its relationship to the social behavior in autistic children. Journal of Autism and Developmental Disorders, 17, 487-498.

Geraldine Dawson, Ph.D. **PUBLICATIONS** (continued)

Dawson, G. (1987). The role of abnormal hemispheric specialization in the syndrome of autism. In E. Schopler & G. Mesibov (Eds.). Neurobiological Issues in Autism. (pp. 213-228). NY: Plenum.
Dawson, G., Finley, C., Phillips, S. & Galpert. L. (1988). Reduced P3 amplitude of the ERP brain potential: Relationship to language ability in autism. J. of Autism and Devel. Disorders. 18, 493-504.
Dawson, G. (Ed.) (1989). Autism: Nature, Diagnosis and Treatment, New York: Guilford Press.
Dawson, G. and Lewy, A. (1989).Reciprocal subcortical-cortical influences in autism: The role of attentional mechanisms. G. Dawson (Ed.) Autism: Nature, Diagnosis and Treatment, NY: Guilford.
Dawson, G. and Lewy, A. (1989). Arousal, attention and the socioemotional impairments of individuals with autism. In G. Dawson (Ed.), Autism: Nature, Diagnosis, and Treatment, NY: Guilford.
Dawson, G., Finley, C., Phillips, S., & Lewy, A. (1989). A comparison of patterns of cerebral lateralization for speech in autistic and dysphasic children. Brain and Language, 37, 26-41.
Dawson, G., Hill, D., Galpert, L., Spencer, A. & Watson, L (1990). Affective exchanges between young autistic children and their mothers. Journal of Abnormal Child Psychology, 18, 335-345.
Dawson, G., and Galpert, L. (1990). Mothers' use of imitative play for facilitating the social behavior of autistic children. Development and Psychopathology, 2, 151-162.
Dawson, G. (1991). A psychobiological perspective on the early socioemotional development of children with autism. In S. Toth & D. Cicchetti (Eds..) Rochester Symposium on Developmental Psychopathology: Volume 3. Rochester, NY: Univ. of Rochester Press.
Dawson, G. and Castelloe, P. (1992). Autism. In M.C. Roberts and H. Walker (Eds..). Handbook of Clinical Child Psychology (Revised Edition). NY: Wiley and Sons.
Klinger, L. and Dawson, G. (1992). Facilitating the early social and communicative development of children with autism. In S. Warren and J. Reichle (Eds..) Perspectives on Communication and Language Intervention. Brooks.
Dawson, G., Grofer, L., Hill, D., Panagiotides, H., and Spieker, S. (1992). Frontal lobe activity and affective behavior of infants of mothers with depressive symptoms. Child Development, 63, 725-737.
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Dawson, G., Grofer, L., Panagiotides, H., and Spieker, S. (1992). Infants of mothers with depressive symptoms: Electrophysiological and behavioral findings related to attachment status. Development and Psychopathology, 4, 67-80.
Lewy, A. & Dawson, G. (1992). Social stimulation and joint attention deficits in young autistic children. Journal of Abnormal Child Psychology, 20, 555-566.
Dawson, G. (1994). Frontal electrophysiological correlates of individual differences in emotion regulation in infancy: A brain systems perspective. In N. A. Fox (Ed.) Emotion regulation. Monographs of the Society for Research in Child Development, 59, 135-152.
Dawson, G. and Fischer, K. (1994). Human Behavior and the Developing Brain. NY: Guilford.
Dawson, G. (1994). Development of emotional expression and emotion regulation in infancy: Contributions of the frontal lobe. In G. Dawson and K. Fischer (Eds.), Human Behavior and the Developing Brain, (pp. 436-378). NY: Guilford.
Castelloe, P. & Dawson, G. (1993). Subclassification of children with autism and pervasive developmental disorder. Journal of Autism and Developmental Disorders, 33, 229-243.
Osterling, J. & Dawson, G. (1994). Early recognition of children with autism: A study of first birthday home videotapes. Journal of Autism and Developmental Disorders, 24, 247-257.
Klinger, L. & Dawson, G. (1995). A fresh look at categorization abilities in persons with autism. In E. Schopler and G. Mesibov (Eds..) Cognition and learning in autism. New York: Plenum.
Dawson, G., & Osterling, J. (in press). Early intervention in autism: Effectiveness and common elements of current approaches. In M. Guralnick (Ed.), The effectiveness of early intervention: Second generation research. Baltimore: Brookes.
Klinger, L., & Dawson, G. (in press). Autistic disorder. In E. Mash & R. Barkley (Eds). Child Psychopathology. NY: Guilford Press.
Dawson, G., Klinger, L., Panagiotides, H., Lewy, A., & Castelloe, P. (in press). Subgroups of autistic children based on social behavior display distinct patterns of brain activity. Journal of Abnormal Child Psychology.
Dawson, G., Hessl, D., & Frey, K. (1995). Social influences on early-developing biological and behavioral systems related to risk for affective disorder. Development and Psychopathology, 6, 759-780

Biographical Sketch

Felton Earls, M.D.

Felton Earls is professor of child psychiatry at Harvard Medical School, professor of human behavior and development at the Harvard School of Public and a member of the adjunct faculty at the Rockefeller University. Over the past two decades, he has conducted pioneering research on the distribution and determinants of child and adolescent behavioral problems in several societies around the world. Dr. Earls is currently principal investigator of the Project on Human Development in Chicago Neighborhoods. Funded jointly by the John D. and Catherine T. MacArthur Foundation and the National Institute of Justice, this large-scale study is providing a detailed understanding of how the multiple influences of social class, race/ethnicity, neighborhoods, schools, and families determine children's vulnerability to school underachievement, delinquency, substance use and violent behavior. To accomplish this, the project is sampling more than 7,000 children residing in 80 neighborhoods in Chicago, with the aim of studying their growth and development for a decade.

After attending both undergraduate and medical schools at Howard University in Washington, D.C., Dr. Earls completed postgraduate training in neurophysiology at the University of Wisconsin. His was an intern in pediatrics at Metropolitan Hospital in New York, and he trained in psychiatry and child psychiatry at Massachusetts General Hospital and Children's Hospital in Boston. He joined the faculty of Harvard Medical School in 1978.

Dr. Earls is the recipient of several awards, including the Distinguished Psychiatrist Award and the Blanche F. Ittleson Award from the American Psychiatric Association and the Dale Richmond Award from the Academy of Pediatrics. He is a fellow of the American Academy of Arts and Sciences and a member of the Institute of Medicine of the National Academy of Sciences.

CORNELL
UNIVERSITY

College of Human Ecology

Family Life Development Center
G-20 Martha Van Rensselaer Hall
Ithaca, NY 14853-4401
Telephone: 607 255-7794

Biographical Sketch

JAMES GARBARINO, Ph.D.
Director, Family Life Development Center
Professor, Human Development and Family Studies
Cornell University

James Garbarino served as President of the Erikson Institute for Advanced Study in Child Development from 1985 - 1994. He earned his B.A. from St. Lawrence University in 1968, and his Ph.D. in Human Development and Family Studies from Cornell University in 1973.

Dr. Garbarino has served as consultant or advisor to a wide range of organizations including the National Committee for the Prevention of Child Abuse, the National Institute for Mental Health, the American Medical Association, the National Black Child Development Institute, the National Science Foundation, the National Resource Center for Children in Poverty, Childwatch International Research Network and the U.S. Advisory Board on Child Abuse and Neglect. In 1991 he undertook the missions for UNICEF to assess the impact of the Gulf War upon children in Kuwait and Iraq, and has served as a consultant for programs serving Bosnian and Croatian children. Books he has authored or edited include: Protecting Children From Abuse and Neglect (1980); Understanding Abusive Families (1980); Successful Schools and Competent Students (1981); Children and Families in the Social Environment, Second edition (1992); Social Support Networks (1983); Adolescent Development: An Ecological Perspective (1985); Troubled Youth, Troubled Families (1986); The Psychologically Battered Child (1986); Special Children/Special Risks: The Maltreatment of Children with Disabilities (1987); What Children Can Tell Us (1989); No Place To Be A Child: Growing Up In A War Zone (1991); Saving Children: A Guide to Injury Prevention (1991); Towards A Sustainable Society: An Economic, Social, and Environmental Agenda for our Children's Future (1992); Children in Danger: Coping With The Consequences of Community Violence (1992); for children, Let's Talk About Living in a World with Violence (1993), and Raising Children in a Socially Toxic Environment (1995).

Dr. Garbarino has been a consultant to television, magazine, and newspaper reports on children and families, and in 1981, received the Silver Award at the International Film and Television Festival of New York for co-authoring "Don't Get Stuck There: A Film on Adolescent Abuse." In 1985, he collaborated with John Merrow to produce "Assault on the Psyche," a videotaped program dealing with psychological abuse. He has served as a scientific expert witness in criminal and civil cases involving issues of violence and children.

The National Conference on Child Abuse and Neglect honored Dr. Garbarino in 1985 with its first C. Henry Kempe Award, in recognition of his efforts on behalf of abused and neglected children. In 1975, Dr. Garbarino was named a Spencer Fellow by the National Academy of Education and, in 1981, named a National Fellow by the Kellogg Foundation. In 1979, and again in 1981, he received the Mitchell Prize from the Woodlands Conference on Sustainable Societies. In 1987, he was elected President of the American Psychological Association's Division on Child, Youth and Family Services, In 1988, he received the American Humane Association's Vincent De Francis Award for nationally significant contributions to child protection. In 1989, he received the American Psychological Association's Award for Distinguished Professional Contributions to Public Service. In 1992, he received the Society for Psychological Study of Social Issues prize for research on child abuse. In 1993, he received the Brandt F. Steele Award from the Kempe National Center on Child Abuse and Neglect. In 1994 the American Psychological Association's Division on Child, Youth and Family Services presented him with its Nicholas Hobbs Award. Also in 1994, he received the Dale Richmond Award from the American Academy of Pediatrics Section on Behavioral and Developmental Pediatrics. In 1995, he was awarded an honorary Doctor of Humane Letters by St. Lawrence University.

19 October 1995

Murray Gell-Mann

Professor Murray Gell-Mann is the Robert Andrews Millikan Professor of Theoretical Physics at the California Institute of Technology. In 1969, he received the Nobel Prize in physics for his work on the theory of elementary particles. Prof. Gell-Mann's "eightfold way" theory brought order to the chaos created by the discovery of some 100 particles in the atom's nucleus. Then he found that all of those particles, including the neutron and proton, are composed of fundamental building blocks that he named "quarks." The quarks are permanently confined by forces coming from the exchange of "gluons." He and others later constructed the quantum field theory of quarks and gluons, called "quantum chromodynamics," which seems to account for all the nuclear particles and their strong interactions.

Besides being a Nobel laureate, Prof. Gell-Mann has received the Ernest O. Lawrence Memorial Award of the Atomic Energy Commission, the Franklin Medal of the Franklin Institute, the Research Corporation Award, and the John J. Carty medal of the National Academy of Sciences. He has been awarded honorary doctoral degrees from many institutions, including the University of Chicago, the University of Turin, Italy, and Cambridge University, England, and, in 1988 he was listed on the United Nations Environmental Program Roll of Honor for Environmental Achievement (the Global 500).

Prof. Gell-Mann has been a member of the Caltech faculty since 1955. He is a director of the J.D. and C.T. MacArthur Foundation, a member of the American Academy of Arts and Sciences, a Fellow of the American Physical Society, a Foreign Member of the Royal Society of London, a member of the Council on Foreign Relations, a former Citizen Regent of the Smithsonian, 1974-1988, and a former member of the President's Science Advisory Committee, 1969-1972.

Although a theoretical physicist, Prof. Gell-Mann's interests extend to many other subjects, including natural history, historical linguistics, archaeology, history, depth psychology, and creative thinking, all subjects connected with biological evolution, cultural evolution, and learning and thinking. His recent research, both at Caltech and at the Santa Fe Institute, has focused on complex adaptive systems, which brings all these areas of study together. He is also concerned about policy matters related to world environmental quality (including conservation of biological diversity), restraint in population growth, sustainable economic development, and stability of the world political system (including the strategic arms situation). He is a Founding Member of the Board of Trustees of the Santa Fe Institute (1982-present), and has been co-Chairman of its Science Board since 1985.

LINDA GILKERSON, PhD

Director of Irving B. Harris Infant Studies
Erikson Institute • Chicago, Illinois

Dr. Gilkerson has worked in the field of early childhood special education for 26 years, at the University of Illinois, the University of North Carolina, and Wheelock College in Boston, Massachusetts, where she designed and directed one of the first graduate training programs to focus solely on infants at risk.

In her current position at the Erikson Institute, Dr. Gilkerson has worked on the Infant Mortality Reduction Initiative, the National Collaborative Research Institute for Early Childhood Intervention, and Early Head Start. Her research interests include developmental intervention with premature infants and parenting in high-risk communities.

As Director of the Infant Care Program in the Department of Pediatrics at Evanston Hospital, she and her colleagues developed the Family Administered Neonatal Activities, an innovative adaptation of the Brazelton scale, and adapted this service for families of infants with Down Syndrome.

Dr. Gilkerson served on the boards of the Illinois Association for Infant Mental Health; Zero to Three National Center for Infants, Toddlers and Families; the Illinois Interagency Council for Early Intervention; and the Advisory Board for the National Early Childhood Technical Assistance System.

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DOCUMENT NO. AND TYPE	SUBJECT/TITLE	DATE	RESTRICTION
001a. resume	Stanley Greenspan (partial) (1 page)	nd	P6/b(6)

COLLECTION:

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Work and Families Institute Conference Background-Brain Development in Young Children, June 1996 [1]

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Presidential Records Act - [44 U.S.C. 2204(a)]

P1 National Security Classified Information [(a)(1) of the PRA]
P2 Relating to the appointment to Federal office [(a)(2) of the PRA]
P3 Release would violate a Federal statute [(a)(3) of the PRA]
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P5 Release would disclose confidential advice between the President and his advisors, or between such advisors [a)(5) of the PRA]
P6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

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Freedom of Information Act - [5 U.S.C. 552(b)]

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b(9) Release would disclose geological or geophysical information concerning wells [(b)(9) of the FOIA]

P6/(b)(6)
Bethesda, MD 20814
P6/(b)(6)

001[a]

STANLEY I. GREENSPAN, M.D. - SUMMARY OF C.V.

Degrees: Harvard, A.B., cum laude, 1962
Yale Medical School, M.D., 1966

Occupation: Practicing Child and Adult Psychiatrist and Psychoanalyst; Clinical Professor Psychiatry and Behavioral Sciences and Pediatrics, George Washington University Medical School; Supervising Child Psychoanalyst, Washington Psychoanalytic Institute.

Professional Activities: Researcher on the prevention of emotional disorders in infants and children; a founder of ZERO TO THREE/National Center for Clinical Infant Programs (NCCIP); President, NCCIP, 1975-84; Chairman, Committee on Program Liaison, American Psychoanalytic Association; Chairman, Diagnostic Classification Committee, NCCIP; Past Chief, Mental Health Study Center and Clinical Infant Development Program, National Institute of Mental Health; Past Member, Surgeon General's Task Force on Infant Mortality; Past Regional Vice President, World Association for Infant Psychiatry and Allied Disciplines. Editorial Boards (Present and Past): Clinical Infant Reports (Chair); Journal of the American Psychoanalytic Association, Journal of Preventive Psychiatry, Journal of Psychoanalytic Inquiry, Infant Mental Health Journal, Journal of Psychotherapy Practice and Research. Member, Advisory Boards: Institute for Mental Health Initiatives, Ounce of Prevention Foundation, Center for National Policy, Parents as Teachers National Center.

Publications: Over 100 articles and chapters. Author or editor of over 20 monographs and books. Books include Playground Politics: The Emotional Development of the School-Aged Child, Infancy and Early Childhood: The Practice of Clinical Assessment and Intervention with Emotional and Developmental Challenges, The Development of the Ego, Infants in Multirisk Families, Psychopathology and Adaptation in Infancy and Early Childhood, The Clinical Interview of the Child, Intelligence and Adaptation: An Integration of the Psychoanalytic and Piagetian Developmental Psychology, First Feelings: Milestones in the Emotional Development of Your Baby and Child, The Essential Partnership: How Parents and Children Can Meet the Emotional Challenge of Infancy and Childhood. The formulations of Emotional Milestones and related strategies to facilitate emotional growth have been incorporated into guidelines for pediatric well baby care by the American Academy of Pediatrics; featured in a PBS NOVA documentary ("Life's First Feelings") which received the American Psychological Association's 1986 award for Best Educational Program; the basis for a video tape entitles "Exploring First Feelings," being shown to new mothers in over 200 hospitals; and a video tape for educators and parents entitled "Floor Time," produced by Scholastic, Inc.

Honors: The American Psychiatric Association's Ittleson Prize for outstanding contributions to Child Psychiatry Research; The Edward A. Strecker Award for outstanding contributions to American psychiatry; Distinguished Psychiatrist Lecturer Award from the Scientifice Program Committee of the American Psychiatric Association; The Public Health Service Special Recognition Award; The Heintz Hartman Prize for contributions to psychoanalysis; Fellow of the American Psychiatric Association; Elected to the American College of Psychiatry and the American College of Psychoanalysis.

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Domestic Policy Council (Nicole Rabner)
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Work and Families Institute Conference Background-Brain Development in Young Children, June 1996 [1]

2012-1035-S
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[0016]

IRVING B. HARRIS

P6/(b)(6)
Chicago, Illinois 60602-3703
P6/(b)(6)

CURRENT POSITIONS:

Chairman of the Executive Committee and Director, Pittway Corporation
Chairman of the Board and Director, The Acorn Fund
Chairman, The Harris Foundation
Chairman, The Pittway Corporation Charitable Foundation
Chairman, William Harris Investors, Inc.
Director, Teva Pharmaceutical Industries Ltd.
Director, Harriscope of Los Angeles

PAST POSITIONS:

Chairman of the Board and Director, Harriscope Broadcasting Corporation, 1950-1986
Chairman of the Board and Director, Pittway Corporation, 1962-1984
President, The Harris Group, 1959-1976
Chairman of the Board, Science Research Associates, 1953-1958
Director, Gillette Safety Razor Company, 1948-1960
Executive Vice-President, Toni Company, 1946-1952 (sold to Gillette, 1948)
Executive, Aircraft Parts Business, 1944-1946
Office of Price Administration, 1943
Board of Economic Warfare, 1942
Finance Business, 1931-1942

EDUCATION:

St. Paul Academy
Yale University, B.A., Phi Beta Kappa, 1931

VOLUNTARY ASSOCIATIONS AND TRUSTEESHIPS:

Chairman and Co-Founder, The Ounce of Prevention Fund, 1982-1996, presently Chairman Emeritus
Chairman of the Board, Family Focus, Inc., 1979-1985, presently Chairman Emeritus
President and Founder, Erikson Institute, 1966-1983, presently Chairman Emeritus
President, Chicago Institute for Psychoanalysis, 1965-1975, presently Trustee
Former Chairman and President, Chicago Educational Television Association, presently Trustee
Visiting Committee, University of Chicago School of Public Policy Studies
Governing Member, Chicago Symphony Orchestra
Member of National Commission on Children
Member of Cleveland Commission on Poverty

Member of American Academy of Pediatrics Partnership for Child Health
Member of Subcommittee on Education and Child Development, Committee for Economic Development
Trustee, The University of Chicago
Trustee, National Center for Clinical Infant Programs
Trustee, American Jewish Committee
Trustee, The Milton S. Eisenhower Foundation
Member, Council on Foreign Relations
Chairman of the Advisory Board of the Illinois Department of Children and Family Services Training Institute
Chairman of the Advisory Board of the Illinois Competitive Access and Reimbursement Equity Program
Special Counselor to the Select Committee on Children of the Illinois General Assembly
Member, Chicago Housing Authority Citizens Task Force
U.S. Department of Health & Human Services Advisory Committee on Infant Mortality

AWARDS AND HONORS:

Honorary Membership Award, Chicago Pediatric Society, 1983
Chicago UNICEF World of Children Award, 1985
American Orthopsychiatric Association Award, 1986
Clifford Beers Lecturer, Yale University, 1987
Honorary Fellow, American Academy of Pediatrics, 1988
Statesman of the Year Award, Harvard Club of Chicago, 1989
Fellow, American Academy of Arts and Sciences, 1989
Member, The President's Circle, National Academy of Sciences, 1989
Citizen Fellow, The Institute of Medicine of Chicago, 1990
Distinguished Service to State Government Award, National Governors' Association, 1990
Amicus Certus Award, Lutheran Social Services of Illinois, 1990
The Community Partnership Award, United Neighborhood Organization of Chicago, 1990
"As They Grow" Award, Parents, 1991
Chicago Metropolitan Association for the Education of Young Children "Service to Young Children" Award, 1995
American Orthopsychiatric Association Marion F. Langer Award, 1995

Honorary Degree, Loyola University, 1976
Honorary Degree, Kenyon College, 1986
Honorary Degree, Columbia College, 1987
Honorary Degree, Lesley College, 1988
Honorary Degree, Bank Street College of Education, 1988
Honorary Degree, DePauw University, 1989
Honorary Degree, Yale University, 1990
Honorary Degree, The University of Illinois at Chicago, 1992
Honorary Degree, Roosevelt University, 1996

Myron A. Hofer, M.D.

Myron A. Hofer (M.D. 1958, Harvard University) is a Professor of Psychiatry at Columbia University College of Physicians and Surgeons and Director of the Division of Developmental Psychobiology at New York State Psychiatric Institute. His postdoctoral training was in Medicine (Massachusetts General Hospital), Psychiatric Research (National Institute of Mental Health (NIMH)), and Animal Behavior (American Museum of Natural History). His research interests have centered on the basic biological processes underlying early development, maternal separation, attachment and the parent-infant relationship.

He holds a Research Scientist Award from NIMH (since 1978) and has been president of the American Psychosomatic Society and the International Society for Developmental Psychobiology. He is on the editorial boards of the journals *Behavioral Neuroscience, Developmental Psychobiology,* and *Psychosomatic Medicine* and is the author of *The Roots of Human Behavior* (1981) and co-editor of the *Developmental Psychobiology: New Methods and Changing Concepts* (1991).

BIOGRAPHICAL NOTES
Samuel S. Kessel, M.D., M.P.H.

As an engineer, physician, scientist, husband, and father of two, Dr. Kessel has a comprehensive perspective on national and international health policy, public and personal health, and health promotion and disease prevention. Raised in Philadelphia, Pennsylvania and educated in Philadelphia, New York, Boston, Washington, D.C., and Baltimore, he has first-hand community-based expertise in pediatrics and developing and implementing programmatic health strategies at Federal, State and local levels. He is experienced in the legislative process and program management and administration, including the Maternal and Child Health Services Block Grant authorized by Title V of the Social Security Act as amended. He has had experience in policy development, analysis, and implementation at the White House and throughout the Department of Health and Human Services, including the Office of the Secretary, Office of the Assistant Secretary for Health, the National Institutes of Health, and the Health Resources and Services Administration.

He has applied his skills in seeking to reduce infant mortality and low birth weight, improve prenatal care, reduce ethnic and racial disparities, promote minority professional development, advance the standard of medical care, and enhance access to needed services at the national, State, and local level. He has directed new approaches for the education of health professionals in order to improve primary care for the underserved and highly vulnerable populations and strengthen the public health infra-structure via local health care delivery systems which are community-based, family-centered, problem solving and outcome focused. Dr. Kessel has worked to assure the delivery of effective services based upon scientific evidence, and qualitative and quantitative analysis. He has focused his attention across a spectrum of health issues of considerable scope and complexity - from health promotion and prevention to the enhancement of families and children to empower and enable them reach their full potential. He has been at the forefront of efforts to address concerns for adolescents, children with special health needs, technology dependent children, the family, smoking cessation, drug abuse, and AIDS treatment and prevention. He has also led efforts to improve management, data and information initiatives, and qualitative and quantitative problem solving.

Examples of his leadership include the development of the "Surgeon General's Workshop" concept, a mechanism for the U.S. Surgeon General to assemble national experts from the sciences, professional community, government, and community to address public health problems of great importance to our nation in a dynamic and interactive fashion. He directed the analysis of complex program and cost-effective information critical to the development of national policy for children which led directly to the formulation of a Presidential Healthy Start Initiative. He directed the development of a new set of national recommendations for the enhancement of the content of prenatal care and incorporation of health promotion and prevention concepts into new national child health supervision guidelines. He led the development of an initiative that brings together pediatricians and local institutional resources at the community level in a partnership for children translating science into practice. The Healthy Tomorrows Partnership for Children, as the program is known, is one of the most successful new MCHB endeavors ever undertaken and has been acclaimed by the Surgeon General as an excellent example of community programming. He also directed the publication and dissemination of *Child Health USA*, a highly acclaimed new monograph on the health status of our nation's children.

It was as a consequence of his efforts that Secretary Schweiker initiated the Healthy Mothers Healthy Babies Coalition and Secretary Heckler initiated the Black and Minority Health Task Force. He led the development of Secretary Bowen's Infant Health Initiative. He has briefed Assistant Secretary for Health Richmond, Brandt, MacDonald, Windom, Mason and Lee on child health policy matters. He has been a resource for Surgeon Generals Richmond, Koop, Novello and Elders on numerous topics. He has been an expert consultant and witness for numerous commissions and committees, such as the National Commission on Children and the National Commission to Prevent Infant Mortality and testified before House subcommittees and been called upon to brief Congressional members and staff.

He has worked extensively with professional organizations such as the American Academy of Pediatrics (AAP), the American Board of Pediatrics, and the Ambulatory Pediatrics Association to focus attention on addressing new morbidities of children and adolescents. He has collaborated with the Robert Wood Johnson Foundation and the Southern Governors' Association to improve infant health in the southern region of the United States. He has worked with the AAP and the American College of Obstetricians and Gynecologists to establish office-based research networks to investigate clinical child health issues in a setting where the majority of the nation's children receive their care. These networks are real world based and hold great promise for capturing new knowledge critical to the advancement of child health.

Through his work, he has established a respected national and international reputation and is a recognized authority on maternal and child health. He has an unusual ability to sense future directions and issues needing attention and the leadership ability to muster the professional energy of his colleagues to address those challenges. His ability to synthesize, evaluate and analyze information has allowed for both shaping Federal policy and formulating programmatic strategies for improving child health that have had substantial broad based appeal both nationally and internationally. He has significant knowledge and experience in both regional health affairs and resource development, as well as national public health experience. Most importantly, his strong interpersonal skills and supervisory/management skills have led to increased productivity, a strong sense of fairness, a congenial work atmosphere, and an integration of public and private resources. He has a great appreciation of both private and public sector problem solving and a demonstrated ability to utilize this knowledge and combine it with programmatic and management skill to advance the health of the nation.

RONALD KOTULAK

Science Writer

Chicago Tribune

A Chicago Tribune science writer since 1963, Kotulak has covered many of the most important scientific advances of the last three decades, ranging from space travel to the AIDS epidemic, and from molecular biology to the genetics revolution.

He received the 1994 Pulitzer Prize for explanatory journalism for two related series on brain research: "Unraveling the Mysteries of the Brain" and "Roots of Violence."

A graduate of the University of Michigan, Kotulak is a past president of the National Association of Science Writers. He has won a number of national writing honors, including awards from the American Psychiatric Associaton, American Chemical Society, American Medical Association, Arthritis Foundation, National Society for Medical Research, American Heart Association and the National Mental Health Association.

In 1995, Kotulak received the American Diabetes Association's C. Everett Koop Medal for Health Promotion and Awareness.

THE UNIVERSITY OF CHICAGO

DEPARTMENTS OF PSYCHIATRY AND PEDIATRICS
5841 SOUTH MARYLAND AVENUE
CHICAGO, ILLINOIS 60637

Division of Child
& Adolescent Psychiatry

BIOGRAPHICAL SKETCH

Bennett L. Leventhal, M.D.

Dr. Leventhal was born in Chicago, Illinois and grew up in Arkansas, Illinois and Louisiana. After receiving his M.D. from Louisiana State University School of Medicine at New Orleans, Dr. Leventhal completed his residency and fellowship in child and adolescent psychiatry at Duke University Medical Center. At Duke, he served as chief resident and as a junior faculty member. Following two years as a medical officer at the Naval Regional Medical Center at Portsmouth, Virginia, Dr. Leventhal joined the faculty of the University of Chicago, where is he is currently Professor of Psychiatry and Pediatrics, and Chairman of the Department of Psychiatry. He is a Diplomate of the American Board of Psychiatry and Neurology in both general and child psychiatry, a Fellow of the American Academy of Child and Adolescent Psychiatry and the American Psychiatric Association. Dr. Leventhal is Past President of the Society of Professors of Child and Adolescent Psychiatry and Past President of the Illinois Council of Child and Adolescent Psychiatry, and Board Member, MacArthur Foundation Juvenile Court Project. An active clinician, teacher, and investigator, he has worked extensively in the areas of autism, developmental disorders, psychopharmacology and attention disorders.

5/6/96

Alicia F. Lieberman is Professor of Psychology at the University of California San Francisco Department of Psychiatry, Director of the Child Trauma Research Project and Senior Psychologist at the Infant-Parent Program, San Francisco General Hospital. She is a clinical consultant at the San Francisco Department of Social Services on issues involving the mental health needs of children in the Child Protective Services. She is a member of the Board of Directors of Zero to Three: The National Center for Infants, Toddlers and Families, and on the Editorial Board of Infant Mental Health Journal. Dr. Lieberman is the author of **The Emotional World of the Toddler** and co-author with Stanley Greenspan, Serena Wieder and others of **Infants in Multiproblem Families**. Her major interest is in infant mental health, with specific focus on disorders of attachment and the effects of psychological trauma on children's development. Her current research involves a treatment outcome study of infant-parent psychotherapy with three year olds who witnessed domestic violence. As a bilingual, bicultural Latina, she has a special interest in cultural issues in child development, childrearing, and infant mental health intervention, particularly as they relate to the experiences of Latino families in the United States.

MARGARET E. MAHONEY
BRIEF BIOGRAPHY

Margaret E. Mahoney, is President of MEM Associates, Inc., and Immediate Past President of The Commonwealth Fund, a national philanthropic foundation located in New York City. She has devoted her career to work with philanthropies on issues concerning health, education, the arts and humanities. She was the first woman to head a major foundation.

Miss Mahoney is Chair of "Healthy Steps for Young Children," a new national initiative to help parents foster the healthy growth and development of their very young children. The goal of this private effort is to assist health care systems and professionals in improving the care of children from birth to age three.

Previously, Miss Mahoney served as a Foreign Affairs Officer in the United States Department of State, from 1946 to 1953. She was with The Carnegie Corporation of New York from 1953 to 1972 and was Vice President of The Robert Wood Johnson Foundation from 1972 to 1980 when she was named President of The Commonwealth Fund.

Miss Mahoney is a member of and Visiting Scholar at the New York Academy of Medicine, and a member of The Institute of Medicine, Council on Foreign Relations, American Philosophical Society, and Alpha Omega Alpha. She is a fellow of the American Association for the Advancement of Science and the American Academy of Arts and Sciences. Currently, Miss Mahoney serves on the boards of Columbia University, Columbia University Press, Goucher College, the Alliance for Aging Research, the John D. and Catherine T. MacArthur Foundation, the Carnegie Institute for the Advancement of Teaching, the Dole Foundation, the National Foundation for the Centers for Disease Control and Prevention, the New York Academy of Medicine, and Skillbuilders Fund. In New York City, Miss Mahoney serves on the board of the Office of the Chief Medical Examiner and is also serving the Office of the Mayor of the City of New York on a Blue Ribbon Panel studying the future of the city's Health and Hospitals Corporation.

A native of Nashville, Tennessee, Miss Mahoney graduated magna cum laude from Vanderbilt University and has honorary degrees from Beaver, Smith, Williams, Marymount and Meharry Medical Colleges, Brandeis University, the University of Florida in Gainesville, the Medical College of Pennsylvania, and the State University of New York in Brooklyn. In 1984, she received the Frank H. Lahey Memorial Award, and in 1989, she became one of first recipients of the Women's Forum Award. In 1992, she received the Associated Medical Schools of New York's Walsh McDermott Award, and in 1993, was honored with the Council on Foundation's Distinguished Grantmaker Award and the New York Academy of Medicine Plaque. She was honored in 1994 by the American College of Physician with the Edward R. Loveland Award, by the Community Family Planning Council with the David Axelrod Award, and by the American Association of Medical Colleges with a Special Recognition Award. In 1995, she was honored by Grantmakers in Health with the Terrance Keenan Leadership Award.

Updated 6/6/96

Curriculum Vitae

Linda Carol Mayes, M.D.
Yale Child Study Center
Yale University School of Medicine
P.O. Box 3333
New Haven, CT 06510
(203) 785-2513

Education

University of the South Sewanee, Tennessee	B.A. Chemistry	1969-1973
Vanderbilt University Graduate School Nashville, Tennessee	History	1973-1974
Vanderbilt University School of Medicine Nashville, Tennessee	M.D.	1973-1977

Professional Training

Intern in Pediatrics Vanderbilt University School of Medicine Nashville, Tennessee	1977-1978
Resident in Pediatrics Vanderbilt University School of Medicine Nashville, Tennessee	1978-1980
Fellow in Neonatology Vanderbilt University School of Medicine Nashville, Tennessee	1980-1982

Awards, Honorary Societies

University of the South Summa cum laude with honors in chemistry Senior award in chemistry Wilkins Scholar Phi Beta Kappa Valedictorian	1969-1973
Vanderbilt Medical School Alpha Omega Alpha Amos Christie Award in Pediatrics	1973-1977
James Hudson Brown--Alexander Coxe Research Award, Yale University School of Medicine	1984-1985
Sigma Xi	1985
Research and Teaching Award Ambulatory Pediatrics Association Plenary Session of Spring Meeting Washington, D.C.	1985
Johnson and Johnson Advanced Pediatric Research Award	1984-1986
William T. Grant Faculty Scholar's Award	1986-1991
Career Development Award (K02) National Institute on Drug Abuse	1994-1999
Doctor of Science (*honoris causa*) University of the South	October, 1994

Boards, Consultative Positions

Children's Clinical Research Center Yale University School of Medicine	1987-1990
Adjunct Scientist, National Institute of Child Health and Human Development	1990-
Gesell Institute	1991

Special Commission on Infant Health City of New Haven, CT	1992-
Special Review Committee, National Institute on Drug Abuse	1992-

Professional Organizations

Ambulatory Pediatric Association	1984
Society for Research in Child Development	1986
World Association for Infant Psychiatry	1987
American Psychoanalytic Association-affiliate member	1989
Connecticut Council of Child Psychiatrists	1992

BIOGRAPHY

Judith Smith Musick was the founding director of the Ounce of Prevention Fund, a statewide initiative for teenage mothers in Illinois. She currently serves as the Vice Chair of its Board of Directors. She is also a visiting faculty member at Loyola University's Erikson Institute for Advanced Study in Child Development. She has spent the past seventeen years developing and studying prevention and intervention programs for children, youth and parents, and conducts research and writes about the development of girls growing up in various high risk environments in the U.S. and abroad. She was the recipient of a multi-year grant from the Rockefeller Foundation to synthesize and write about her work with adolescent mothers which resulted in the book, Young, Poor and Pregnant: The Psychology of Teenage Motherhood, published by Yale University Press. Her study of former participants in a national demonstration program for young, single mothers on welfare, is described in the monograph, Lives of Promise, Lives of Pain: Young Mothers After New Chance, published by Manpower Demonstration Research Corporation (Janet Quint and Judith Musick with Joyce Ladner). Most recently she completed a study of home day care providers, parents, and children in a model, multi-site, day care and economic development initiative for low income families. This study is described in The Family Child Care Connection: Helping Low Income Parents Move Ahead Without Leaving Their Children Behind.

Dr. Musick received her Ph.D. in child development and educational psychology from Northwestern University, and completed a post-doctoral traineeship in clinical developmental psychology at Northwestern's School of Medicine and Prentice Women's Hospital. She is currently conducting research on leadership and economic development with girls and women living in disadvantaged communities across the country. A list of Dr. Musick's publications is available on request.

BIOGRAPHICAL INFORMATION

Bruce Duncan Perry, M.D., Ph.D.

Dr. Perry is the Thomas S. Trammell Research Professor of Child Psychiatry, the Executive Director of the CIVITAS ChildTrauma Programs and the Vice-Chairman for Research in the Department of Psychiatry and Behavioral Sciences at the Baylor College of Medicine in Houston, Texas. Within the Baylor College of Medicine clinical system, he serves as Chief of Psychiatry at Texas Children's Hospital. Dr. Perry has secondary appointments in Pediatrics, Pharmacology and Neuroscience.

Dr. Perry, a native of Bismarck, North Dakota, was an undergraduate at Stanford University and Amherst College. He attended medical and graduate school at Northwestern University, receiving both M.D. and Ph.D. degrees. Dr. Perry completed a residency in general psychiatry at Yale University School of Medicine and a fellowship in Child and Adolescent Psychiatry at The University of Chicago.

Dr. Perry's neuroscience research had examined the effects of prenatal drug exposure on brain development, the neurobiology of human neuropsychiatric disorders, the neurophysiology of traumatic life events and basic mechanisms related to the development of neurotransmitters in the brain. His clinical research and practice has focused on traumatized children – examining long-term cognitive, behavioral, emotional, social, and physiological effects of trauma in children, adolescents and adults. This work has been instrumental in describing how traumatic events in childhood change the biology of the brain. Dr. Perry is the author of over 150 journal articles, book chapters and scientific proceedings and is the recipient of a variety of professional awards and honors.

Dr. Perry is the author of *Maltreated Children: Experience, Brain Development and the Next Generation* to be published by W. W. Norton & Co. in 1996.

Kyle Dean Pruett, MD

Current Responsibilities

Clinical Professor Psychiatry, Yale Child Study Center (Training Director, Child Development Unit)

Private Practice; Infant, Child, Adolescent, Family Psychiatry

Principal Investigator, Longitudinal Study of Developmental Competence in Children of Primary Paternal Care

Areas of Interest/Expertise

Consultant to Vice President Al Gore, White House Conference "Men in Children's Lives"

Legal dimensions of Fatherhood (Divorce, Custody, Reproductive Technology and Child Development)

School and Day Care Consultation, both public and private sector

Local and National Affiliations/ Activities

Zero to Three: National Center for Infants, Toddlers, and their Families, President-Elect

Performing Arts Medicine Association (Vocal performance in children, and performance anxiety)

Program for the Humanities in Medicine, Yale University

Chair, International Study Group on Fathers and Child Development

Publications/Media

Contributing Editor, Goodhouskeeping Magazine (1993-95)

Contributing Editor, Child (1994-)

Consultant, "CBS Morning News" (1988-)

Host: "Your Child 6-12 with Dr. Pruett", Lifetime Television (1993-95)

Author of The Nurturing Father,(Warner), The American Health Book Award (1988)

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[001c]

April/96

Curriculum Vitae

Pasko Rakic

P6/(b)(6)

Degrees: M.D. (1959) Medicine, University of Belgrade Medical School
Sc.D. (1969) Developmental Biology and Genetics, University of Belgrade
M.S. (1978) Honorary, Yale University, New Haven, Connecticut

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Tel: (203) 785-5288 Fax: (203) 785-5263
E-mail: pasko.rakic@qm.yale.edu

Residence:
P6/(b)(6)

Research Interests: Developmental Neurobiology; Cellular and Molecular Mechanisms of Neuronal Migration, Axonal Navigation and Synaptogenesis; Genetic and Epigenetic Regulation of Neuronal Interactions During Development, Neuropathology of Congenital Disorters.

Professional Experience

1959-61	Assistant Professor of Pathological Physiology, University of Belgrade
1961-62	Resident in Neurosurgery, University Hospital, Belgrade
1962-66	Clinical and Research Fellow in Neurosurgery, Harvard Medical School, Boston
1967-72	Assistant Professor of Neuropathology, Harvard Medical School, Boston
1972-77	Associate Professor of Neuropathology, Harvard Medical School
1977-	Professor of Neuroscience, Yale University School of Medicine, New Haven
1978-	Dorys McConnell Duberg Chair in Neuroscience, Yale University
1990-	Chairman, Section of Neurobiology, Yale University School of Medicine

Honors and Awards

Member, National Academy of Sciences, USA, 1985; American Academy of Arts and Sciences, 1994; Croatian Academy of Arts and Sciences, 1990; Serbian Academy of Arts and Sciences, 1985; President, Society for Neuroscience, 1995/6; President, Cajal Society, 1992; Grass Foundation Award and Lecture, 1985; Karl Spencer Lashley Award, Amer. Philosophical Society, 1986; Francois I Medal, College de France, 1986; Pattison Award in Neuroscience, 1986; Kreig Award, Cajal Society, 1989; F.O. Schmitt Medal and Lecture, 1992; Weinstein-Goldenson Scientific Award (United Cerebral Palsy Foundation), 1994; Fyssen International Science Prize, 1992; Henry Gray Award, AAA, 1996; Neuroscience Research Program, Associate 1980-1989; Selby Fellow, Australian Academy of Science, 1983; Javits Neuroscience Investigator Award, 1984, 1991; Doctor Honoris Causa, A. Sent-Georgyi Univ., Szeged; Doctor Honoris Causa Universitatis Studiorum Zagrabiensis; Numerous eponymic lectures including the Sally Harrington Goldwater, Pickney Harmon (Cajal Club), Jenkins Memorial (Oxford), Bernard Sacks (AAPN), Yesup (Columbia), Philip Bard (Johns Hopkins), Ariens Kappers (Royal Netherlands Academy of Sciences), Gordon Holmes (London), C.N.Woolsey (Madison), R.J. Terry (St. Louis), D.O. Hebb (Montreal); Cotzias (American Academy of Neurology); Moontcastle (Johns Hopkims).

Editorial Boards

Advances in Neurology (1988-Present); Brain Research (1977-Present); Brain Research Bulletin (1973-1988); Cerebral Cortex, Co-Editor (1990-present); Developmental Brain Research (1979-Present); Year Book for Encyclopedia of Neuroscience (1987-Present); Experimental Brain Research (1977-Present); Glia (1988-Present); Human Neurobiology (1982-86); Journal of Cognitive Science (1988-Present); Journal of Comparative Neurology (1979-Present); Journal of Neurocytology (1975-present); Journal of Neuroscience (1981-90); Neuroscience (1973-Present).

Advisory Activities

Board Member: Kuratorium, Max-Planck Institute, Germany, 1982-96; Councilor, Society for Neuroscience, 1980-84; ; United Nations Commission on Radiological Protection (ICRP), 1983; U.S. National Committee for IBRO, 1982-88, Chairman, 1988-92; Advisory Board, British Neurological Research Trust, 1988-93; Board of Trustees, Neuroscience Institute, Rockefeller University (1988-91); Advisory Board, Frontier Research Program, RIKEN, Tokyo, Japan, 1992-95; Advisory Board, National Allience for Autism Research, 1994- ; Advisory Board, March of Dimes Basil O'Connor Award Committee, 1994-1997.

NIH Study Sections: Neurology A, 1978-82; Visual Sciences B, 1984-88; Reserve 1988-92. NIH Special Foreign Currency Grants, 1972-78; Special Consultant NIH Program Project Review Section, 1977; Advisor to NIDA, Grant Review Panel, 1975-77; Technical Review Panel on Neuroscience, NIDA-ADAMHA, 1979; NIMH Panel on Neural Development, 1993

Consultant for: National Science Foundation; Atomic Energy Control Board (Canada); Canadian Medical Research Council; The March of Dimes Foundation; J.S. Guggenheim Memorial Foundation; Huntington Chorea Foundation; Human Frontier Foundation.

Selected Publications (from over 200)

Rakic, P. 1971 Neuron-glia relationship during granule cell migration in developing cerebellar cortex. A Golgi and electronmicroscopic study in Macacus rhesus. *J. Comp. Neurol.* 141: 283-312.

Rakic, P. 1972 Mode of cell migration to the superficial layers of fetal monkey neocortex. *J. Comp. Neurol.* 145: 61-84.

Rakic, P. and Sidman, R.L. 1973 Weaver mutant mouse cerebellum; defective neuronal migration secondary to specific abnormality of Bergmann glia. *Proc. Natl. Acad. Sci. (USA)* 70: 240-244.

Rakic, P. 1973 Kinetics of proliferation and latency between final cell division and onset of differentiation of cerebellar stellate and basket neurons. *J. Comp. Neurol.* 147: 523-546.

Sidman, R.L. and Rakic, P. 1973 Neuronal migration with special reference to developing human brain: a review. *Brain Res.* 62: 1-35.

Rakic, P. 1974 Neurons in the monkey visual cortex: Systematic relation between time of origin and eventual disposition. *Science* 183: 425-427.

Rakic, P., Stensaas, L.J., Sayre, E.P. and Sidman, R.L. 1974 Computer-aided three-dimensional reconstruction and quantitative analysis of cells from serial electronmicroscopic montages of fetal monkey brain. *Nature* (London) 250: 31-34.

Rakic, P. 1976 Synaptic specificity in the cerebellar cortex: Study of anomalous circuits induced by a single gene mutation in mice. In: *The Synapse*. Cold Spring Harbor Symposia on Quantitative Biology. 40: 333-346.

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Rakic, P. 1977 Genesis of the dorsal lateral geniculate nucleus in the rhesus monkey: site and time of origin, kinetics of proliferation, routes of migration and pattern of distribution of neurons. *J. Comp. Neurol.* 176: 23-52.

Caviness, V.S., Jr. and Rakic, P. 1978 Mechanisms of cortical development: a view from mutations in mice. *Ann. Rev. Neurosci.* 1: 297-326.

Knyihar, E., Csillik, B. and Rakic, P. 1978 Transient synaptic contacts in the embryonic primate spinal cord. *Science* 202: 1206-1209.

Schmechel, D.E. and Rakic, P. 1979 Arrested proliferation of radial glial cells during midgestation in rhesus monkey. *Nature* (London) 227: 303-305.

Levitt, P., Cooper, M.L. and Rakic, P. 1981 Coexistence of neuronal and glial precursor cells in the cerebral ventricular zone of the fetal monkey: An ultrastructural immunoperoxidase analysis. *J. Neurosci.* 1: 27-39.

Rakic, P. and Nowakowski, R.S. 1981 Time of origin of neurons in the hippocampal region of the rhesus monkey. *J. Comp. Neurol.* 196: 99-124.

Shatz, C. and Rakic, P. 1981 The genesis of efferent connections from the visual cortex of the fetal rhesus monkey. *J. Comp. Neurol.* 196: 287-307.

Rakic, P. 1981 Development of visual centers in the primate brain depends on binocular competition before birth. *Science* 214: 928-931.

Rakic, P. and Riley, K.P. 1983 Overproduction and elimination of retinal axons in the fetal rhesus monkey. *Science* 209: 1441-1444.

Rakic, P. and Riley, K.P. 1983 Regulation of axon numbers in the primate optic nerve by prenatal binocular competition. *Nature* 305: 135-137.

Easter, S.S., Jr., Purves, D., Rakic, P. and Spitzer, N.C. 1985 The changing view of neural specificity. *Science* 230: 507-511.

Rakic, P. 1985 Limits of neurogenesis in primates. *Science* 227: 154-156.

Rakic, P., Bourgeois, J.-P., Eckenhoff, M.E., Zecevic, N. and Goldman-Rakic, P.S. 1986 Concurrent overproduction of synapses in diverse regions of the primate cerebral cortex. *Science* 232: 232-235.

Williams, R.W. and Rakic, P. 1988 Elimination of neurons in the rhesus monkey's lateral geniculate nucleus during development. *J. Comp. Neurol.* 272: 424-436.

Rakic, P. 1988 Specification of cerebral cortical areas. *Science* 241: 170-176.

Kostovic, I. and Rakic, P. 1990 Developmental history of transient subplate zone in the visual and somatosensory cortex of the macaque monkey and human brain. *J. Comp. Neurol.* 297: 441-470.

LaMantia, A.S. and Rakic, P. 1990 Axon overproduction and elimination in the corpus callosum of the developing rhesus monkey. *J. Neurosci.* 10: 2156-2175.

Kuljis, R.O. and Rakic, P. 1990 Hypercolumns in primate visual cortex develop in the absence of cues from photoreceptors. *Proc. Nat. Acad. Sci. USA* 87: 5303-5306.

Rakic, P. 1990 Principles of neuronal cell migration. *Experientia* 46: 882-891

Schwartz, M.L., Rakic, P. and Goldman-Rakic, P.S. 1991 Early phenotype expression of cortical neurons: Evidence that a subclass of migrating neurons have callosal axons. *Proc. Natl. Acad. Sci. (USA)* 88: 1354-1358.

LaVail, M.M., Rapaport, D.H. and Rakic, P. 1991 Cytogenesis in the monkey retina. *J. Comp. Neurol.* 309: 86-114.

Rakic, P., Suner, I. and Williams, R.W. 1991 A novel cytoarchitectonic area induced experimentally within the primate visual cortex. *Proc. Natl. Acad. Sci. (USA)* 88: 2083-2087.

Lidow, M.S., Goldman-Rakic, P.S. and Rakic, P. 1991 Synchronized overproduction of neurotransmitter receptors in diverse regions of the primate cerebral cortex. *Proc. Nat. Acad. Sci. USA* 88: 10218-10221.

Wikler, K.C. and Rakic, P. 1991 Emergence of the photoreceptor mosaic from a protomap of early-differentiating cones in the primate retina. *Nature* 351: 397-400.

Komuro, H. and Rakic, P. 1992 Specific role of N-type calcium channels in neuronal migration. *Science* 257:806-809.

Bourgeois, J.-P. and Rakic, P. 1993 Changing of synaptic density in the primary visual cortex of the rhesus monkey from fetal to adult stage. *J. Neurosci.* 13: 2801-2820.

Komuro, H. and Rakic, P. 1993 Modulation of neuronal migration by NMDA receptors. *Science* 260: 95-97.

Cameron, R.S. and Rakic, P. 1994 Polypeptides that comprise the plasmalemal microdomain between migrating neuronal and glial cells. *J. Neurosci.*, 14: 3139-3155.

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Rakic., P. 1995 Development of cerebral cortex in human and nonhuman primates. In: *Child and Adolescent Psychiatry*. (M. Lewis, ed), Williams and Wilkins, Baltimore, Second Edition, pp. 9-29

Kornack, D. R. and Rakic, P. 1995 Radial and horizontal deployment of clonally related cells in the primate neocortex: Relationship to distinct mitotic lineages. *Neuron,* 15: 311-321

Rakic, P. (1995) A small step for the cell - a giant leap for mankind: a hypothesis of neocortical expansion during evolution. *Trends in Neuroscience,* 18: 383-388

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Bouergois, J.-P. and Rakic, P. 1996 Synaptoarchitecture of the occipital cortex in macaque monkey devoid of retinal input from early embryonic stages. *Euro. J. Neurosci.*, 8: 942-950

Suner I. and Rakic, P. 1996 Numerical Relationship between Neurons in the Lateral Geniculate Nucleus and Primary Visual Cortex in Adult Macaque Monkeys. *Visual Neurosci.*, 13: 585-590

Wikler, K.C. and Rakic, P. 1996 Developmnet of photorecptor mosaic in the primate retina *Perspetive on Developmental Neuroboiology,* 3: 161-175

Anton, S.A., Cameron. R. S. and Rakic, P. 1996 Role of neuron-glial junctional proteins in the meintainance and termination of neuronal migration across the embryonic cerebral wall. *J. Neurosci.* 16: 2283-2293

Recent key references include:

Ramey, C.T., Bryant, D.M., Wasik, B.H., Sparling, J.J., Fendt, K.H., & LaVange, L.M. (1992). Infant Health and Development Program for low birthweight, premature infants: Program elements, family participation, and child intelligence. Pediatrics, 89, 454-465.

Ramey, C. (1992). High-risk children and IQ: Altering intergenerational patterns. Intelligence, 16, 239-256.

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Campbell, F.A., & Ramey, C.T. (1995). Cognitive and school outcomes for high risk African American students at middle adolescence: Positive effects of early intervention. American Education Research Journal.

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[0014]

Biographical Sketch

THE REV. DR. KENNETH B. SMITH, SR.

Dr. Smith is President and Associate Professor of Ministry at The Chicago Theological Seminary. He is an ordained minister of the United Church of Christ, having been ordained by the former Chicago Congregational Christian Association in May of 1960. Dr. Smith was elected President by the Board of Trustees of the Seminary on May 21, 1984, and began his tenure on October 1, 1984.

He was born in P6/(b)(6)

He serves as a Director, Illinois Federal/Service Loan Association - Chicago, Illinois and Board of Advisors of Alford Group.

EDUCATION Educated in the public schools of Montclair and graduated from Montclair High School; Class of 1949.

1992	**DOCTOR OF SACRED THEOLOGY,** (Honorary) Olivet College, Olivet, MI
1990	**DOCTOR OF HUMANE LETTERS,** (Honorary) Chicago State University, Chicago, IL
1987	**DOCTOR OF DIVINITY,** (Honorary) Shaw University, Raleigh, NC
1981	**DOCTOR OF PUBLIC SERVICE** (Honorary) National-Lewis University, Wilmette, IL
1971	**DOCTOR OF DIVINITY** (Honorary) Elmhurst College, Elmhurst, IL
1960	**BACHELOR OF DIVINITY** Bethany Theological Seminary, Oak Brook, IL

1953-54 Graduate Study
Drew University Madison, NJ

1953 **BACHELOR OF ARTS**
Virginia Union University Richmond, VA

EMPLOYMENT and **MINISTERIAL** <u>**SERVICE**</u>

1968-84 <u>Senior Minister</u>, Church of the Good Shepherd, Congregational, United Church of Christ, Chicago, Illinois. During Dr. Smith's tenure the congregation completed a major renovation of its facilities including the installation of a custom-made Wicks American Classical Pipe Organ; initiated programs in pre-school education, after school care and recreation; nutritional and recreational programs for retired persons; and a special program for teenagers with unique needs in cooperation with the Illinois Department of Children and Family Services.

The congregation also constructed 150 units of housing for the elderly (1979 -Good Shepherd Manor) and an additional 60 units of housing for the elderly (Good Shepherd Tower - 1984).

1966-68 <u>Minister of Urban Affairs</u>
The Community Renewal Society
Chicago, Illinois

1961-66 <u>Organizing Minister and Pastor</u>, Trinity United Church of Christ, (called by the Illinois Conference of the United Church of Christ). During Dr. Smith's tenure the church grew to be self-sustaining and moved into the first unit in 1966. Chicago, Illinois

1957-61 <u>Associate Minister and Director of Parish Activities</u>, The Congregational Church of Park Manor Chicago, Illinois

	1954-57	Program Secretary, YMCA of Metropolitan Chicago (Wabash Avenue Department)
CURRENT VOLUNTARY SERVICE	1982	Member, Christian Century Foundation Board; Member, Board of Directors, Chicago Chapter The National Conference
	1983	Member, The Executive Committee, Chicago Community Trust (A Chicago Foundation); Chairperson, 1995 -
	1984	Chairman, Visiting Committee: School of Social Service Administration, University of Chicago
	1986	Member, The Board of Trustees, DePaul University; Member, YMCA of Metropolitan Chicago Board of Managers
	1990	Member, Continental Bank Community Development Corporation; Trustee, National Trust for Historic Preservation
	1991	Chair, The Council of UCC Seminary Presidents
	1992	Member, Board of Trustees - National Center for the Humanities, Research Triangle Park, NC
PAST VOLUNTARY SERVICE	1986-95	Member, The Board of Trustees of National Youth Advocates, Washington, DC
	1986-93	Member, Carnegie Adolescents Council, The Carnegie Corporation of New York
	1986-90	United Way of Chicago
	1988-91	Member, National Board of Trustees, National

Conference of Christians and Jews;

Monthly Commentator on Channel 5 (NBC) on the Everyman Show sponsored by the Church Federation of Greater Chicago

1987-90	Member, Board of Directors, the Latino Institute
	Member, Board of Directors, the Bensenville Home Society
1984-87	Chairman and Board member, Leadership Greater Chicago
1983-87	President, The Community Renewal Society, Board of Directors, Chicago, IL
1979-82	Member, Chicago Board of Education
1980-81	President, Chicago Board of Education
1982-90	Treasurer, Board of Directors, United Way of Chicago
1980-81	Member, Public Buildings Commission of Chicago
1975-79	Chairman, Board of Directors, Chicago Urban League
1972	Member, The United Church of Christ Peace Priority Team Travel in Eastern Europe
1971-73	Chairman, National Executive Council, The United Church of Christ
1970	Delegate, World Alliance of Reformed Churches in Nairobi, Kenya

PUBLICATIONS

1976	Lenten Book of Meditation - Eden Publishing Company
1986	With Dr. Dorothy C. Bass, edited The United Church of Christ - Issues in its Quest for Denominational Identity, published by Exploration Press

AMONG HONORS AND AWARDS are

1980	**Presidential Citation**, Chicago State University
1980	**Urban Leaguer of the Year Award**, Chicago Urban League
1980	**The Protestant Foundation of Greater Chicago Award**
1980	**Par Excellence** Award, Blackbook Directory
1980	**Citizen of the Year**, Omega Psi Phi Fraternity
1980	**Humanitarian Award**, Plano Chicago Development Center
1981	**Educational Award**, National Convention: Operation PUSH
1983	**Volunteer of the Year** - Chicago Chapter National Society of Fund Raisers
1989	**Gutenberg Award**, The Chicago Bible Society
1990	**Chairman's Volunteer of the Year Award**, The United Way of Chicago
1993	The Tree of Life, Anti-Defamation League - Chicago Regional Board

	1994	**The Victor Freemont Lawson Award** - Community Renewal Society
	1996	**Harold Washington Leadership Award for Public Service** - The Chicago Historical Society
OTHER	Listed in:	
		Who's Who in America Who's Who in Religion Who's Who in Black America The Ebony Success Library

<u>FRATERNITIES</u>

Omega Psi Phi
Sigma Pi Phi
Omicron Delta Kappa (Honorary)

<u>CLUBS</u>

University Club of Chicago
Commercial Club of Chicago
Quadrangle Club, University of Chicago

<u>FAMILY</u>: Dr. Smith is the son the late Mr. and Mrs. William Smith of Montclair, New Jersey. He is married to the former Gladys Y. Moran, teacher in the Chicago Public Schools. They have three children: Kenneth Bryant, Jr., Kourtney Beth, and Kristen Bernard. The family resides on the Seminary campus.

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Revised
6/96

Alan Sroufe is the William Harris Professor Child Psychology in the Institute of Child Development and Adjunct Professor in the Department of Psychiatry at the University of Minnesota. Professor Sroufe received his Ph.D. in Clinical Psychology from the University of Wisconsin in 1967, with a clinical internship at the Langley Porter Neuropsychiatric Institute in San Francisco. In 1984-85 was a fellow at the Center for Advanced Study in the Behavioral Sciences. Dr. Sroufe is a member of the Society for Research in Child Development and is on the editorial boards of 3 professional journals. An internationally recognized expert on early attachment relationships, emotional development, and developmental psychopathology, he has published six books and more than 100 articles on these and related topics. With colleague Byron Egeland, Professor Sroufe is conducting the most detailed longitudinal study from birth through adulthood ever carried out. The study, which follows the development of 200 children of poverty has been important for identifying the origins of both pathology and competence and the factors that make children vulnerable or protect them from developmental problems.

BERNICE WEISSBOURD

Bernice Weissbourd is an early childhood educator, well-known as an initiator and leader of the family support movement. In 1976 she founded Family Focus, a not-for-profit agency providing comprehensive programs in diverse communities for families of children from birth. In 1981 Ms. Weissbourd created the Family Resource Coalition, a national organization serving as a resource on family support programs and policies. Ms. Weissbourd is a contributing editor to Parents Magazine, and has authored and edited numerous publications on family support policies and practices. Her most recent book (1994) co-edited with Sharon Lynn Kagan, is Putting Families First: America's Family Support Movement and the Challenge of Change, published by Jossey-Bass. She is a lecturer at the University of Chicago, School of Social Service Administration.

Ms. Weissbourd is past president of The American Orthopsychiatric Association, a congressional appointee to the National Commission on Children, former Vice President of the National Association for the Education of Young Children, and a member of the Administration for Children and Families' Advisory Committee on Services for Families with Infants and Toddlers. She is on numerous national boards and advisory committees, is the recipient of many awards and honors, and frequently consults with national media on child and family issues.

January 1995

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ZERO TO THREE
National Center for Clinical Infant Programs
June/July 1995 Volume 15 No. 6

Department of Photography, Denver Children's Hospital

Developmentally Supportive Care in the Neonatal Intensive Care Unit

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Program, Erikson Institute, Chicago, Illinois

Over the past 15 years, neonatal intensive care units have been involved in a transformation of care which has been described as the most profound change that has occurred in neonatal nursing practice (Gilkerson & Als, 1995). These nurseries are moving toward a new model of family-centered, developmentally supportive care—a professional and family alliance which supports the parent's engrossment with their child and the child's neurobiologically-based expectations for nurturance (Als, 1993).

Developmentally Supportive Care in the Neonatal Intensive Care Unit

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Brain development in the full-term infant occurs in the intrauterine environment, an environment mediated by maternal protection from environmental perturbations, with an ongoing supply of nutrients, continuous temperature control, and regulating chronobiological rhythms. In contrast, premature infants are cared for in the NICU at the time when their brains are growing more rapidly than any other period in their life (McLennan, Gilles, & Neff, 1983). The preterm infant's nervous system is being shaped in a setting characterized by sensory overload and, therefore, by a stark sensory mismatch to the developing nervous system's expectation for environmental inputs (Als et al, 1979; Freud, 1991; Gottfried & Gaiter, 1985; Wolke, 1987). From an evolutionary perspective as members of the human species, preterm infants are neurobiologically social (Als, 1977; Als et al, 1979; Als & Duffy, 1982) and expect the security of three inherited environments to support their development: their mother's womb, their parents' bodies, and their family's social group (Hofer, 1987). Thus, safeguarding the parent's role as the infant's primary nurturers is fundamental to the survival and growth of the premature infant (Als, 1992; Als, in press). How does one estimate the potential effects on the infant's nervous system of moving too early from the relative equilibrium of the intrauterine aquatic econiche of the mother, to the extrauterine terrestrial environment of the NICU (Alberts & Cramer, 1988) by-passing the on-parent body phase of early nurturance? What impact does this disruption have on the infant's and family's development? How can the life-saving intensive care nursery become a supportive, nurturing environment that enhances the development of all involved?

Developmentally supportive care

The developmental approach views the infant as an active collaborator in his own care, determinedly striving to continue his developmental trajectory (Als, in press). This approach postulates that the infant's behavior provides the best information base from which to design care (Als, 1982). Collaborating with the infant, then, involves inferring from the infant's own behavior what he seeks to accomplish and what strategies he is using, and estimating what supports might be useful to facilitate the infant's overall development and neurobehavioral organization in the face of necessary medical and nursing interventions. The questions become: What is the infant's developmental agenda? (Als, 1978) and How can caregiving be implemented in a way that respects and furthers the infant's development while at the same time accomplishes the caregiving goals?

The Newborn Individualized Developmental Care and Assessment Program (NIDCAP) model was developed as a framework for the implementation of developmental care (Als & Gibes, 1986). The NIDCAP approach includes a systematic method for the detailed observation of infant behavior and for the use of each infant's unique repertoire of strategies as a guide for caregiving. Typically, a developmentally trained professional works in partnership with a developmentally trained nurse to support the primary care team and the family. The developmental professionals conduct the observations, prepare detailed reports with suggestions for ways to support the infant's physiological stability, behavioral organization, and developmental progression, and share this information with the caregiving teams and the family.

Behavioral observation

The detailed behavioral observation documents the language of the infant's behavior in three channels of communication: the autonomic system, motor system, and the state system (Als, 1982). As described elsewhere (Als, in press), the autonomic nervous system's functioning can be observed in the infant's breathing patterns, color fluctuation, visceral stability or instability, and autonomic behaviors such as tremors and startles. Is this an infant who breathes smoothly and regularly? Or does he quickly show, even when challenged with only the slightest touch, movement, or sound, irregular respiration, pauses or tachypneic bursts? Is this an infant who maintains his color well throughout face and body or does he quickly become pale, and cyanotic? Does this infant maintain a steady visceral system even when interacted with vigorously or does he quickly begin to hiccough, gag, spit up, or defecate in response to mild input?

Simultaneously, motor system functioning can be observed in the infant's body tone, postural repertoire and movement patterns. Does the infant maintain tone well, showing animated facial expression and well-toned limbs throughout? Or does he quickly become flaccid, lose tone in the face, trunk, and extremities? When still, does the infant maintain soft flexion or does he quickly become overly flexed, appearing to use hyperflexion for self-protection? Or, the opposite, does the infant overly extend arms, legs, fingers, and toes in full extension, face retracted, head, neck, and back arched and extended? When the infant moves, are the movements smooth and well controlled or are they quickly disorganized, with poor flexor/extensor balance?

The infant's state organization (Brazelton, 1984) can be observed in terms of the infant's range of states, the robustness and modulation of the available states, and the patterns of transition from state to state. Is this an infant who shows the full continuum of states moving from deep sleep to light sleep, to a drowsy state, to quiet alertness, to an active aroused state to upset and crying behavior? Or does the infant typically move from sleep to aroused states and immediately back down to sleep again, skipping the alert state? When the infant is sleeping, is the sleep robust, or does the infant never quite settle, showing facial movements, vocal discharges, and general restlessness? What is the quality of the infant's alert state? Is his expression animated, with shiny-eyed alertness and gently forward-shaped mouth, available for engagement and interaction? Does the infant quickly move to panicked, wide-eyedness or does he barely seem to muster the energy to interact through lidded, glassy-eyed, strained appearance?

The observations may be conducted weekly or as clinically deemed necessary by a developmental specialist and take place at a mutually agreed upon time when the nurse or other caregiver is interacting with the infant (e.g., taking vital signs, diapering, or suctioning). The observer does not interact with the infant, but stands close by watching and recording at two-minute intervals on a NIDCAP check sheet. In order to arrive at a sufficient sample of behavior, the infant is observed for at least 20 minutes before interaction with the caregiver, throughout the caregiver interaction, and for 20 minutes after. In addition to recording the details of behavior, the observer notes physiologic data (e.g., heart rate, respiration rate, and oxygenation), light and sound levels, and environmental activity around the bedside. Caregiving interactions are also described.

Behavioral interpretation

All observations are seen in the context of the infant's efforts at self-regulation through approach and avoidance behaviors (Als, in press). This framework assumes that the infant has strategies available to move toward and take in stimuli, if the input is appropriate in timing, complexity, and intensity in relation to the infant's thresholds of functioning and, conversely, that the infant has strategies to move away from or avoid inputs which are too complex or intense or are inappropriately timed. Such behaviors are thought of as stress behaviors. Of course approach and self-regulatory behaviors can shift and become stress behaviors; the same behaviors, when successful in reducing stress, can serve as self-regulatory strategies. For example, for the very young infant, a hand on the face and mouthing may represent stability, yet if overly frequent, these behaviors may indicate stress, or possibly seizure activity. As a general rule, extension behaviors are thought to reflect stress, and flexion behaviors are thought to reflect self-regulatory competence. Diffuse behaviors are thought to reflect stress, and well-defined behaviors are thought to reflect regulatory balance. Self-regulatory balance is reflected by the presence of regular respirations, pink color, a stable visceral system, smooth movements, modulated tone and softly flexed posture, and steady sleep and awake states.

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Full length view of two incubators at the Chicago Lying-In Hospital, circa 1901.

The developmental professional prepares a descriptive narrative based on the observed behavioral dialogue between the infant and the caregiver. The narrative begins with a description of the environment surrounding the bedspace. Next, the behavioral picture of the infant before active caregiving is described in relationship to physiological measures. Then the caregiving interaction with detailed focus on the infant is documented, including the infant's efforts, initiations, and responses as well as the caregiver's efforts to aid the infant. Repeated observations reveal much information about the infant's strengths and robustness and the goodness-of-fit between the infant and the care provided. The infant's behavior is interpreted as to the infant's apparent current developmental goals. The narrative concludes with caregiving suggestions and environmental modifications to consider in order to more finely attune care to the infant's behavioral thresholds and to support the infant's developmental trajectory. The narrative is shared with the infant's professional caregivers and with the family, and, depending on the nursery's stage in developmental care integration, included in the infant's medical chart (Als et al, 1986; Als et al, 1994).

NIDCAP guidelines for care

In order to effectively implement developmentally supportive care within the NIDCAP framework, Holmes, Sheldon, & Als (in preparation) and Vento & Fineberg (in press) have outlined guidelines for care. Following is a description of a developmental care environment based on their recommendations.

• **Consistency of caregiving:** Within 24 hours after admission, a primary team is identified for each infant. The team includes the family and specific representatives from medicine, nursing, respiratory therapy, and social work as well as a specially trained developmental professional. The team works collaboratively with the family to develop an individualized plan of care which should be reviewed daily on rounds and discussed in regularly scheduled team meetings with the family.

• **Structuring the infant's 24-hour day:** In order to provide the infant with sufficient rest and to support growth, interventions are organized into individually appropriate clusters timed in accordance with the infant's sleep-wake cycles, states of alertness, medical needs, and feeding competence. All caregiving interactions are evaluated regarding their necessity and appropriateness, e.g., does an infant in need of ventilation have to be suctioned on a fixed schedule or as clinically indicated? Taxing procedures such as suctioning are performed by two-person teams.

• **Pacing of caregiving:** During the delivery of care, caregivers approach the infant and family in a calm manner, explaining to the family the goal and sequence of care. The care provider organizes the environment, gathers needed materials, and prepares herself to be attentionally and emotionally available to the infant and family. The infant is observed before hands-on interaction. The caregiver then introduces herself to the infant with a soft voice and gentle containing touch. During care, the infant is offered periods of rest and recovery between caregiving actions and containment through gentle holding or handswaddling, finger-holding, or sucking on a pacifier or finger. Parents are nurtured in supporting their infant during caregiving as the infant needs the comfort and security of this family's care. Since the infant comes to recognize the familiarity of the parents' hands, bodies, and voices, he is comforted by their presence and often shows increased physiologic stability when they are present. The care provider stays with the infant and family by the bedside after care to assure that the infant is settling comfortably.

• **Support during transitions:** Increased support is typically needed around transitions, particularly between caregiving activities (e.g., ventilator care, position changes, feeding, diapering) and around the beginnings and endings of care. Extra support is needed as the infant awakens or when the infant makes efforts to sleep. Caregiver interactions are guided by the infant's behavioral cues with special attention given to the facilitation of restful sleep at the end of the alert state.

• **Appropriate positioning:** Infants are supported into softly flexed, comfortable aligned positions during sleep, feeding, bathing, and necessary procedures. Positioning can be supported with aids such as blanket rolls, nesting, gentle swaddling, special buntings, and hands-on containment. Sidelying or prone positioning, if the infant has sufficient strength, is typically more desirable that supine positioning for comfort and for physiological stability. Supports are used in an effort to enhance the infant's own competence and gradually decreased as the infant's autonomous regulation increases.

• **Individualized feeding support:** Feeding method and schedule are determined by the infant's individual needs and competencies. Feeding should be a pleasurable experience for the infant, one over which the infant takes increased initiation and control. Caregivers hold the infant in a secure and comfortable position. Often semi-upright with soft flexion cradled in the caregiver's arms is quite supportive. Attention to the infant's autonomic, motor, and state systems guide the pace of the feeding.

• **Opportunities for skin-to-skin holding:** Opportunities for mothers and fathers to hold their infants, including ventilated infants, skin-to-skin (Kangaroo Care) are available at all times. Infants have been found to experience increased respiratory stability and more restful sleep when held by the parents, while parents report that they experience a sense of calm and fulfillment. Staff receive support and education so that they are comfortable facilitating skin-to-skin holding and providing caregiving while the infant is being held by the parents.

• **Collaborative care:** All special examination and assessment procedures, including physical exams, ultrasounds, chest films, and neurology examinations are performed collaboratively by the respective specialist assisted by the infant's nurse and, if possible, facilitated by the parent to support the infant's comfort and well-being. This allows infants to be cared for during procedures by persons who know them and how they respond to stress and to comforting.

• **Quiet, soothing environment:** Nurseries should be quiet, soothing places where thoughtful consideration is given to the lighting, sound, and physical arrangement. The lighting plan should include individualized bedside lighting with dimmer capacity and indirect, readily adjustable general lighting. A variety of sound containing procedures are used, including separate spaces away from the infant's beds for admissions and rounds, elimination of radios and overhead pagers, and sound dampening strategies for commonly used equipment (e.g., vibrating rather than sound beepers, sound shielding blankets for incubator covers, and a flashing light which is triggered when the sound rises above agreed upon levels).

• **Family comfort:** A useful way to sensitize staff to the messages conveyed to parents by the environment is for staff to walk the path from the hospital's parking lot to the infant's bedside (Als, in press). What does the layout say to parents about the importance of their role in their child's care? Parents are exquisitely attuned to the emotional ambiance of the setting. What is conveyed by the behavior of those with whom the family comes into contact with, from the parking lot attendant to the attending physician? To increase family comfort in the unit it is recommended that home-like, individualized spaces for families be provided. Recliner chairs big enough for two persons are available at each bedside. Parents should be encouraged to view the space around their infant's bedside as theirs, to be arranged to their liking; to bring clothing, blankets, toys, pictures and other items from home to personalize their infant's bedspace. Twins are cared for by the same team together in the same area, if not in the same incubator or crib. Readily available, trained, child care support is provided for siblings.

- **Developmental support:** Specially trained developmental professionals should be on staff full-time. These professionals should be knowledgeable about infant and family development, support the primary care teams, and serve as resources and catalysts in the implementation of developmental care. Developmental professionals should be linked with their counterparts in other units and have opportunities to participate in relevant local, regional, and national conferences. Nursery-wide implementation should be supported by a multi-disciplinary developmental team. The team should have access to unit-specific training and consultation opportunities, including an opportunity to develop a process for monitoring and reflecting upon the process of change (Gilkerson & Als, 1995). A Parent Council with multicultural representation should also be formed. Families and staff should have ready access to psychosocial support. Formal arrangements to use the expertise of a licensed clinical social worker, psychiatric nurse, or psychology/psychiatry consultant should be in place.

Fundamental principles of infant caregiving

While developmental practices may at first glance seem foreign within the context of newborn intensive care, they are based on fundamental principles of infant caregiving that transcend settings. Winnicott is quoted with saying: "A baby is always contending with being done to." Regardless of the setting, three features should characterize infant caregiving: individualization, responsiveness, and respectfulness (Gerber, 1979). Gonzalez-Mena & Eyer (1980) offer 10 principles of relating to an infant with respect. Among these are: involve infants in things that concern them, invest in time when you are totally available, learn the infants' unique ways of communicating and give them the opportunity to experience yours, respect infants as individuals, build security by teaching trust, and be concerned about the quality of development in each stage (p. 9-10).

Developmental care ensures that infants are thought about individually in the NICU environment, and conceived of as competent to collaborate in their own care. The developmental approach asks NICU caregivers to watch closely for the infant's own efforts, to notice in what context the infant is most well-regulated and competent, and to offer just enough assistance to support the infant's own developing capacities and next steps. The guidelines for feeding stress the importance of the infant's increasing initiative and competence. In this way, caregivers promote the development of effectance, effectance motivation, and the experiences of mastery outside of the womb.

In the day care literature, considerable attention is paid to the activities of physical caregiving: diapering, feeding, sleeping, comforting. Caregiving is defined as not just the activity, but the entire sequence and ambiance of care: what happens before, during, and after. This approach is illustrated in the following description of diapering in an infant care program:

> *First prepare the environment and get the materials ready. Next go to the child, but first, let her be. Watch and wait until she notices you. Let her know what will happen and tell her about each step along the way. After care, stay with her until she has settled with an activity and is re-engaged* (Abel, personal communication, 1995).

The developmental approach brings this same attention to the process of caregiving to the NICU. Because infants are forming their perceptions of the world, they absorb not only what is done in physical caregiving, but the manner in which it is done. Gonzalez-Mena and Eyer (1980) point out that certain basic needs of the infant are met through physical care; other higher level needs are met in the way the physical care is delivered. The pacing of care, so central to the developmental approach, allows for a thoughtful, unhurried, finely attuned dialogue between infant and caregiver. This kind of early experience communicates to the infant important messages about the human environment.

Lally and Phelps (1994) stress that settings for infants should offer security, protection, and intimacy. Primary caregiving arrangements and continuity of providers are central to creating a sense of security and trust for the infant and for the family. When caregivers are continually changing, infants have to work harder to get their message across (Lally & Phelps, 1994); but also have no opportunity to develop expectancies and therewith trust. This has been shown to lead to depression, failure to thrive, and hospitalism syndromes. For infants who are premature and medically fragile, this is of even greater seriousness since the resources to rally in the face of stress are more limited.

The presence of parents is the most fundamental basic security that an infant can have; it is imperative that staff be supported and educated about the primacy of parenting and about their role in supporting the realignment of parental and fetal infant co-regulatory energies. The professional caregiver's own direct interaction with an infant in the NICU needs to model the attunement to the personhood of that infant at all times. This assures the parent of the appropriateness of the affective value with which they imbue each of the child's movements and actions, no matter how small. This co-regulatory nurturance of attunement through modeling and through respectful preparation of appropriate settingss for the parent/infant co-regulation is the professional caregiver's most far reaching responsibility in the service of the infant's well-being. This is of particular importance because of the very intensivist setting which the infant requires. The developmental model not only seeks to protect the infant from inappropriate and overstimulation and from unnecessary procedures but seeks to assure that each infant is cared for by persons who know the infant intimately, that is, who know the infant's ways of initiating and of showing competence and distress. These are caregivers who define their own competence by their co-regulatory responsibility and effectiveness, that is, who have an appropriately educated emotional investment in the infant and parents' increasingly autonomous co-regulatory competence.

Support for the effectiveness of developmental care

Increasingly, research is documenting the role of developmental care as an important framework for newborn intensive care delivery resulting, for the most high-risk group of very low birthweight ventilated infants, in improved medical outcomes such as decreased intraventricular hemorrhage, reduced severity of chronic lung disease, improved growth, earlier discharge, and significantly reduced hospital costs (Als et al, 1986; Becker et al. 1991; 1993; Als et al, 1994; Fleisher et al. in press). Increased protection of and support to the developing nervous system by adapting the environment to the individual capacities of the infants appears to result in improved patterns of brain functioning (Als et al, 1994). This has also been demonstrated for healthy preterm infants receiving developmental care. Their brain functioning patterns were found to be significantly more similar to full-term infants, and very different from those of preterm infants not receiving developmental care (Buehler et al, in press). It appears that developmental care may differentially protect the frontal lobe, a finding of interest, given that the neuronal organization of this region occurs relatively late in the developmental sequence (Huttenlocher, 1984). These findings are particularly encouraging since the frontal lobe is implicated in organizing executive functions of the brain—attention, state regulation, planning, prioritizing, and monitoring. These are the functions which have previously been found to be particularly vulnerable in the preterm infant (Als et al, 1989; Hack et al, 1994).

Challenges of implementing developmental care nursery-wide

Over the past five years, we have collaborated with colleagues from five hospitals on the National Collaborative Research Institute for Early Childhood Intervention (NCRI-ECI), a multi-site study funded by the US Department of Education, to examine the effectiveness of the developmental approach (Als et al in preparation). In addition to an experimental investigation, this study provided the opportunity to examine questions of implementation—to explore the reasons that clinical insight of the individual practitioner about the importance of developmental care is not easily translated into larger scale, nursery-wide implementation. A senior neonatologist anticipated the dilemma 25 years ago as he recalled his first awareness of developmental care:

> *Let me tell you about the first developmental nurse. She seemed to do better at gavage feeding than the others. I watched how she fed the babies. She put the tube in and then she'd stroke around the baby's belly, just like she was calming him. We noticed the babies fed a lot better, didn't spit up as much, and gained weight better. So we noticed that, and our thought was, why doesn't everybody do it?*
> (Gilkerson & Als, 1995, p. 20)

This nurse's caregiving demonstrates her intuitive association between infant behavior and her caregiving practices, a link which resulted in improved outcome. Parents often ask: Why does developmental care need to be proven? Isn't it obvious that this care is what the infant and the family need? Nurses and physicians have commented that it is just common sense to make the baby and family as comfortable as possible. What makes developmental care so challenging? Why is it not practiced by everyone? And how can nursery staff be supported to move toward this new framework for care?

As part of the NCRI-ECI study, interviews were conducted with over 160 NICU professionals and family members to explore issues in implementation. It appears that many of the challenges are tied to the nature of the developmental approach itself—the fact that it is theory-guided, relationship-based, and systems-oriented (Gilkerson & Als, 1995).

The key concept of the developmental care framework is the concept of co-regulation, based in an evolutionary, theoretical framework of a neurobiological basis for the social nature of humans. The concept of co-regulation is central to the understanding and support of the relationship between the infant and family in the NICU. Implementing a theory-guided rather than a procedurally-driven approach is challenging in any setting; it is especially challenging in acute care environments

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which are, by tradition and necessity, oriented to standards, protocols, and caregiving routines (Gilkerson, 1990). A co-regulatory framework to care requires that the caregivers be mindful of others and, therefore, be reflective about their own actions and ways of being. Reflection as a framework for practice is not typically articulated in action-oriented, intensivist care work. Yet, with the move toward developmental care, reflective practice, by necessity, becomes a focus.

The role of reflection in the implementation of developmental care has been spelled out recently in more detail (Gilkerson & Als, 1995). The ZERO TO THREE Work Group on Supervision and Mentorship defines reflection as "the continuing conceptualization of what one is observing and doing" (Fenichel, 1992, p. 10). Reflection provides a framework for "knowing-in-action" (Schön, 1983; 1987) and shifts focus to include self-knowledge as a necessary professional competency (Bowman, 1989). Since the core of developmental care is the observation of infant behavior and the formulation of caregiving plans based on that observation, Schön's (1983) conceptualization of "reflection-in-action" is particularly apt. Developmental care implementation requires "the processes of 'feeling,' 'seeing,' and 'noticing' what it is you are doing; then learning from what you feel, see, and notice; and, finally, intelligently, even intuitively adjusting your practice" (Tremmel, 1993, p.438). Tremmel (1993) points out that to be open to reflection one has to change the way one's mind works, a challenge for any trained professional caregiver. An experienced nurse described how difficult, yet rewarding, it was to let go of familiar formulas that have shaped practice: "So much of nursing is doing routine things in a routine way. I used to suction every 3 hours, regardless. Now I think, 'Who am I suctioning for—me or the baby?'...I knew what to do before, now I know why." (Gilkerson & Als, 1995). Developmental care requires the encouragement of flexible minds, comfortable with "doing, learning, and coming to know" (Tremmel, 1993, p.438).

Relationships imply connections. Nurses who embrace a developmental approach acknowledge the connections between themselves and the infants and families for whom they care.

I used to think "I'm going to go in, put a suction catheter down the endotrachial tube. I'm going to change a diaper, I'm going to flip him, I'm going to close the door, and I'm going on to my next job and I'm not going to look in again until I have more tasks to do to him." I knew what I had to do that day but I really didn't have a sense of who the little person was I was relating to.

My mindset is different now. Now I think when I go into the isolette, it's almost like a visit. I'm coming in to communicate with you [baby] and the baby's going to communicate back with me. I'm going to observe and assess the infant and there are some things I have to do but I'm going to watch what he's telling me and adjust what I have to do given the cues that he's giving me . . . I feel connected, so much more in tune. (Gilkerson & Als, 1995, p.24)

This new connection with the infant strengthens the capacity to nurture relatedness between parent and infant.

Before I learned about the developmental approach, [in talking with parents], I focused on fixed traits like he has blue eyes . . . I didn't talk about . . . his humanness. Now I think I facilitate parents seeing their infant like a family would, knowing their baby at home. (Gilkerson & Als, 1995, p.24)

Yet work with relationships is demanding. The responsibility of connectedness can be threatening, especially to caregivers whose identity is tied to competence with technology and science. A basic tenet within the mental health disciplines is that work with relationships requires ongoing supervision, a component which is typically absent in traditional NICU settings, as it is in many other infant care settings. The ZERO TO THREE Work Group on Supervision and Mentorship (Fenichel, 1992) has defined three essential elements of supervision: regularity, collaboration, and reflection. In this framework, supervision is a relationship for learning where time is set aside on a regular basis, with an experienced and trusted professional, to explore the "imperfect processes" of professional practice (Belenkey et al, 1986) and one's own responses to the work. Shanok (1992) describes supervision as a place where "strengths are emphasized and vulnerabilities are partnered" (p.40). In the NICU the professional is continually called upon to make decisions and to act. In supervision, Shanok explains, learning is by reflection which then translates back into more thoughtful, mindful action. All NICU professionals should have access to opportunities for reflective supervision; at a minimum, members of the core developmental team should have the opportunity for individual supervision to strengthen their self-awareness and their capacity to engage in and support relationships.

The relational nature of developmental care is also evident in the process of implementation. Because of the nature of intensivist care and interdependence among the caregivers, changing patterns of NICU care is a complex endeavor which often requires considerable skill in social negotiation and collaboration. For example, allowing an infant to complete a full sleep-wake cycle without interruption may affect the timing of the physical examination by the attending physician and residents, medical procedures carried out by the fellows, specialty consultations, laboratory work, respiratory or other therapies, or even the services of the housekeeping staff. The developmental team must design a process which considers multiple perspectives and includes all involved. This is particularly important when changes affect what Scheinfeld (Personal communication, 1993) has called the "flow of activities." In a study of staff emotions in a psychiatric hospital setting, Scheinfeld found that the way a staff person typically does a routine or procedure has psychological meaning to him. The "flow of activity" gives comfort, a sense of control, a sense of being able to effect outcome. When this flow is interrupted, there can be a chain of emotional responses—anxiety, loss, anger. Because the developmental approach seeks to provide care with rather than to infants, the developmental model must be implemented in a parallel fashion, that is, with rather than to staff. For implementation to succeed, an experienced nurse manager explained, the unit must work simultaneously towards two goals: "We must integrate developmental care into practice and build collaborative relationships at the same time." Therefore, one of the most important capacities for the developmentalist in the intensive care setting is the ability to stay engaged with others despite apparent differences. Bettelheim (Bettelheim & Rosenfeld, 1993) states that when we don't know how to perceive another's behavior we "start with the assumption that the reasons or motives that lie behind his actions...seem good to him" (p. 107). "We must always proceed on the assumption that the other person's thoughts and actions are worthy of being considered in the most positive way possible" (p.119). Staying connected in this way requires a high degree of intrapersonal and interpersonal knowledge and skill, another reason why the provision of ongoing reflective supervision is essential.

In the beginning days of implementing the developmental approach in one nursery, a staff nurse remarked that she often felt torn between the needs of the baby and the needs of the staff. The polarization which this nurse experienced results in part from the press of clinical work and the lack of time to consider the needs and perspectives of all involved. In the NCRI-ECI study, we found that it was essential for the developmental team and the nursery leadership to set aside regular opportunities to reflect upon the process of implementation to slow down the process and to consider all aspects of the evolution toward developmentally supportive care. A model for this process is described elsewhere (Gilkerson & Als, 1995).

The relational nature of developmental care, by definition, makes it systems-oriented. As noted above, a change in any one part of the system has effects for the entirety of the system. Changes in the larger system, in turn, affect the dynamics within the smaller unit. As part of the periodic review of the implementation process, it is important to step back and take the pulse of the larger nursery system (Gilkerson, 1993) in order to understand the unit culture, particularly patterns of communication and conflict management (Shortell et al, 1991); critical events affecting the unit; and, most importantly, the unit's identity and sense of distinctive competence (Cooperrider & Srivastva, 1987). Fostering of change and growth, therefore, must always keep in mind the two interrelated and mutually catalyzing components of the system's growth and of the growth of individuals within the system.

Summary

The biggest change in NICU care, the move from protocol and procedure-driven to relationship-based developmental care is gaining momentum. A methodology for teaching about the observation of the infant's behavior is now available. Research documenting the efficacy of the approach is increasing; insights into individual and systems supports needed to ensure success and effectiveness of the approach are becoming increasingly understood and articulated. As the NICU begins to define itself not only as a physical care setting, but also one that supports emotional well-being, the infants and families in its care will gain. Moreover the sense of effectiveness and satisfaction of the professionals in the setting will also increase.

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Original Contributions

Individualized Developmental Care for the Very Low-Birth-Weight Preterm Infant

Medical and Neurofunctional Effects

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Objective.—To investigate the effectiveness of individualized developmental care in reducing medical and neurodevelopmental sequelae for very low-birth-weight infants.

Design.—Randomized controlled trial.

Setting.—Newborn intensive care unit.

Patients.—Thirty-eight singleton preterm infants, free of known congenital abnormalities, weighing less than 1250 g, born before 30 weeks' gestation, mechanically ventilated within 3 hours of delivery and for more than 24 hours in the first 48 hours, randomly assigned to a control or an experimental group.

Intervention.—Caregiving by nurses specifically trained in individualized developmental care; observation and documentation of the infants' behavior within 12 hours of admission, and subsequently every 10th day; developmental care recommendations and ongoing clinical support for the nurses and parents based on regular observation of the infant by developmental specialists; and the availability of special caregiving accessories.

Main Outcome Measures.—Medical outcome, including average daily weight gain; number of days the infant required mechanical ventilation, oxygen, gavage tube feeding, and hospitalization; severity of retinopathy of prematurity, bronchopulmonary dysplasia, pneumothorax, and intraventricular hemorrhage; pediatric complications; age at discharge; and hospital charges. Neurodevelopmental outcome, including Assessment of Preterm Infants' Behavior scale and quantified electroencephalography (2 weeks after due date); and Bayley Scales of Infant Development and Kangaroo Box Paradigm (9 months after due date).

Results.—The infants in the experimental group had a significantly shorter duration of mechanical ventilation and supplemental oxygen support; earlier oral feeding; reduced incidence of intraventricular hemorrhage, pneumothorax, and severe bronchopulmonary dysplasia; improved daily weight gain; shorter hospital stays; younger ages at hospital discharge; and reduced hospital charges compared with the infants in the control group. At 2 weeks after their due dates, these infants also showed improved autonomic regulation, motor system functioning, self-regulatory abilities, and visual evoked potential measures; and at 9 months, they had improved Bayley Mental and Psychomotor Developmental Index scores, as well as Kangaroo Box Paradigm scores.

Conclusion.—Very low-birth-weight preterm infants may benefit from individualized developmental care in the neonatal intensive care unit in terms of medical and neurodevelopmental outcome.

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VERY LOW-BIRTH-WEIGHT infants who need mechanical ventilation are at high risk for bronchopulmonary dysplasia (BPD), intraventricular hemorrhage (IVH), and retinopathy of prematurity. These conditions are frequently associated with long-term pulmonary, neurological, cognitive, behavioral, and emotional compromise. They produce high costs in newborn intensive care and ambulatory care after discharge.[1] Reducing such costs is a top priority for current neonatal intensive care.

Current neonatal intensive care unit (NICU) environments, with their constant noise, lights, and procedures, have been found to influence infants' arterial oxygen saturations directly and contribute to the development of chronic lung disease.[2] Concerns have also been raised that unexpected activation of the premature infant's immature brain, as occurs in the NICU environment, may inhibit developing neuronal pathways and interfere with full differentiation.[3]

For editorial comment see p 890.

Changing the NICU environment to reduce stress to the infant may help improve these outcomes. An approach to intensive care has been developed that is geared to support the individual infant's own efforts toward self-regulation and competent functioning. Since even very immature infants display reliably observable behaviors in the form of autonomic and visceral responses, movement patterns, postures, tone fluctuation, and levels of awakeness,[4,5] repeated systematic observation of the infants' behavior before, during, and after provision of care is used to identify the infants' current behavioral goals, strengths, and vulnerabilities. Trained staff then deliver care in a way that makes use of and enhances the infants'

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Dr Als holds a patent for the bunting, one of the special caregiving accessories available for the infants in the experimental group. She has a royalty arrangement with the manufacturer and a contract with the coinventor for profit sharing.

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specific strengths and diminishes their vulnerabilities. The approach is referred to as individualized, developmentally focused intensive care[6] and is increasingly advocated clinically. So far, however, only two investigations have tested its effectiveness. Both used phase-lag historical designs.[7,8] The purpose of the current study was to test the impact of individualized developmental care, with the use of a more rigorous design with random assignment and initiation of the intervention at the time of admission.

PATIENTS AND METHODS

The study was conducted at the Brigham and Women's Hospital in Boston, Mass, in a 46-bed, level III NICU, with a 98% inborn population, and with primary care nursing.

Patients

The study population was derived from a group of 43 eligible infants consecutively admitted in a 21-month period, who met the following criteria: (1) inborn; (2) birth weight less than 1250 g; (3) less than 30 weeks and more than 24 weeks of estimated gestational age at birth[9]; (4) mechanical ventilation starting within the first 3 hours after birth and (5) lasting longer than 24 hours in the first 48 hours; (6) alive at 48 hours; (7) absence of chromosomal or other major genetic anomalies, congenital infections, and known fetal exposure to drugs of addiction; (8) singleton; (9) at least one family member with some English-language facility; (10) telephone access; and (11) living within the greater Boston area.

On admission to the NICU, infants were screened for meeting selection criteria 1 through 4 and 7 through 11. Informed consent was obtained in accordance with the study hospital's guidelines. Group status was determined by means of a sealed-envelope random assignment procedure. Experimental primary care teams were assigned to the care of infants in the experimental group within 3 hours. Control group status was not revealed to staff, nor was staffing for infants in the control group influenced in any way. Four infants were judged not viable by the admitting physician; all four of these died. One family refused participation.

Experimental Intervention

The experimental treatment consisted of staffing by specially educated nurses; regular evaluation of the infants' behavior with suggestions for ways to support their development, performed by a developmental psychologist (H.A.) and/or a developmentally trained clinical nurse specialist (G.L.); and the availability of special caregiving accessories.

Forty of 160 nurses volunteered for education in developmental care. This education was conducted by the psychologist and the nurse specialist before the start of the experimental component of the project. It was geared to bring about a shift from protocol-dependent to strategic thinking, with focus on the recognition of infants as being competent and as actively participating in their own care and shaping their own development. Extensive training[5,6] in the systematic observation of each infant's unique repertoire of behaviors, and in the understanding of the opportunities these behaviors offer for care provision, constituted the core of this education, as described elsewhere.[7] For the infants in the experimental group, at least one shift in a 24-hour cycle from admission on was staffed by a nurse specifically educated in this approach.

The psychologist and clinical nurse specialist provided ongoing support for the care teams and parents of the infants in the experimental group in jointly planning and implementing individually supportive care and environments. To this end, they conducted formal observations of each infant's behavior, starting during the acute phase of initial stabilization within 12 hours of admission, and subsequently every 10th day until hospital discharge. For each observation, the infants' responses were systematically recorded for approximately 20 minutes before a necessary medical or nursing caregiving activity, throughout the duration of the caregiving, and for approximately 20 minutes after the caregiving activity.

Ninety-one behaviors, including autonomic (respiration, heart rate, color changes, visceral signs), motor (postures, muscle tone fluctuations, movements), and state organization behaviors (levels of arousal, patterns of transitions between states, clarity and robustness of sleep and awake states), were monitored every 2 minutes.[6,7] Interrater reliability was established at greater than 85% accuracy. Behaviors were conceptualized as stress (eg, flaccidity, agitated or frantic movements, hyperextensions, duskiness, respiratory pauses, gagging, spitting up, finger splaying, arching, gaze aversion) and regulatory behaviors (eg, hand to mouth, hand clasping, grasping, efforts to suck, tucking) and interpreted as indexes of the infants' current vulnerabilities and strengths, respectively.

The observations were then used to formulate descriptive neurobehavioral reports, including specific suggestions for ways to promote the infants' stability and competence in regulating themselves. Suggestions included, for instance, gently placing the infant in a flexed position to promote restfulness; encouraging supportive holding during and after procedures and taxing manipulations; structuring sleep and feeding in synchronization with the infant's sleep and wake cycles; instituting dark and quietness; and, from admission on, supporting the parents in assisting as well as in nurturing and caring for their infants. Several accessories specifically designed to support the experimental group infants could be used as indicated, including a terry cloth bunting, a hammock, and a soft nipple sewn into a long, soft terry cloth band. The behavioral reports were used by the parents and primary care teams, with support by the psychologist and nurse specialist, to formulate specific individualized developmental care plans for the infants in the experimental group.

Control Group Treatment

Control group infants received the standard care practiced throughout the Brigham and Women's Hospital NICU. This included primary care nursing and a standard developmental protocol, involving uniform shielding of incubators with blanket covers, use of clothing, as well as a 24-hour visiting policy for the parents.

Background and Outcome Assessment

The effectiveness of the individualized, developmentally based approach to intensive care was assessed in terms of medical and developmental outcome at 2 weeks and 9 months after the expected date of confinement (EDC). After discharge, the infants' medical records, after removal of the neurobehavioral reports, were reviewed by trained research staff who were unaware of the group status of the infants and the goals of the study. Medical background variables assessed included birth weight; gestational age at birth[9]; Apgar scores[10] at 1 and 5 minutes; mean and maximum levels of fractions of inspired oxygen in the first 48 hours and first 10 days; the presence of patent ductus arteriosus; mode of delivery; obstetric complications[11]; and antenatal corticosteroid treatment, all known to influence outcome. Demographic background variables included maternal age, social class,[12] marital status, child's gender, birth order, and ethnic background. The interaction of gender and ethnic background with the mean and maximum levels of fraction of inspired oxygen in the first 48 hours and to day 10, and with patent ductus arteriosus, were also assessed.

Medical outcome variables included days of mechanical ventilator support, ie,

Table 1.—Medical and Demographic Background Variables*

Variable	Control Group (n=18)	Experimental Group (n=20)	df	F	χ^2	P
Birth weight, g	862±145	872±173	1, 36	0.04	...	.85
Gestational age at birth, wk	26.5±1.4	27.1±1.6	1, 36	1.90	...	.18
Apgar score						
1 min	2.9±1.7	3.8±2.3	1, 36	1.88	...	.18
5 min	5.5±1.8	5.6±2.5	1, 36	0.02	...	.89
Fraction of inspired oxygen						
1st 48 h						
Mean	0.55±0.19	0.48±0.17	1, 36	1.20	...	.28
Maximum	0.85±0.23	0.80±0.24	1, 36	0.42	...	.52
Day 1-day 10						
Mean	0.38±0.11	0.33±0.08	1, 36	2.77	...	.11
Maximum	0.86±0.22	0.81±0.24	1, 36	0.39	...	.53
Maternal age, y	28.33±5.18	27.65±5.63	1, 36	0.15	...	.70
Obstetric Complications Scale scores (mean, 100; SD, 20)	58.72±11.45	59.10±11.85	1, 36	0.01	...	.92
Patent ductus arteriosus, No. yes/no	9/9	8/12	1	...	0.38	.54
Prenatal corticosteroids, No. yes/no	1/17	3/17	1	...	0.90	.34
Parents married or attached, No. yes/no	16/2	18/2	1	...	0.01	.91
No. firstborn/later born	9/9	9/11	1	...	0.10	.76
Sex, No. M/F	11/7	9/11	1	...	0.99	.32
Race, No. black/other	3/15	8/12	1	...	2.51	.11
Race of female infants, No. black/other	2/5	4/7	1	...	0.12	.73
Vaginal deliveries, No. yes/no	7/11	7/13	1	...	0.06	.80
Social class, No. I and II/III/IV and V	10/3/5	9/4/7	2	...	0.43	.81

*Results are mean±SD except as otherwise stated. One-way analysis of variance: F, two tailed; χ^2 test, two tailed.

Table 2.—Medical Outcome Variables*

Variable	Control Group (n=18)	Experimental Group (n=20)	df	F	χ^2	P
Average daily weight gain from birth to 2 wk after EDC, g	20±6	24±7	1, 36	3.18	...	.08
Age after LMP at discharge, wk	48.3±17.3	39.7±3.1	1, 18	4.27	...	.05
No. of days in hospital	151±120	87±26	1, 18	4.78	...	.04
No. of days of mechanical ventilation	63.8±72.9	28.3±23.3	1, 20	3.93	...	.06
No. of days of oxygen	139.4±166.1	56.8±39.3	1, 19	4.25	...	.05
No. of days before bottle feeding	104.1±85.8	59.2±25.8	1, 18	4.33	...	.05
Pediatric Complications Scale scores (mean, 100; SD, 20)	53.1±2.5	55.5±4.4	1, 31	4.43	...	.04
Hospital charges, $1000s	189±174	98±37	1, 18	4.72	...	.04
Retinopathy of prematurity, No.						
None	5	10				
Mild (stages I and II)	10	8	2	...	1.99	.37
Moderate (stage III)	3	2				
Severe (stages IV and V)	0	0				
Bronchopulmonary dysplasia, No.						
None	3	2				
Mild (stage I)	7	13	3	...	9.21	.03
Moderate (stage II)	2	5				
Severe (stage III)	6	0				
Pneumothorax, No.						
No	12	19				
Mild	1	1	3	...	6.49	.09
Moderate	3	0				
Severe	2	0				
Intraventricular hemorrhage, No.						
None	8	19				
Grade I	3	0				
Grade II	1	0	4	...	12.75	.01
Grade III	2	1				
Grade IV	4	0				

*Results are mean±SD except as otherwise stated. Brown-Forsythe one-way analysis of variance: F, two tailed; χ^2, two tailed. EDC indicates expected date of confinement; LMP, last menstrual period.

endotracheal intubation; days of oxygen therapy; incidence and severity of pneumothorax and of BPD assessed by double-blind review of chest roentgenograms (J.G.B.),[13] of IVH assessed by double-blind review of cranial ultrasound scans by a consultant senior radiologist,[14] and of retinopathy of prematurity assessed by the NICU pediatric ophthalmologist[15]; days of intravenous and gavage tube feeding; average daily weight gain to 2 weeks after EDC; gestational age at discharge; number of days of hospital stay; pediatric complications[16]; and hospital charges from admission to discharge. Developmental outcome evaluation included, at 2 weeks after EDC, the Assessment of Preterm Infants' Behavior (APIB) using the 32 standard a priori variables,[4] as well as quantified electroencephalography and evoked potentials with topographic mapping.[3] At 9 months after EDC, it included the Bayley Scales of Infant Development[17] and a videotaped 15-minute play observation (Kangaroo Box Paradigm).[18] Weight, height, and head circumference were measured at both age points. All developmental outcome assessments were conducted at the Enders Pediatric Research Laboratories, Children's Hospital, Boston, Mass, by trained examiners not familiar with the goals of the study or the group membership of the infants.

Analyses

At a probability level of <.05, two tailed, the sample size chosen ensures the detection of medium to large effects accounting for between 23% and 69% of the variance.[19] For those outcome variables that showed significant group differences in terms of variance, instead of the one-way analysis of variance test (F), the conservative Brown-Forsythe Equality of Means Test (F^*)[20,21] was used, which does not assume equivalence of variances between groups. For categorical variables, the χ^2 test with Yates' correction was used. Canonical correlation analysis,[22] which defines covariation for two groups of variables, was performed to test the relationship of the behavioral findings from the newborn to 9-month testing. Path analysis[23,24] was used to investigate the influence of IVH and BPD on the other significant outcome findings. The technique was used as a way of describing partial associations within the structure of the data. It does not imply completeness of the model.

RESULTS

None of the background measures showed significant differences (Table 1), nor did any of the interactions tested, supporting the assumption of comparability of the control and experimental groups on admission to the study.

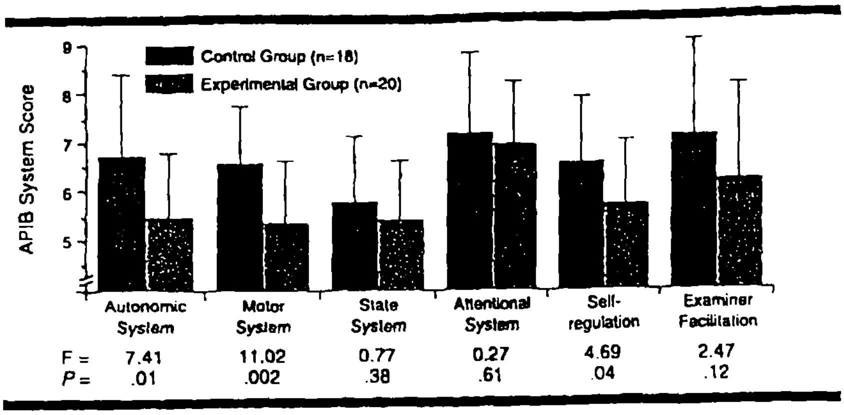

Figure 1.—Assessment of Preterm Infants' Behavior (APIB) system scores 2 weeks after expected date of confinement (mean±SD). Higher scores represent more poorly organized performance. Scores for autonomic, motor, state, and self-regulation systems are based on 18 scores per infant; for the attentional system, three scores; and for examiner facilitation, six scores. Significant F scores for the autonomic, motor, and self-regulation systems indicate that infants in the experimental group had better functioning of these systems.

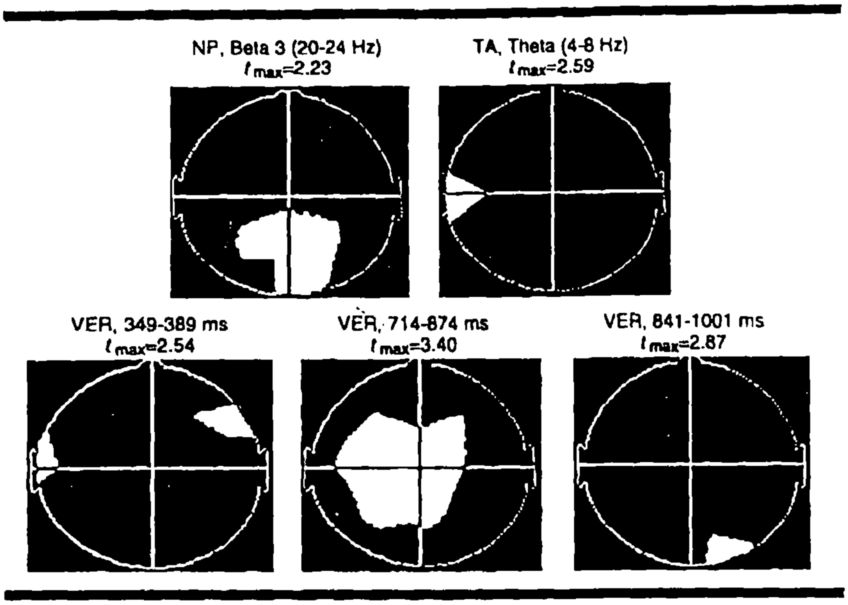

Figure 2.—Electrophysiological group differences 2 weeks after expected date of confinement. Schematic outlines show the nose at the top, the left ear to the left, and the right ear to the right. The white areas represent regions of significant between-group differences ($P<.05$, two tailed). The state of brain activation and the maximum t value (t_{max}) are as follows: nonprocessing awake (NP), in the electroencephalographic beta 3 range of 20 to 24 Hz; tracé alternant (TA), or quiet sleep, in the electroencephalographic theta range of 4 to 8 Hz; and visual-evoked response (VER) in quiet sleep from the times indicated. There were 14 infants in the control group and 17 in the experimental group.

Medical Outcome

Of the 12 medical outcome variables, eight were statistically significantly different, favoring the experimental group (Table 2). Although severity of lung disease and incidence of pneumothorax were significantly lower for the experimental group, there was no significant correlation between them ($r=.17$; $P>.50$). The earliest pneumothorax occurred on day 3 and the latest on day 21, ie, all well beyond the time of treatment onset for the experimental group.

Significantly more infants in the control group developed IVH, again after the time of treatment onset for the experimental group. Of the 10 infants in the control group with IVH, eight had normal ultrasound studies of the head on days 1 and/or 2, with the day of birth counted as day 0. One infant had a questionable grade II IVH on the first ultrasound performed on day 1, and one had a grade IV IVH by day 2, when the first ultrasound was performed. The one infant in the experimental group with IVH showed a grade II IVH on the first ultrasound performed on day 1, which developed into a grade III IVH by day 2. Although IVH was significantly more common in the control group, the correlation of IVH with severity of lung disease ($r=-.009$; $P>.50$) was not significant. Thus, the experimental group appeared to show an independent reduction in lung and in brain morbidity.

Developmental Outcome

Age at developmental outcome assessment was similar for the two groups at both outcome points (mean±SD, 18±5 vs 16±4 days after EDC and 9.2±0.6 vs 9.4±0.5 months after EDC). Growth variables measured did not show group differences at either outcome point. However, at 2 weeks after EDC, three of the six APIB system scores, ie, more than expected by chance, were significantly different, all favoring the infants in the experimental group. Figure 1 shows the APIB system score comparisons. Infants in the experimental group were better modulated in autonomic and motor system regulation, as well as in self-regulation. Furthermore, four of the 18 APIB summary variables[25]—symmetry of orientation ($P<.003$), autonomic stability ($P<.0002$), modulation of tone, movement, and posture ($P<.03$), and symmetry of motor performance ($P<.02$)—showed differences, favoring the experimental group, which also showed a significantly lower number of abnormal reflexes ($P<.002$) as assessed on the APIB.

Results of the neuroelectrophysiological evaluation in the brain activation states of alert processing, awake and not processing, quiet sleep, and flash visual-evoked response during quiet sleep for 14 infants in the control group and 17 in the experimental group identified five regions of significant differences between groups (Figure 2). These involved the parieto-occipital regions, the left midtemporal region, the right frontal and occipital regions, and a large bilateral central region. Two-group stepwise discriminant function analysis entering all five variables numerically representing the regions depicted yielded a Wilks' Λ of 0.476 ($P<.0003$), implying a large difference between the groups. Classification was 83.9% successful.

By 9 months after EDC, two infants in the control group were unavailable for study. On assessment with the Bayley Scales of Infant Development, the experimental group compared with the control group showed a significantly higher Mental Developmental Index (118.30±17.35 vs 94.38±23.31; $F=12.47$; $df=1, 34$; $P\leq.001$) and Psychomotor Developmental Index (100.60±20.19 vs 83.56±17.97; $F=6.97$; $df=1, 34$; $P\leq.01$).

Furthermore, of 20 infant variables measured in the 6-minute Kangaroo Br Paradigm Play Episode, 17 showed (ferences favoring the experimen group. They ranged in significance level from <.03 to <.0001. The largest differences were found in gross and fine motor modulation, overflow postures and associated movements, complexity and modulation of combining object and social play, ability to stay engaged in the task, and degree of facilitation necessary. In the 6-minute Stillface Episode, 12 of 19 infant variables showed significant group differences (P<.04 to <.0001), again favoring the experimental group. None of the 14 parent variables assessed showed a significant group difference, yet three interaction variables (turntaking, overall synchrony of the interaction, and overall quality of the interaction [all P<.0004]) favored the experimental group. Thus, the infants in the experimental group appeared significantly more well organized, well differentiated, and well modulated than the infants in the control group. Canonical correlation between the factors derived from the APIB variables and the factors derived from the Kangaroo Box variables was significant (canonical r=.84367; χ^2=50.77; df=20; P<.0002). This indicates a strong relationship between overall behavioral regulation at 2 weeks, as measured with the APIB, and overall regulation at 9 months, as measured with the Kangaroo Box Paradigm.

Influence of IVH and BPD

Neither IVH nor BPD had significant indirect effects on any of the medical outcome variables (Table 3). In terms of electrophysiological outcome, IVH had a significant indirect effect on only one variable. However, the direct intervention effect was stronger. The presence of BPD had no indirect effect on any of the electrophysiological findings. Neither IVH nor BPD had any significant indirect effects on any of the APIB or Bayley outcome measures. Furthermore, only two of the 32 Kangaroo Box measures showed significant indirect IVH effects, and none showed indirect BPD effects. Thus, the direct effects of the intervention appeared to go beyond the indirect contribution from reduction in IVH and BPD on the other outcomes.

Table 3.—Path Analysis to Medical, Electrophysiologic, and Behavioral Outcome Measures via IVH and BPD*

Variable	Direct Effect (P_{14})	Indirect Effect IVH ($P_{24} \times P_{12}$)	Indirect Effect BPD ($P_{34} \times P_{13}$)	r
Medical outcome measures (n=38)				
Age after LMP at discharge	−0.32†	0.12	−0.14	−.34†
No. of days in hospital	−0.32†	0.11	−0.15	−.36†
No. of days of oxygen	−0.31†	0.13	−0.16	−.34†
No. of days before bottle feeding	−0.27	0.06	−0.14	−.35†
Pediatric Complications Scale scores	0.24	0.02	0.07	.32
Hospital charges	−0.27	0.07	−0.16	−.36†
Electrophysiological outcome (n=31)				
Awake *nonprocessing*, beta 3 (20-24 *Hz*)	0.18	0.23	−0.01	.41†
Quiet sleep, theta (4-8 Hz)	−0.28	−0.16	0.01	−.44†
VER				
From 349-389 ms	0.25	0.19	−0.00	.44†
From 714-874 ms	−0.32†	−0.29†	−0.01	−.61‡
From 841-1001 ms	0.15	0.30	−0.00	.44†
Behavioral outcome: APIB (n=38)				
Autonomic system	−0.31†	0.01	−0.12	−.41†
Motor system	−0.45†	0.02	−0.05	−.48§
Self-regulation system	−0.36	0.07	−0.05	−.34†
Symmetry of orientation	0.53§	−0.02	−0.02	.49§
Autonomic stability	0.36†	0.00	0.13	.48§
Modulation of tone, movement, and posture	0.19	0.06	0.10	.35†
Symmetry of motor performance	0.38	0.03	−0.03	.39†
No. of abnormal reflexes	−0.50§	0.09	−0.07	−.49§
Behavioral outcome: Bayley Scales (n=36)				
Mental Developmental Index	0.41†	0.04	0.08	.52§
Psychomotor Developmental Index	0.24	0.07	0.10	.41†

*The path analysis tests the relationship of the independent variable, namely, the experimental treatment, to each of the dependent variables, namely, the outcome variables, taking the two intervening variables, intraventricular hemorrhage (IVH) and bronchopulmonary dysplasia (BPD), into account. The direct effect (P_{14}) and the two indirect effects ($P_{24} \times P_{12}$ and $P_{34} \times P_{13}$) sum to yield Pearson product moment correlations (r) between the experimental treatment and the outcome variables. LMP indicates last menstrual period; VER, visual-evoked response; and APIB, Assessment of Preterm Infants' Behavior.

†$P \leq .05$, two tailed.

‡$P \leq .005$, two tailed.

§$P \leq .01$, two tailed.

COMMENT

This study shows significant effects of a developmentally based, individualized approach to newborn intensive care, in terms of improved medical status and developmental outcome. Chance cannot account for the findings, since the number of effects was significantly larger than would be expected.[19] The pattern of the results was orderly and in keeping with the theory underlying the approach tested, which sees infants in the NICU as actively seeking behavioral support of their initial stabilization, ongoing differentiation, and developmental progression. Support to the infants' behavioral organizational efforts and competencies from the initial acute phase on may yield calmer infants, resulting in reduced cerebral blood flow velocity changes and fewer IVHs.[26] Since eight of 10 IVHs in the control group definitely occurred after the onset of the study, only two may potentially have occurred in utero, as did possibly the one IVH in the experimental group.[27] When these three instances of possibly intrauterine hemorrhages were excluded, the difference in incidence between the two groups was still significant (P<.002). Calmer infants also may require less supplemental oxygen and therewith develop less severe lung disease. This is in keeping with accepted mechanisms of lung disease.[28] The relatively low overall incidence of retinopathy of prematurity in both groups may in part be attributable to the covering of incubators in the study nursery for all infants,[29] and perhaps the closer attention to oxygenation levels.

Given the reduction in severity of lung disease and in incidence of IVHs, one would expect better neurobehavioral outcomes. The reduction in IVH did indeed contribute to some extent to improved neurobehavioral functioning and especially to improved neuroelectrophysiological functioning. The large bilateral central region found in the control group on the quantified electroencephalogram is consistent with data from positron emission tomographic studies,[30] suggesting broad regions of hypometabolism associated with extensive IVH. Yet a large number of outcome differences do not appear to be attributable to increased IVH and BPD in the control group, as the lack of correlation between IVH and BPD and the results of the path analysis showed. In fact, of the six infants in the control group with severe IVH (grade III and IV), only one showed severe chronic lung disease. Of the other five infants with severe BPD, three had no IVH and two had a grade I IVH only. The direct effect of the intervention may in part be associated with a reduction in progressive central nervous system injury from chronic hypoxemia[31] or might also reflect differences in sensory environmental experience,[3] leading to improved brain development and neurobehavioral functioning. The strong correlation of improved neuroregulation in the newborn period and at 9 months appears to support the postulation of improved brain development.

Despite the encouraging results of this study, caution in interpretation is nevertheless indicated for several reasons. Although none of the background measures available showed significant group differences, other measures of initial severity of respiratory illness, such as mean airway pressure, will need to be evaluated in a future study. Furthermore, one might want to evaluate the developmental approach for a very low-birth-weight population treated with surfactant,[32] although to date, no significant surfactant effects on health and development at 1 and 2 years of age have been reported.[33]

A further factor to be considered in interpreting the results of this study is the possible differential skill, maturity, previous NICU experience, and motivation of the nursing staff who volunteered for developmental education, which might have accounted for the improved outcome in the intervention group. However, the nurses who volunteered were significantly younger (29.4±3.5 vs 32.3±4.5 years; $P<.002$) and had fewer years of NICU experience (4.7±3 vs 7.1±4.3 years; $P<.005$). Motivation is harder to measure. It will be important to study the success of developmental education for staff who are required to obtain such education, rather than who volunteer to do so. Since the study was conducted in one unit, it is probable that spillover of developmental care principles to control infants occurred. This is not of concern, however, since it would work against finding an effect.

A possible confounding factor on outcome at 9 months might be the effect of early intervention after hospital discharge. However, there was no difference in the number of infants in the control group who received early intervention after discharge compared with infants in the experimental group (14 of 16 vs 11 of 20; $P<.08$). Although information on outcome beyond 9 months is not available at this point, other studies have indicated predictive validity of the APIB and Kangaroo Box Paradigm assessments to ages 5 and 8 years.[34,35]

In summary, this highly controlled randomized trial suggests that for ve[r]y low-birth-weight, initially very ill, a[n]d early born infants, individualized, developmentally based intensive care improves outcomes medically and developmentally. The results validate and extend the findings of initial studies. Provision of expert intensive medical care within an individualized, developmental framework is not only feasible but necessary to enhance the effectiveness of NICU care.

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Editorials

Editorials represent the opinions of the authors and THE JOURNAL and not those of the American Medical Association.

Individualized Developmental Care

An Emerging New Standard for Neonatal Intensive Care Units?

Many factors have improved the infant and neonatal mortality in this country. The evolution of nurseries for premature newborns into modern neonatal intensive care units (NICUs) and technological advances used in NICUs have certainly contributed to the reduction in mortality for all birth-weight/gestational-age categories. This reduction in mortality has been most dramatic in recent years for very low-birth-weight (<1500 g) and extremely low-birth-weight (<1000 g) infants. Mortality has traditionally been the tool used to evaluate the success of NICUs with these small infants. However, today both short-term and long-term morbidity and neurodevelopmental outcome must be evaluated when assessing any new intervention used in the NICU.

See also p 853.

The acceptance of new innovations in care in perinatal medicine has an unfortunate history. Unproven therapies or therapies with inappropriate risks have been adopted, while proven therapies remain underused. In the 1940s and 1950s, an epidemic of blindness, due to retinopathy of prematurity, was associated with the widespread use of oxygen to treat periodic breathing in infants. Many causes were suspected, but a multicenter randomized controlled trial confirmed the relationship between high oxygen concentrations and retinopathy of prematurity.[1] Subsequently, when oxygen was restricted, there was an increase in mortality and spastic diplegia. Better understanding of the risks and benefits of oxygen therapy, along with technological advances allowing for close monitoring of oxygen, has led to reductions in retinopathy of prematurity, spastic diplegia, and mortality. Conversely, in controlled trials as early as 1972, maternal steroids were shown to decrease the incidence and severity of respiratory distress syndrome in premature infants.[2] Yet the National Institutes of Health found it necessary to hold a consensus conference in 1994 because of the extremely low usage rate for maternal corticosteroids in eligible patients (<20%) throughout the country. After reviewing the available data, the consensus conference recommended maternal corticosteroids for nearly all mothers whose premature infants would be at risk for respiratory distress syndrome.[3]

In this issue of THE JOURNAL, Als and colleagues[4] present a carefully designed and executed randomized controlled trial of individualized developmental care for very low-birth-weight infants. Although previous work suggests that the individualized developmental care approach is beneficial, Als et al recognized the importance of a randomized controlled trial to minimize the effects of bias on their evaluation. They appropriately evaluated the effects of their proposed new therapy on both neonatal medical morbidities and neurodevelopmental outcome. As noted previously, these critical measures are necessary before the widespread use of any new intervention in NICUs.

Als et al demonstrated a significantly shorter duration of mechanical ventilation and supplemental oxygen use and a reduced incidence of pneumothorax and severe bronchopulmonary dysplasia in the experimental group. The experimental group also fed earlier, had better daily weight gain, and had a shorter hospital stay. They also had a reduced incidence of intraventricular hemorrhage and reduced hospital charges. In addition, at 2 weeks and at 9 months, the infants cared for with the individualized developmental care approach had better neurodevelopmental outcomes when compared with the control infants. Thus, their randomized controlled trial showed clear benefits without significant adverse effects.

The study is not without problems. The incidence of intraventricular hemorrhage is higher in the control group than in many other NICUs; the study was conducted before the widespread use of surfactant; the study was conducted in a single nursery with volunteer nurses for the experimental group. Despite these shortcomings, the clear differences in medical morbidity and neurodevelopmental outcome cannot be ignored. It is time that nurseries implement this type of care for ventilated, very low-birth-weight infants. Here is a "therapy" that reduces the most common and serious medical morbidities, improves neurodevelopmental outcome, and reduces overall hospital charges. Despite initial costs for changes in the physical environment of the NICUs and for the training

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of the professional staff in the newborn individualized developmental care and assessment program, shorter periods of ventilator dependence and hospital stay should save money.[5] Should third-party payers consider favoring nurseries that use individualized neurodevelopmental care to save money, while improving both medical and neurodevelopmental outcome? The NICUs choosing not to implement this form of therapy should have clear reasons and should consider their own randomized trial to attempt to disprove this work.

This is not a glamorous, high-technology form of neonatal intensive care. It does not dramatically rescue babies who are at immediate risk of death, as high-frequency ventilation, inhaled nitric oxide, or extracorporeal membrane oxygenation do. These high-technology interventions are widely used despite lack of well-controlled trials demonstrating their efficacy and safety. Will individualized developmental care for the very low-birth-weight infant be as widely accepted and implemented?

It is time for the American Academy of Pediatrics Committee on the Fetus and Newborn to critically evaluate this approach and make recommendations regarding the appropriateness of its use in NICUs. Unresolved questions should be addressed so that an appropriate research agenda can be recommended for study and funding. In particular, it will be crucial to study whether individual components of the nursery environment are important, or if they should be considered in the context of an individualized developmental care approach to the infant, as recommendations for levels of lighting, sound, and so on are developed or revised. Since the joint American Academy of Pediatrics and American College of Obstetricians and Gynecologists publication, *Guidelines for Perinatal Care*,[6] is currently being revised for a fourth edition, consideration should be given to making recommendations relative to individualized developmental care for very low-birth-weight infants.

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Invasive Procedures in Acute Myocardial Infarction

Are They Beneficial?

The article entitled "Does More Intensive Treatment of Acute Myocardial Infarction in the Elderly Reduce Mortality? Analysis Using Instrumental Variables" by McClellan et al[1] in this issue of THE JOURNAL is important for several reasons. The authors describe a new method in medical outcomes research called instrumental variables estimation. In principle, this approach eliminates the bias of patient selection on mortality in the Medicare population receiving varying intensities of treatment for acute myocardial infarction, particularly cardiac catheterization and associated coronary revascularization. The authors argue that this approach has the same effect as prospective randomization in eliminating unrecognized biases of patient selection on outcomes of differing treatment intensities.

The article makes the following conclusions for the Medicare population: (1) after acute myocardial infarction, cardiac catheterization and associated revascularization are performed less frequently in women and black men than in white men; (2) cardiac catheterization and associated revascularization have a marginal benefit and possibly no true effect on mortality after acute myocardial infarction in comparison with "intensive" medical management without cardiac catheterization; (3) after acute myocardial infarction, some aspects of acute care at hospitals with catheterization and revascularization capacity improve survival compared with hospitals without such capacity; however, this improved survival is not

See also p 859.

attributable to cardiac catheterization and subsequent revascularization itself, because improved survival at hospitals with catheterization and revascularization capacity is greatest in the first 24 hours after admission before cardiac catheterization and revascularization were performed; and (4) the data imply that reducing cardiac catheterization in the Medicare population with acute myocardial infarction would reduce costs without significant increases in mortality.

Are these conclusions warranted and what do they mean? In the traditional randomized trial of a treatment intervention, patients are selected for the study according to strict

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In Press: Infant Behavior & Development

AUDITORY TEMPORAL PROCESSING THRESHOLDS, HABITUATION, AND RECOGNITION MEMORY OVER THE FIRST YEAR

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Running head: AUDITORY TEMPORAL PROCESSING IN INFANTS.

Abstract

Selective impairments have been found in the ability of language impaired (LI) children to process the rapidly changing temporal cues critical to language comprehension and production. Performance on temporal perception and production tasks alone enable correct identification of 98% of LI from normal children. These findings suggest that auditory temporal processing (ATP) deficits might serve as a behavioral "marker" of language impairment and could be useful in early identification. Measures of perceptual-cognitive abilities in infancy such as habituation and recognition memory have been shown to be particularly sensitive to language delays. Specific links have been demonstrated between these measures and language comprehension. We hypothesize that a critical mechanism contributing to "speed of processing", as measured by rate and amount of habituation and novelty preference on recognition memory tests, may be temporal processing efficiency in infancy. ATP thresholds were examined in two groups of infants from 6 to 10 months of age: infants from families with no known history of LI and infants from families with a positive history of LI. Infants from families with a positive history of LI had significantly lower mean thresholds than control infants. ATP thresholds, habituation, and recognition memory were found to be significantly associated suggesting that they may be tapping similar processes.

Auditory Temporal Processing Thresholds, Habituation, and Recognition Memory Over The First Year.

Some 3 to 10 percent of preschool children are estimated to have a form of developmental speech or language disorder that can not be traced to a known cause such as hearing impairment, mental retardation, childhood schizophrenia, infantile autism, or frank neurological causes such as seizures or motor paralysis. This disorder is referred to as Specific Language Impairment (LI) or developmental dysphasia and may affect primarily expressive language or both receptive and expressive language development. Over the past 18 years Tallal and colleagues have reported highly significant and persistent perceptual-cognitive (nonverbal temporal perceptual, motor and memory) deficits in children with specific language impairments (See Tallal, Miller, & Fitch, 1993 for a review). LI children have been shown to be selectively impaired in their ability to both perceive and produce those speech sounds which are characterized by brief or rapidly changing temporal cues in their acoustic spectra (Tallal, Stark, & Mellits, 1985a, 1985b). The degree of temporal processing deficit has also proved to be highly correlated with the degree of language comprehension deficits in LI children as well as in adults with acquired aphasia (Tallal & Newcombe, 1978; Tallal & Piercey, 1973a,b; Tallal et al., 1985a,b).

This body of research demonstrates that LI individuals are characterized by deficits on tasks which require rapid integration of two or more sensory events which enter the nervous system in rapid succession, regardless of whether these stimuli are auditory, visual, tactile or cross-modal or whether they are verbal or non-verbal (Tallal et al., 1985a, 1985b). These findings have been replicated across laboratories in several different populations of LI and reading impaired (dyslexic) individuals over a broad age range (4-24 years) using a number of experimental paradigms (Godfrey, Syrdal-Lasky, Millay, & Knox, 1981; Reed, 1989; Snowling, Goulandris, Bowlby, & Howell, 1986; Werker & Tees, 1987).

Results of neuropathological as well as brain imaging (MRI) studies suggest that neuropathology that appears to be implicated in developmental dysphasia occurs early in life, thus the processing deficits seen in children with specific language impairments may also be detectable well before language disorders are noted (Gallaburda & Livingstone, 1993; Hagman et al., 1992; Jernigan, Hesselink, Sowell, & Tallal, 1991; Tallal et al., 1990). It has also been shown that there is a highly significant increase in family aggregation in specific developmental language disorder. It was found that language impaired children have significantly more mothers, fathers and siblings also affected with language disabilities than well matched control families (Bishop & Edmundson, 1986; Robinson, 1987; Tallal, Ross, & Curtis, 1989a). Based on these findings, autosomal dominant transmission of specific language impairment (SLI) has been hypothesized (Tallal, Ross, & Curtis, 1989b). These familial studies suggest that babies born into families with multiple members already affected with language disorders are at increased risk to develop the disorder and these infants will have a 50/50 chance of being language delayed. Furthermore, LI children with a positive family history for developmental language/learning problems perform more poorly on standardized academic tests as well as on tests of auditory processing as compared to LI children with a negative family history (Tallal, Townsend, Curtiss, & Wulfeck, 1991). Taken together these data suggest that temporal processing thresholds may be abnormal early in life and as such may present the opportunity for early screening for LI. Despite these compelling findings no attempt has been made to assess infant temporal processing abilities as a potential "marker" of later language impairment. The ability to evaluate auditory temporal processing thresholds in infancy would enable investigation of the relationship between early temporal processing ability and subsequent speech perception and language abilities.

At present, however, procedures for assessing specific temporal auditory processing deficits have been developed only for use with individuals from age 4 years through adulthood. Tallal's Repetition Test (Tallal & Piercy, 1973a), a test of auditory temporal processing, has been shown to discriminate language impaired from normally developing children with a high degree of accuracy, as well as to predict longitudinal language outcomes in preschool and school-age children (Tallal et al., 1985a,b). In the studies reported here, an infant operant conditioning paradigm designed to have the same parameters as the Tallal Repetition Test[1] was used to investigate infant auditory temporal processing abilities in infants with differing family histories of language and learning development.

Studies of auditory perception informed this research initiative. From the age of 6 weeks infants are able to discriminate complex acoustic stimuli including speech (Olsho, Koch, Carter, Halpin, & Spetner, 1988; Trehub & Jakubovicz, 1976; Trehub, Schneider, & Endman, 1980). By the age of five months, infants can discriminate between multi-tone patterns with different temporal groupings (Chang & Trehub, 1977), and from 6 months of age they can discriminate the spectral composition, duration, intensity, and pattern of a series of tones (Trehub, Bull, & Thorpe, 1984; Trehub, Thorpe, & Morrongiello, 1987). Gap detection tasks are of particular interest as they depend heavily on temporal acuity. Both gap-detection thresholds and precedence effects (the ability to detect time delays between two sound onsets) have been reported to be poorer in infants than in adults and older children (Morrongiello, Kulig, & Clifton, 1984; Werner, Marean, Halpin, Spetner, & Gillenwater, 1992). Werner and colleagues report that gap-detection thresholds for infants of 3, 6, and 12 months of age are five to eight times those of adults (Werner, et al., 1992). Nevertheless, infants are able to detect silent intervals of 80 ms within rhythmic tone sequences (Thorpe, Trehub, Morrongiello, & Bull, 1988). Infants of two to three months have also been shown to discriminate onset-time differences of as little as 30 ms under certain listening conditions (Jusczyk, Pisoni, Walley, & Murray, 1980). Systematic developmental change is also seen across childhood in processing of auditory temporal information about stimulus duration (Irwin, Ball, Kay, Stillman, & Rosser, 1985; Jensen & Neff, 1993). By 6 months of age, infants show reliable discrimination for duration changes of 20 ms. and longer (Morrongiello & Trehub, 1987). Auditory information (such as stimulus onset and offset) that is available for such brief durations is more than sufficient for discrimination of the invariant acoustic cues critical for speech perception (Eilers, Morse, Gavin & Oller, 1981; Jusczyk, Smith, & Murphy, 1981). Aslin's (1989) study examining 6.5 to 9 month old infants' discrimination of rapid frequency transitions (upward and downward linear frequency sweeps) suggests that infants, while not at adult perceptual levels, do an excellent job of discriminating these rapid frequency transitions. Discrimination of such frequency sweeps are critical to discrimination and categorization of phonetic distinctions in natural speech (Aslin, 1989, p. 588).

Crucial information relating to infants' ability to process rapidly changing auditory information has also come from studies of discrimination of consonant-vowel (CV) phonetic contrasts such as /ba/ and /da/. Infants as young as two months of age can discriminate between-category differences for most phonetic contrasts, even those not used in their native language (Best, 1984; Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992; Aslin, Pisoni, & Jusczyk, 1983). Infants of two to three months of age can also categorize spectrally dissimilar vowels phonetically (Marean, Werner, & Kuhl, 1992). These studies show that the acoustic abilities infants need to effectively process the phonetic units of speech are in place from a very early age. Moreover, taken together, the research reviewed here also strongly suggests that very young infants have the ability to perceive the brief, rapidly changing temporal cues which are critical for discrimination of certain speech sounds although they are not yet producing them.

Infant acoustic capabilities reported to date in the developmental literature represents the performance of the "best" processers. Most auditory perception studies report pooled group data; moreover, subject loss during infant psychoacoustic procedures is fairly high. Even in research using adaptive, staircase procedures developed for estimation of infant acoustic thresholds (e.g. Berg & Smith, 1983; Sinnott, Pisoni, & Aslin, 1983; Trehub, Bull, Schneider, & Morrongiello, 1986), there is a subset of infants for whom data can not be obtained. Some preschool children need much more time to process temporal information than the norm and these individual differences are linked to language development (Tallal et al., 1985a,b). We suggest that temporal processing thresholds may also vary in individual infants early in life and that variation in ATP thresholds early in life may have consequences for later language.

In addition to implications for speech, processing rate has been suggested to play a role in perceptual-cognitive development. Specifically, differences in processing abilities seem to be the critical factor in perceptual-cognitive performance between normally developing infants and those at risk for cognitive impairment (Columbo,1993; Fagan 1984; Rose, 1989; Rose & Feldman, 1995). These processing differences were demonstrated using visual as well as cross-modal (tactual-to-visual) stimuli and "perceptual speed" in later childhood was shown to be an important correlate of infant perceptual-cognitive measures (Rose & Feldman, 1995; Rose & Wallace, 1985). Measures of infant perceptual-cognitive abilities, such as habituation decrement (an index of speed of processing) and recognition memory have also been found to predict both specific language outcome (most often comprehension) as well as general cognitive outcomes (Benasich & Bejar, 1992; Bornstein & Sigman, 1986; Rose, Feldman, Wallace, & Cohen, 1991a; Tamis-LeMonda & Bornstein, 1989; Thompson, Fagan, & Fulker, 1991). Although many of the habituation and recognition memory studies cited have used infant response to visual stimuli as a predictor, at least one study has reported that response to auditory novelty at 4 months is predictive of 5 year Stanford-Binet scores (O'Connor, Cohen, & Parmelee, 1984) and auditory processing measures hold much promise as predictors (Morrongiello, 1990). A recent meta-analysis of infant habituation and recognition memory performance as predictors of later IQ concluded that independent of laboratory or particular response measure, in both risk and nonrisk samples, habituation and recognition memory reliably and substantially predict to childhood IQ (McCall & Carriger, 1993).

The underlying mechanisms responsible for such cross-age cognitive continuities are just beginning to be explored (Rose, Feldman, & Wallace, 1992; Columbo, 1993). For example, individual differences in the ability to abstract common features or to inhibit attention, differences in short-term memory (i.e. encoding, storage, or retrieval), temperamental differences in the propensity to seek out novelty, as well as speed or rate of processing or encoding have all been offered as possible mechanisms by which cognitive continuity could be shown (Berg & Sternberg, 1985; Bornstein & Sigman, 1986; Fagan, 1984; McCall, 1994; Rose et al.,1991a; Rose, Feldman, Wallace & McCarton, 1991b). Although processing speed has been frequently offered as a basis for subsequent correlations with language and cognitive outcomes, overt empirical testing of this hypothesis remains to be done.

Overall, these findings suggest that the processes that support perceptual-cognitive abilities (such as habituation and recognition memory) in infancy may also be important for language acquisition and later cognitive development. Infants participating in these studies received a visual infant-control habituation and recognition-memory task as well as an auditory temporal processing task in order to explicate the concurrent role of processing speed across tasks. We hypothesized that a critical mechanism contributing to "speed of processing" (as measured by rate and amount of infant habituation and novelty preference on recognition memory tests) may be temporal processing efficiency (as measured by auditory temporal processing). Further, we suggest that this mechanism might account for some of the relations seen between infant perceptual-cognitive measures and childhood language (specifically comprehension) and IQ scores.

The goals of this research were: 1) to develop an operant conditioning paradigm to investigate infant auditory temporal processing abilities using the same stimuli and similar methodology to the Tallal Repetition Test[2] 2) to determine the range of temporal processing abilities of infants with and without a family history of language-based learning disabilities; and 3) to examine the concurrent relationships among temporal processing, habituation, and recognition memory measures.

STUDY 1:

Methods

Subjects

Families with young infants were recruited from local (New York City, Newark, and New Jersey suburbs) pediatric practices. The final sample included 44 infants; 32 had complete data across all tasks. All infants were full-term, had uneventful pre- and perinatal circumstances, Apgar scores of 9 or 10, and birthweights above 2,500 grams. There was no history of hearing dysfunction, no recent occurrences of otitis media, and no family history of congenital hearing loss, speech, language, or reading disorder. There were twenty-four male and twenty female infants; thirty-nine (89%) were first born, four (9%) were second born, and one (2%) was a third child. Thirty-five infants were Caucasian (80%), four were Black (9%), three were Hispanic (6%), and two were Asian (5%). The families were of middle to upper-middle class background (M = 50.6 on the Hollingshead Four factor Index; Hollingshead, 1975; Gottfried, 1985). Eighteen infants were between 6 and 7.5 months, sixteen were between 7.6 and 8.5 months, and the remaining ten were between 8.6 and 10 months. Mean age at test was 7.5 months (S.D. = 2.5). Nineteen additional infants were tested but were not included for the following reasons: experiment terminated prior to completing criterion trials due to drowsy or fussy state (n = 11); experiment terminated during test phase before 10 trials or 6 reversals were accrued due to drowsy or fussy state (n = 5); experiment terminated during test phase due to climbing out of seat or inability to settle (n = 3).

Each infant received an auditory temporal processing task and an infant-control habituation and recognition-memory task as well as a standardized cognitive assessment, the Bayley Scales of Infant Development/Mental Scale (Bayley, 1970, 1993). Sociodemographic data as well as information about infant and maternal health, obstetrical history, and familial language-based learning disorders were collected via parental questionnaire.

Auditory Temporal Processing Threshold Task

Stimuli

The stimuli were two 75 ms duration complex tones with a rise and fall time of 20 ms. The tones were generated to closely match the tones used in the Tallal Repetition Test (see Tallal & Piercy, 1974, p.84). Tone 1 had a fundamental frequency of 100 Hz and Tone 2 of 300 Hz; both tones contained all harmonics with a 6dB rolloff per octave. Stimulus sequence 1 = Tone 1 followed by Tone 2. Stimulus sequence 2 = Tone 1 followed by Tone 1. The ISI varied from 500 to 8 ms. depending on the testing phase. Both tone sequences were presented at an initial amplitude of 72 dBC (68 dBA); if the infant startled the intensity was decreased by about 5 dB. Stimuli were generated by a National Instruments Digital Signal Processing Virtual Instrument (via a Lab View 2 system on a Macintosh Quadra microcomputer) and presented via a Realistic SA-150 Stereo Amplifier (Radio Shack) to one channel of a Realistic Minimus 77 speaker (Radio Shack). Sound levels were routinely checked with a Gold Line Model SPL 120 sound level meter.

Procedure

The infant was seated in a standard infant seat 60 cm from a 65 x 130 cm panel containing two rear projection screens (see Figure 1) in a sound-attenuated experimental room. A fixation point, a red flickering light 2 cm in diameter, was 3.5 cm above the infant's eye level. The infant's looking patterns and direction of gaze were videotaped with a video camera hidden behind the display panel with the lens located in a 1.3 cm hole central in the panel at the infant's eye level. To the left and right of the panel were two dark plexiglass boxes. Each of these boxes could be illuminated and a moving electrical toy activated. These two different animated toys (a clown and a bear) served as rewards for discrimination learning. A loudspeaker was centrally placed just above the stimulus panel. The video and audio signals were videotaped, and the video signal was also displayed on TV monitors (Panasonic Color Video Monitors Model 2082) in the control room to the experimenter and parent(s). Before each trial the infant was visually oriented by a momentary flashing of the signal light. Trials were initiated by the experimenter when the infant's head was at midline. Trial duration, stimulus order, and delivery of reinforcement were controlled by a custom-designed microprocessor. The infant's head position and central fixations were monitored by an experimenter in the control room and entered into a Macintosh Quadra microprocessor with a Lab View 2.1 system (National Instruments) via a button box interface. Ambient sound level in the room at the level of the infant's head was 54 dBC (57 dBA).

Insert Figure 1 about here.

Infants had to learn to discriminate between two auditory tone sequences, associate each auditory stimulus with a direction (left or right), and make a correct headturn. The experiment consisted of three phases: a Shaping phase, an Association phase and a Variable Interstimulus Interval (ISI) Test phase. During the Shaping and Association phases the tone pair that comprised each stimulus was separated by a 500 ms. ISI; in the Variable ISI Test phase the ISI within each stimulus was varied between 8 and 300 ms.

Shaping Phase: During the initial 15 trials reinforcement was not contingent on response. Two seconds after presentation of the tone sequence, the appropriate toy was automatically lit and activated whatever the infant's response; the reward segment (toy activation) lasted approximately 4 s.

Association Phase: Stimulus 1 and Stimulus 2 were randomly presented with ISIs of 500 ms. Reinforcement was contingent on a correct headturn. If the infant made a headturn in the correct direction (e.g. to the left for Stimulus 1 and to the right for Stimulus 2), the box was lit and the toy began to move. If the infant made an incorrect headturn, or failed to respond within 5 s. after stimulus presentation, no toy was activated and the next trial was presented. When the infant reached a criterion of six correct responses out of seven consecutive trials, the microprocessor signaled the end of the association phase, and the infant entered the test phase. If the infants failed to reach criterion after 20 trials the procedure was automatically terminated and the infant was retrained (Shaping phase) or rescheduled.

Variable ISI Test Phase: The same contingent procedure outlined above for the association phase was followed. Stimulus 1 and Stimulus 2 were randomly presented with ISIs varying from 300 to 8 ms., using a 1-up, 1- down adaptive procedure (Levitt, 1971) with a step size of 20 ms., until six reversals were signaled by the microprocessor. A reversal was a move from a correct response (Hit) to an incorrect response (Miss) or from a Miss to Hit. Suprathreshold stimuli (tone sequences with the 500 ms ISI used during training) were used as probe stimuli. A Probe stimulus (500 ms. ISI) was presented after two Misses or two No Response trials or any combination of these two. Failure to respond to two consecutive Probe stimuli automatically aborted the test phase. After a correct response to a Probe, the program resumed stimulus presentation at the last correct step in the adaptive procedure. Probe ISIs were not included in threshold or reversal computations.

Variables

Looking patterns were scored into the computer in real time and post hoc from the videotape by trained coders blind to type of stimulus presentation; comparisons with online scoring were made for reliability estimates on 64% of the sessions (N= 28) with $r = .99$ for direction of head turn and $r = .84$ for latencies. Mean auditory temporal thresholds were automatically calculated for each infant as well as latency to look (to right, to left, and mean latency). The mean of the last six reversal points as well as the mean of the last four reversal points was calculated for each infant in order to estimate auditory temporal processing thresholds. If infants continued to respond correctly and their state remained good after six reversals, a manual override allowed subjects to accumulate additional reversals. In practice, no infants accumulated more than seven reversals.

Habituation-Recognition Memory Task

Experimental Arrangements

At each testing session the infant was placed in a standard infant seat approximately 60 cm in front of a matte-white stimulus panel itself approximately 65 x 130 cm. The rest of the infant area was enclosed by off-white curtaining. Stimulus slides were rear projected onto two screens approximately 60 cm square by projectors behind the display apparatus. A dim signal light, 2 cm in diameter was embedded centrally between the screens 3.5 cm above the infant's eye level. The infant's looking patterns were videotaped with a video camera hidden behind the display apparatus with a lens located in a 1.3 cm hole central in the panel and at the infant's eye level. The video signal was also displayed on TV monitors to the experimenter and parent(s) in the control room.

Stimuli

Infants were habituated to black and white slides of faces with affectively neutral expressions. Two sets of stimuli were used with a pair of faces in each set. Individual stimuli in each pair were physically equivalent: for example, the two faces used had approximately equal amounts of contour and equal areas of illumination, as did the geometric stimuli used for the pretest and posttest. Pilot testing ensured that the stimuli were equivalently discriminable and equally attractive to infants[3]. In a given session, infants were habituated to one stimulus, a single face. Thus, during habituation, the paired stimuli presented in each task were identical. After habituation, infants were tested with a novel stimulus (the other face in the stimulus pair) paired with the now familiar face stimulus. Altogether new stimuli (geometric) served as pretest and posttest stimuli. All stimuli subtended approximately 25° of visual angle.

Procedure

Each infant experienced the same procedure: pretest, habituation, recognition-memory test, and posttest. During pretest and posttest, the same stimulus was shown once for 10 s. Habituation consisted of consecutive discrete trials based on the infant's individual looks and followed a version of the infant-control procedure developed by Bornstein and Benasich (1986). Before each trial, the infant was visually oriented by the momentary flash of the signal light; when oriented, the infant was then shown the habituation stimulus. Infant looking times were scored in real time by pressing buttons on a remote unit that fed directly into the timer and memory of a computer. The infant began to accumulate looking time when judged to be looking at either stimulus for a minimum of 0.3 s. To terminate a trial, the infant had to look away from the stimuli for a minimum of 1.5 s. These parameters were programmed into the microprocessor. A single "look" with these parameters defined a trial. The mean duration of the baby's first two looks constituted a baseline and was automatically set at 100%. The same stimuli were presented until the microprocessor signaled that the infant had reached a habituation criterion of two consecutive looks each less than or equal to 50% of the baseline. Immediately following habituation, the infant was tested with the habituation stimulus and a novel stimulus paired in a randomized, counterbalanced design. Each stimuli pair was presented twice for 10 s. each with right-left positions reversed for the second 10 s. presentation. The session was videotaped and looking patterns were scored both on-line and post hoc by a second experimenter. Scorers were blind to the stimulus seen by the baby and in our laboratory interobserver reliability for this type of visual scoring is very high. Two experimenters independently scored infant looking from the videotapes for 69% (n=25) of the sessions and they averaged r = .98. On-line as compared to post hoc scoring averaged r =.94.

Variables

Habituation measures obtained for each infant included: number of trials through criterion, accumulated looking time through criterion, first look at habituation stimulus, and amount of response decrement (A-B/A X 100 = % Decrement; where A = the mean of the first two trials and B = the mean of the last two trials). Another quantitative index of habituation rate was generated by fitting linear regression functions (slopes) to each infant's real looking time in s. across habituation trials, as well as to the percentage of baseline scores generated for each trial during the habituation procedure. Visual recognition memory (VRM) was indexed by percent of novelty preference (N/F+N X 100 = %N; where N = seconds of fixation to the novel stimulus and F = seconds of fixation to the familiarized stimulus).

The Bayley Scales of Infant Development: Second Edition (Bayley, 1970, 1993) were administered to each infant by psychologists trained on the editions of the test being used and unaware of the child's perceptual-cognitive or temporal processing status. This assessment provided a commonly-used, standardized assessment of the infants' concurrent cognitive development.

Results

Auditory Temporal Processing Threshold Task. A total of thirty-two infants completed the Variable ISI test phase of the auditory temporal processing threshold task. Mean auditory temporal processing thresholds for all completed test sessions, were 110.6 ms. (SD = 58.7 ms) after a minimum of 6 reversals and 70.6 ms. (SD = 25.1 ms) across the last four reversals. Mean number of trials in the test phase was 32 with a range of 28 to 47 trials. Table 1 presents the means and standard deviations for all measures.

Insert Table 1 about here.

Trial by trial sessions for two infants completing the ATP Variable ISI test phase are presented in Figure 2. The mean across the last four reversals was used as a conservative estimate of infant ATP threshold given the momentary fluctuations of attention typical in infants and the likelihood that when using an adaptive staircase some reversals could occur by chance. Figure 3 shows the distribution of auditory temporal processing thresholds over the last four reversals ($n = 32$). Examination of mean ATP threshold for boys ($M = 69.41$, $SD = 25.3$, $n = 17$) as compared to girls ($M = 72.07$, $SD = 25.8$, $n = 15$) showed no significant effect of gender (t [30] = 0.29, NS). An age (3) by ATP threshold ANOVA computed to examine the effect of age (6 to 7.5 mths, 7.6 to 8.5 mths, 8.6 to 10 mths) on ATP threshold after four reversals failed to reach significance (F [2,29] = .39, NS) suggesting no age effect for this sample.

Insert Figure 2 and Figure 3 about here.

The mean latency across infants for Hits was 1.37 s. ($SD = 0.8$) and 2.38 s. ($SD = 1.2$) for Misses. A paired t-test for the difference between Hit and Miss latencies was significant (t (30) = 3.04 , $p < .001$). Shorter latencies for Hits versus Misses provides a second measure that demonstrates that infants were discriminating between the two tone sequences. An additional twelve infants, not included in these analyses, did not complete the test phase due to failure to respond to two "probe" stimuli in a row. However, these infants provided enough data to compute latencies for Hits and Misses. Mean number of trials in the test phase for these 12 infants was 16 with a range of 10 to 16 trials completed. Latencies for completed test sessions for these infants showed a similar pattern of response with mean latency for Hits equal to 1.97 s. ($SD = 0.6$) and mean latency for Misses 3.74 s. ($SD = 1.9$). These latencies were also significantly different (paired t (10) = 9.37, p = < .001) suggesting that, as a group, they continued to discriminate between the two tone sequences. Thus attentional or state factors rather than discrimination were more likely to be the critical factor in their failure to complete the test phase.

Older infants learned the operant conditioning procedure faster than younger infants, a mean of 10 trials in the Association phase for 9 to 10-month-olds as compared to a mean of 16 trials for the 6 to 8-month-olds. However, older infants were more physically restless during the test phase even when their state was good and they were performing accurately. Five 4-month olds and six 5-month-olds not included in this sample were unable to learn the headturn contingency.

Habituation and Recognition Memory -- All infants completed the habituation recognition-memory tasks and all habituated. Infants' level of looking on the pretest ($M= 6.1$ s., $SD = 2.2$) and posttest ($M= 5.8$ s., $SD = 2.7$) was equivalent with t(31) = 0.42. The means and standard deviations for all habituation variables for the 32 infants completing all tasks are shown in Table 1. The variables of interest regarding speed of processing are number of Trials to Criterion ($M = 6.1$, $SD = 2.8$) and the two regression functions fitted to infant looking across trials during habituation, Real looking time Slope ($M = -2.11$; $SD = 2.7$) and Slope of the percentage of baseline looking ($M = -19.40$; $SD = 13.2$). Overall, infant's novelty preference following habituation significantly exceeded chance (50%) with $M = 63.0\%$, $SD = 10.8$, t (31) = 6.78, p<.0001.

Relationships among ATP, Habituation, and Visual Recognition Memory -- In order to determine whether ATP performance was related to habituation and VRM, Pearson Product Moment Correlations (Table 2) were computed for infants with complete data across all tasks (n = 32). Habituation (H) and VRM variables included: First look length in s. (H); Baseline looking amount in s. (H); Total looking time in s. (H); Number of trials to criterion (H); Slope of the habituation function (real time in s) (H); Slope of the habituation function (as a percentage of the baseline) (H); % Novelty in test (VRM). ATP variables included: Mean ATP threshold in ms. (mean of the last 4 reversals) and Number of trials to ATP training criterion (total number of trials in the Association phase). These correlations are shown in Table 2.

Insert Table 2 about here.

A stepwise multiple regression analysis was performed in order to further investigate the relationship among ATP, habituation, and recognition memory measures. Based on the correlations seen among the variables, ATP threshold was entered as the dependent measure, and five habituation variables, first look length (1st LK), real time slope (Slope RT), slope as a percentage of the baseline (Slope%), total trials to habituation criterion (TTC), and percent novelty in the VRM test (%N) as dependent variables. Variables were free to enter the regression equation at each step based on their ability to add significant variance as yet unaccounted for in the model. Results showed that Slope% entered into the regression equation first and accounted for 53% of the variance ($F(1,30) = 39.84$, $p < .0001$) and TTC entered second, accounting for an additional 7% of explained variance ($F(2,29) = 27.35$, $p < .0001$). No other variable added a significant amount of variance in the analysis. The partial correlation between Slope% and TTC was $r = .54$, thus the amount of unique variance accounted for by TTC was constrained.

Discussion

In this study we found that we were able to estimate auditory temporal processing thresholds in infants using stimulus parameters and methodology similar to that defined by Tallal and colleagues (Tallal et al, 1985a, 1985b). Mean thresholds were comparable to those found by Werner et al. (1992) for infants detecting a silent gap in a broadband noise. Latencies for Misses were significantly longer than latencies for Hits both for infants completing the Association and Variable ISI Test phases as well as for infants who failed to complete the Variable ISI Test phase. Significant latency differences between Hits and Misses provide an alternate method for demonstrating discrimination. Thus, even those children not completing the test phase due to state changes or fatigue, were able to demonstrate that they could discriminate between the sequences. About 73% of infants meeting criterion completed the test phase. Although this proportion is comparable to the percentage retained in most studies of this kind, a higher completion rate is critical in a task designed ultimately for clinical screening. This priority must be addressed in future studies. Since four and five-month-old infants were not able to learn the contingency, seeming to respond randomly during the criterion phase, the earliest age at which this procedure could be used is 6 months. We also found significant relations among ATP thresholds, habituation, and recognition memory suggesting that these measures of information processing are tapping a similar mechanism, perhaps speed of processing.

Given the literature suggesting a genetic component to language-based learning disorders and reports of poorer temporal processing among first degree relatives of LI individuals (Tallal et al., 1989, 1991) we were interested in testing infants from families with a positive history of developmental language-based learning disorders. The magnitude of difference found between normally-developing children and LI children on auditory temporal processing tasks is quite large. Control children 6 to 9 years old need only about 8 ms. between 75 ms. tones to discriminate and sequence these tones, whereas LI children require more than 250 ms. ISI (Tallal et al., 1985a). Thus we hypothesized that if infants with a positive family history for LI (FH+) demonstrated temporal processing deficits, they would likely show large differences in ATP thresholds compared to infants with a negative family history for LI (FH-).

STUDY 2:

Methods

Subjects

Infants were recruited from families with a history of developmental language-based learning disorders. Families were referred by local (New York City, Newark, and New Jersey suburbs) pediatric practices and from our ongoing genetic study of developmental language impairment. Infants were identified for study inclusion by 4 to 6 months of age. The final sample for Study 2 included 11 infants. As in the previous study, all infants were full-term, had uneventful pre- and perinatal circumstances, Apgar scores of 9 or 10, and birthweights above 2,500 grams. There was no history of hearing dysfunction, no recent occurrences of otitis media, and no family history of congenital hearing loss. All families reported a history of speech, language, or reading disorder (questionnaire and/or interview data) and most had an LI child clinically identified and participating in our family study as a proband[4]. There were seven male and four female infants; two (18%) were first born, seven (64%) were second born, and two (18%) were third children. Nine infants were Caucasian (82%), one was Black (9%), and one was Asian (9%). The families were comparable to those seen in Study 1 with a mean Hollingshead Index of 52.3 (Hollingshead Four factor Index; Hollingshead, 1975; Gottfried, 1985). Seven infants were between 6.2 and 7.5 months, three were between 7.6 and 8.5 months, and the remaining child was 10 months, 1 day. Mean age at test was 7.6 months (S.D. = 1.1). Four additional infants were tested but were not included for the following reasons: experiment terminated during shaping phase due to inability to test (n = 1; a 12-month-old); experiment terminated prior to completing criterion trials due to poor state (n = 2); experiment terminated during test phase before 10 trials or 6 reversals were accrued due to poor state (n = 1).

Stimuli, Experimental Arrangements, and Procedure

Stimuli, experimental arrangements and procedure were identical to those employed in Study 1. Each infant received the same auditory temporal processing task and infant-control habituation and recognition-memory task described previously as well as the Bayley Scales of Infant Development/Mental Scale (Bayley, 1970, 1993).

Results

Auditory Temporal Processing Threshold Task. All eleven infants completed the Variable ISI test phase of the auditory temporal processing threshold task. Mean auditory temporal processing thresholds for all completed test sessions, were 210.6 ms. (SD = 44.3 ms) after a minimum of 6 reversals and 148.2 ms. (SD = 77.2 ms) across the last four reversals. As was the case for the infants in the previous study, all analyses were conducted using ATP mean thresholds computed across the last four reversals. Mean number of trials in the test phase was 30 with a range of 26 to 44 trials. Examination of mean ATP threshold for boys (M = 177.71, SD = 78.7, n = 7) as compared to girls (M = 96.50, SD = 43.6, n = 4) showed no significant effect of gender (two-tailed t [9] = -1.88, p = .09). Given the small sample, age was split into two rather than three categories to examine the effect of age (6 to 7.5 mths, 7.6 to 8.5 mths) with the one 10-month-old added to the second category. An age (2) by ATP threshold ANOVA failed to reach significance (F [1,9] = .006, NS) suggesting no strong age effect. Table 3 presents the means and standard deviations for all measures for infants with a positive family history for LI (FH+).

Insert Table 3 about here.

Trial by trial sessions for a FH+ infant completing the ATP Variable ISI test phase is shown in Figure 4. Of the eleven FH+ infants tested, five (45%) showed this response pattern and the remainder showed patterns similar to Figure 2. Note that all infants were performing well at 500 ms. ISI; in order to enter the test phase, a criterion of six correct responses out of seven consecutive trials was required. Figure 5 shows the distribution of auditory temporal processing thresholds for the FH+ infants. A Kolmogorov-Smirnov test was used to compare the shapes of the distributions of the ATP threshold scores for FH+ and control (Study 1) infants. This nonparametric statistic examined differences in the proportions of subjects obtaining particular thresholds and suggested that these two distributions were significantly different (X^2 (2) = 10.57, $p < .01$).

Insert Figure 4 and Figure 5 about here.

Mean ATP thresholds for the two samples were also compared using a two-tailed, unpaired t-test after first testing for homogeneity of variance. Mean thresholds were significantly different in these two samples (t (41) = -5.04, $p < .0001$) as is shown in Figure 6. The mean latency across infants for Hits was 1.43 s. (SD = 0.8) and 1.69 s. (SD = 0.5) for Misses. A paired t-test for the difference between Hit and Miss latencies was not significant (two-tailed t (9) = 1.62, p = .14) suggesting that, as a group, FH+ infants were not discriminating between the two tone sequences once ISIs dropped below 300 ms.

Insert Figure 6 about here.

Habituation and Recognition Memory -- All infants completed the habituation recognition-memory tasks and all habituated. Infants' level of looking on the pretest (M= 5.8 s., SD = 2.0) and posttest (M= 6.0 s., SD = 2.4) was equivalent t (10) = 0.23. The means and standard deviations for all habituation variables for the FH+ infants are shown in Table 3. Once again, the variables of interest regarding speed of processing were TTC (M = 6.2, SD = 2.0) and the two regression functions fitted to infant looking across trials during habituation, Slope RT (M = -2.05; SD = 2.8) and Slope% (M = -13.48; SD = 13.4). Examination of FH+ infants' novelty preference following habituation revealed that the mean N% scores did not significantly differ from chance (50%) with M = 54.9%, SD = 17.7, two-tailed t (10) = 0.92, NS).

Relationships among ATP, Habituation, and Visual Recognition Memory -- In order to determine whether ATP performance was related to habituation and VRM in the FH+ infants, Pearson Product Moment Correlations were computed. The same habituation (H) and VRM variables were included as in Study 1: First look length in s. (H); Baseline looking amount in s. (H); Total looking time in s. (H); TTC (H); Slope RT (real time in s) (H); Slope % (H); % Novelty (VRM). ATP variables included: Mean ATP threshold in ms. (mean of the last 4 reversals) and Number of trials to ATP training criterion (total number of trials in the Association phase). These correlations are shown in Table 4. Although none of these correlations reached significance, the pattern of associations seen are strikingly similar to those seen in the Study 1. Even in this small sample, habituation Slope% approached significance.

Insert Table 4 about here.

Discussion

This study revealed elevated ATP thresholds in infants from families with a positive history for language-based learning disorders, albeit in a very small sample. As a consequence of the small number of infants, our statistical power is low. Nevertheless, the results are compelling. Comparison of ATP thresholds in Study 1 (FH- infants) with those in Study 2 (FH+ infants) suggest that these scores are drawn from different populations. Mean threshold differences across the two samples are robust and inspection of the individual trial-by-trial plots reveal a characteristic pattern (as seen in Figure 4) in about 45% of the FH+ infants. Patterns of genetic transmission previously documented in LIs hypothesize an autosomal dominant transmission of LI and predict that approximately 50% of children born into these families could show developmental language impairments (Tallal, Ross, & Curtis, 1989b). Research by Tallal (et al.,1985a, b) provides group curves for LI versus control children on a similar auditory temporal processing task. Performance is shown to be identical for LI and control children for stimuli with ISIs of 500 ms, but the curves sharply diverge at about 300 ms. with LI children falling rapidly to chance (50% correct) performance levels (Tallal et al., 1985a). At 8 ms. ISI, however, the well-matched control children are still performing at high levels (80%). The pattern of results for the FH+ infants with poor ATP thresholds (Figure 4) looks very much like Tallal et al.'s curves for the LI sample. Recall that these infants are prelinguistic and have no present indications of language or cognitive delays. Mean VRM scores (%N) were lower than in Study 1 and the FH+ group %N scores were not significantly different from chance. This is also a noteworthy finding given the literature suggesting that %N in VRM tasks obtained in the first year are sensitive predictors of childhood cognitive outcomes for both normal and high-risk samples (McCall & Carriger, 1993; Rose & Feldman, 1995; Ross, Tesman, Auld, & Nass, 1992).

General Discussion

The studies presented here represent the first attempt to assess auditory temporal processing in infancy using the parameters and methodology defined by Tallal and colleagues to differentiate LI children from controls (Tallal et al., 1985a, 1985b). We found that infants from 6 to 10 months of age discriminate between two brief, rapidly-presented auditory tone sequences and can associate each auditory stimulus with a directional response. Furthermore, we were able to establish the normative range of auditory temporal processing thresholds of 6 to 10 month old infants using this procedure. The results demonstrate the feasibility of using a two-alternative forced-choice infant operant conditioning paradigm to assess individual ATP thresholds.

Our findings extend research demonstrating differences between LI and normal children to infants at risk for LI. As a group, infants from families with a family history of language-based learning disabilities (Study 2) had lower ATP thresholds as compared to control infants (Study 1). Nevertheless, inspection of individual performance plots in this group (as well as ATP thresholds) revealed that 55% of FH+ infants obtained functions that looked indistingishable from control infants. Plots of temporal processing thresholds from infants in the FH+ group with the poorest thresholds virtually map onto trial-by-trial data from LI children on the Tallal Repetition Test. Studies of temporal processing of tone sequences with varying ISIs in rat, using an operantly conditioned go/no-go paradigm (modeled on the Tallal Repetition Test), show similar trial-by-trial functions for rats with induced ectopias, one hypothesized mechanism for LI (Fitch et al., 1994). Elevation of auditory fusion thresholds as well as deficits in temporal-order discrimination have also been reported in cortically-damaged adults (Lackner, 1982; Lackner & Teuber, 1973; Swisher & Hirsh, 1972).

Twenty years of research on LI subjects from age four through adulthood has consistently shown deficits on tasks which require rapid integration of two or more sensory events which enter the nervous system in rapid succession (see Tallal, Miller & Fitch, 1993 for review). Because results of neuropathological as well as brain imaging (MRI) studies suggest that neuropathology occurs early in life, the processing deficits seen in children with specific language impairments should also be detectable early in life, well before language disorders are noted (Hagman et al., 1992; Jernigan et al., 1991; Jernigan & Tallal, 1990; Tallal et al., 1990). Our results in Study 2 lend support to this hypothesis. A procedure with the potential to identify significant individual differences in individual temporal processing thresholds in early infancy would be an important step toward identification and remediation of infants at risk for language-based learning disorders. Such an assessment may also be important in clarifying issues pertaining to precedence of temporal processing versus phonological processing deficits in LI children, an area hotly contended in the literature.

A related issue to be addressed in future studies concerns developmental change in temporal processing abilities. Normal children of 5 to 8 years of age demonstrate mean ATP thresholds of about 8 ms. as do adults (Tallal et al., 1985a, 1985b). Do ATP abilities improve over time and if so what is the rate of change across infancy? It is known that temporal coding in the primary auditory pathways matures more slowly than pathways for absolute sensitivity and frequency resolution (Brugge, Javel, & Kitzes, 1978; Kettner, Feng, & Brugge, 1985; Sanes & Rubel, 1988). Werner et al. (1992), have found large age differences in performance on gap-detection tasks, however, a recent study examining gap detection thresholds across the life span suggests that infant-adult differences may be smaller than originally proposed due to failure to account for stimuli adaptation effects (Trehub, Schneider, & Henderson, in press). The current sample is not large enough to examine psychophysical issues from a developmental perspective and such questions will be addressed in future studies. However, we did not see differences in ATP thresholds across the age range (6 to 10 months) included in this study.

This research also attempted to address issues relating to speed of processing and the search for basic mechanisms that might underlie the observed relations between perceptual-cognitive measures in infancy and later language and cognitive achievement. Only a few studies have tried to explicate these processes (Columbo et al., 1989; Rose et al., 1992; Thompson et al., 1991) and the critical nature of this enterprise is clear (Columbo, 1993). We had hypothesized that temporal integration rates might be a critical underlying mechanism, if speed of processing is indeed the key factor in the ability of habituation and recognition memory to capture differential performance. (See Columbo, 1993 for a discussion of mechanisms underlying developmental continuity.) One of the most sensitive measures in previous studies has been rate of habituation as indexed by the slope of the habituation function and/or number of trials to criterion.

In Study 1, we found that both habituation slope measures were significantly correlated to mean ATP threshold and that number of trials to criterion in habituation, another measure of speed of encoding was also significantly correlated to ATP threshold. In addition, TTC was significantly related to the number of trials to attain ATP training criterion, a measure we had hypothesized to be related to general acquisition. A number of studies have shown novelty preferences in infancy to be associated with speed of processing measures (Columbo, Mitchell, & Horowitz, 1988; Fagan, 1984; Rose et al., 1991b). Columbo (1993) suggests that the novelty preference measure captures <u>both</u> speed and memory components of processing (p.115-116). Our data appear to support that interpretation. However, only Slope% and TTC contributed significant variance to the concurrent prediction of ATP thresholds.

In Study 2, we found a similar though nonsignificant pattern of relations among habituation, VRM, and ATP measures. Furthermore, we found that, as a group, infants with a positive family history for LI did not show significant recognition memory in the VRM test. This is a provocative finding in such a population given the ability of infant VRM to predict individual differences in cognitive development in other high risk populations (Rose, 1983; Landry & Chapieski, 1988; Sigman & Parmelee, 1974; Spungen, Kurtzberg, & Vaughan, 1985) and studies suggesting a genetic component to LI (Tallal et al., 1989; 1991). Correlations in both studies between Bayley MDI and the two ATP variables were small and insignificant. Historically, infancy tests such as the Bayley Scales have not captured information processing differences du the large sensorimotor component of these early assessments.

In the studies described here we looked at relations across auditory and visual modalities. The question of modality specificity has been only minimally addressed since many infant paradigms use the visual modality. The infant literature contains considerable support for the premise that information processing may not be modality specific. For example, there is substantial evidence that the infant's world is one that is both multimodal and temporally organized and that infants are responsive to and discriminate cross-modal temporal relations (Lewkowicz, 1992; Spelke, Born, & Chu 1983). Infants as young as 4 to 5 months detect relations between auditory and visual information and integrate multimodal information (Bahrick, 1983; Schiff, Benasich, & Bornstein, 1989). A unified, integrated response to temporal cues arriving via different modalities would provide a processing advantage in many domains (Marks, 1978). The infant who can integrate and process information efficiently across domains is likely to acquire a larger, more detailed knowledge base over a particular time period than an infant who processes more slowly. Our results lend support to this contention. Those infants who were better temporal processors (lower ATP thresholds) also habituated more efficiently (fewer trials to criterion and steeper habituation slopes) and discriminated better (higher VRM novelty scores). This was true even over the "normal" range of ATP thresholds (Study 1) and was particularly striking when comparing control (FH-) infants to infants with a family history of language-based learning disorders (Study 2).

We further suggest that the deficits seen in LI children are not specific to auditory processing but reflect a more global deficit in temporal information processing. Tallal (1985b) found that specific deficits in rate of sensory and perceptual information processing in LI children were present across auditory, visual and somatosensory domains. Although only one study has examined relations between auditory habituation and later measures (O'Connor, Cohen, & Parmelee, 1984), when this is added to findings that tactual-to-visual cross-modal transfer in infancy also predicts cognitive outcomes (for example, Rose & Feldman, 1995; Rose & Wallace, 1985) a nonmodality specific mechanism is suggested. The relations shown between the infant information-processing measures (habituation and recognition memory) and ATP strongly suggest that speed of processing is an important component of these types of measures. Since the ability to abstract information in any perceptual situation is inevitably temporally bounded, faster perceptual speed should favor better or more complete encoding. In the case of temporal processing within the time window with which we are primarily concerned in this study (tens of milliseconds), deficits in this very basic level of processing could further constrain perceptual speed (or "speed of encoding").

A number of methodological issues must also be addressed. In this study, mean auditory temporal processing thresholds across four reversals (about 70 ms) were comparable to mean thresholds found for infants detecting a silent gap in a broadband noise (Werner et al. ,1992). However, more recent work suggests that gap detection thresholds are significantly lower (Trehub et al., in press). The transitional period for stop consonant syllables (such as /ba/ and /da/) which enable discrimination of /ba/ from /da/ occurs over approximately 40 ms. Given that infants appear to make these discriminations very early in life (see Aslin, Pisoni, & Juczyk, 1983 for a review), one would expect much lower (i.e. better) thresholds. There may be several reasons for the higher thresholds seen here. First, infant state may have varied across trials. Infant state was closely monitored and the "probe" stimuli were designed to detect the point at which we were no longer assessing temporal discrimination and were tapping attentional or motivational aspects of the infant. However, infant state did vary within the procedure to the extent that we lost several infants halfway through the test phase. Examination of the plots for each infant suggest that momentary lapses in attention did occur, although the effect on the final threshold is not clear. Second, and perhaps more importantly, the operant conditioning procedure is lengthy (mean length of approximately 7 min.). Given the necessity of first training the infant to a criterion before data collection can begin, the more difficult discriminations must be made at the end of the procedure. This difficulty might be overcome by using stimuli blocked by ISI rather than using an up-down-adaptive procedure. However, a blocked-stimulus design provides less information about individual ATP thresholds. Alternatively, changes could be made in the step size during the test phase so that larger steps would occur at the beginning with progressively smaller steps as threshold is approached. The PESTI procedure (Trehub, Bull, Schneider, & Morrongiello, 1986) is an example of an adaptive program that might be modified to obtain ATP thresholds in infants.

Although a modest cross-sectional sample is examined in the present study, the results are quite robust and we can begin to draw some conclusions. We have hypothesized that habituation, recognition memory, and temporal processing measures all tap "speed of processing". These data provide empirical support for this hypothesis. As our measures are concurrent we can not yet examine the direction of these relationships. Longer-term studies with larger samples are necessary to ascertain whether temporal processing efficacy supports habituation and recognition memory or simply shares the underlying construct of processing speed. Given the findings that infant habituation and recognition memory reliably and substantially predict to childhood IQ (Bornstein & Sigman, 1986; Fagan, 1984; McCall & Carriger, 1993; Rose & Feldman, 1995; Ross et al., 1992) and the associations this study has shown among these measures, the question of prediction to later language outcomes becomes key. The study sample reported on here is being followed prospectively to determine whether auditory temporal processing thresholds are predictive of later cognitive and language development. Infants obtaining a lower threshold even in the "normal" range may be more efficient temporal processors, and this efficiency may have developmental consequences. Specifically, we hypothesize that infants requiring longer duration intervals between tones (longer processing time) will be slower to develop receptive language skills than those who process more quickly. Preliminary analysis of follow-up data from a subset of infants seen in Study 1 provide tentative support for these predictions as significant associations are seen between infant ATP thresholds and language variables at 12 and 16 months (Benasich & Tallal, 1994).

Conclusions

We have demonstrated that auditory temporal processing thresholds can be assessed in the first year of life using a technique comparable to that used in older children and adults. In Study 1 we were able to establish the normative range of temporal processing thresholds using this paradigm in 6 to 10-month-old infants. Based on the extant literature on temporal processing deficits in older children, adults, and aphasic adults (Frumkin & Rapin, 1980; Tallal et al., 1993) we predicted that infants with auditory-processing deficits, or those at high risk for subsequent cognitive or linguistic deficits or delays might have great difficulty with this type of task. Results of Study 2 add strength to this prediction. Robust differences were found in mean auditory temporal processing thresholds in a normally developing sample of infants with a positive family history of language-based learning disorders as compared to infants with a negative family history. Our findings of strong concurrent relationships among habituation, recognition memory, and temporal processing further supports this hypothesis as habituation and recognition memory have been shown to identify infants at biological risk for developmental delays (Landry, Leslie, Fletcher, & Francis, 1985; Miranda & Hack, 1979; Rose et al., 1991b; Rose, Feldman, & Wallace, 1988; Sigman & Parmelee; 1974; Sigman, Kopp, Littman, and Parmelee, 1977; Spungen et al., 1985). Finally, this study provides data regarding "speed of processing" measures that may elucidate the underlying mechanisms that determine individual differences in perceptual cognitive abilities and ultimately provide a basis for long-term prediction (Columbo, 1993; Rose et al., 1992).

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Footnotes

[1] Our model for the infant temporal processing task was the Tallal Repetition Test (Tallal & Piercy, 1973a). As used with older children and adults this test is a hierarchical battery of nonverbal tests of auditory temporal processing assessing detection, discrimination, sequencing, and memory. The sounds used as stimuli in the Tallal Repetition Test are two complex tones, composed of frequencies within the speech range combined into two-element stimuli with interstimulus intervals (ISIs) varying from 8 to 305 ms. The data consist of the percentage of correct responses at each level of the hierarchical task sequence. However, the methods used with older individuals (button pressing) were not suited to young infants. Adapting this test for infants we were primarily concerned with the initial level of this procedure where the subject's task is to detect and discriminate two different two-tone sequences at varying interstimulus intervals and identify them as same or different.

[2] A number of fairly reliable methodologies have been developed to examine infant acoustic sensitivity including the non-nutritive sucking paradigm, conditioned head-turning, and evoked brain stem responses (Baruch & Werner, 1994; Kuhl, 1985; Schneider & Trehub, 1985). Several adaptive, staircase procedures have been developed for estimation of individual auditory thresholds, however, all involve training infants to turn toward one of two alternative sound sources (Berg & Smith, 1983; Sinnott, Pisoni, & Aslin, 1983; Trehub, Bull, Schneider, & Morrongiello, 1986). To our knowledge, no auditory procedure had been developed to train an infant to make a two-alternative forced-choice headturn using one centrally-presented sound (i.e. without using sound localization information). Therefore, we developed a two-alternative, forced-choice auditory procedure modeled on the Tallal Repetition Task and on de Schonen and Bry's (1987) operant conditioning divided visual-field paradigm to assess infant auditory temporal processing thresholds.

[3] Each stimulus set was pretested on a total of 88 to 120 infants participating in previous habituation experiments. Pretesting of stimuli is an ongoing process and is appended to an ongoing experiment. However, the process is the same for both social and geometric stimuli. One stimulus was designated A and the second B. Each infant received two 10 s. paired preference trials for each stimulus set with right-left positions reversed for the second trial. Infant looking times were scored as described in the method section. For each stimulus pair we computed: first look at the stimulus in s., total looking time in s., and percent looking at stimulus A versus stimulus B across trials (%N). Paired 2-tailed t-tests compared mean looking times across infants for each stimulus pair. %N scores were compared to chance responding (50%). First, any stimulus pair with a N% significantly different from chance was eliminated. Then only those pairs of stimuli with no significant differences in first looks at each stimulus within a pair as well as no significant differences in total looking time across both trials for each stimulus were retained for use in subsequent habituation tasks.

[4] A proband is the clinically identified family member who meets the study criteria and upon which the selection of a family as affected is made.

Figure Captions

Figure 1. Diagram of the testing apparatus used for both infant tasks. The reinforcement boxes contained two different animated toys that could be illuminated and set in motion.

Figure 2. Trial-by-trial recordings from two infants completing the Variable Interstimulus Interval test phase of the Auditory Temporal Processing Threshold Task.

Figure 3. Distribution of mean auditory temporal processing thresholds across four reversals in the Variable Interstimulus Interval test phase of the Auditory Temporal Processing Threshold Task in infants (mean age = 7.5 months) with no reported family history of language-based learning disabilities.

Figure 4. Trial-by-trial recording for the Variable Interstimulus Interval test phase of the Auditory Temporal Processing Threshold Task.from an infant with a family history of language-based learning disability.

Figure 5. Distribution of mean auditory temporal processing thresholds across four reversals in the Variable Interstimulus Interval test phase of the Auditory Temporal Processing Threshold Task in infants (mean age = 7.6 months) with a family history of language-based learning disabilities.

Figure 6. Comparison of mean auditory temporal processing thresholds (across four reversals) for infants with and without a family history of language-based learning disabilities.

TABLE 1

Means and Standard Deviations for ATP, Habituation, and Recognition Memory Variables

(n = 32)

	MEAN (SD)
Auditory Temporal Processing	
Mean ATP Threshold in msec. (4 rev)	70.6 (25.1)
# of Trials to ATP Criterion	10.6 (8.7)
Mean Hit Latency in sec	1.37 (0.8)
Mean Miss Latency in sec	2.28 (1.2)
Habituation/VRM	
First Look Length in sec	11.19 (11.6)
Baseline Looking Amount in sec	8.82 (6.7)
Total Looking Time in sec	39.48 (25.6)
Habituation Slope (real time)	-2.11 (2.7)
Habituation Slope (%)	-19.40 (13.2)
# of Trials to Hab. Criterion	6.1 (2.8)
% Decrement	69.04 (8.9)
% Novelty in VRM Test	63.00 (11.0)
Bayley MDI	97.72 (12.4)

TABLE 2

Pearson Product Moment Correlations for ATP, Habituation, & Recognition Memory Variables

(n = 32)

	Auditory Temporal Processing	
Habituation/VRM	Mean ATP Threshold	# of Trials to ATP Criterion
First Look Length	0.25	0.38 *
Baseline Looking Amount	0.31	0.17
Total Looking Time	0.27	- 0.16
Habituation Slope (real time)	- 0.48 **	0.21
Habituation Slope (%)	- 0.76 ***	0.19
# of Trials to Hab. Criterion	0.70 ***	0.49**
% Decrement	0.02	0.03
% Novelty in VRM Test	- 0.44 *	- 0.34
Bayley MDI	- 0.04	- 0.26

* ***p (2-tailed)*** **< 0.05**

*****p 2-tailed)*** **< 0.005**

******p 2-tailed)*** **< 0.001**

TABLE 3

Means and Standard Deviations for ATP, Habituation, and Recognition Memory Variables in LI Family History Infants

(n = 11)

	MEAN (SD)
Auditory Temporal Processing	
Mean ATP Threshold in msec. (4 rev)	148.0 (77.1)
# of Trials to ATP Criterion	11.1 (8.1)
Mean Hit Latency in sec	1.43 (0.8)
Mean Miss Latency in sec	1.69 (0.5)
Habituation/VRM	
First Look Length in sec	6.80 (3.8)
Baseline Looking Amount in sec	6.72 (2.5)
Total Looking Time in sec	27.88 (13.9)
Habituation Slope (real time)	-2.05 (2.8)
Habituation Slope (%)	-18.94 (13.4)
# of Trials to Hab. Criterion	6.2 (2.0)
% Decrement	63.55 (8.1)
% Novelty in VRM Test	54.90 (17.7)
Bayley MDI	97.00 (6.6)

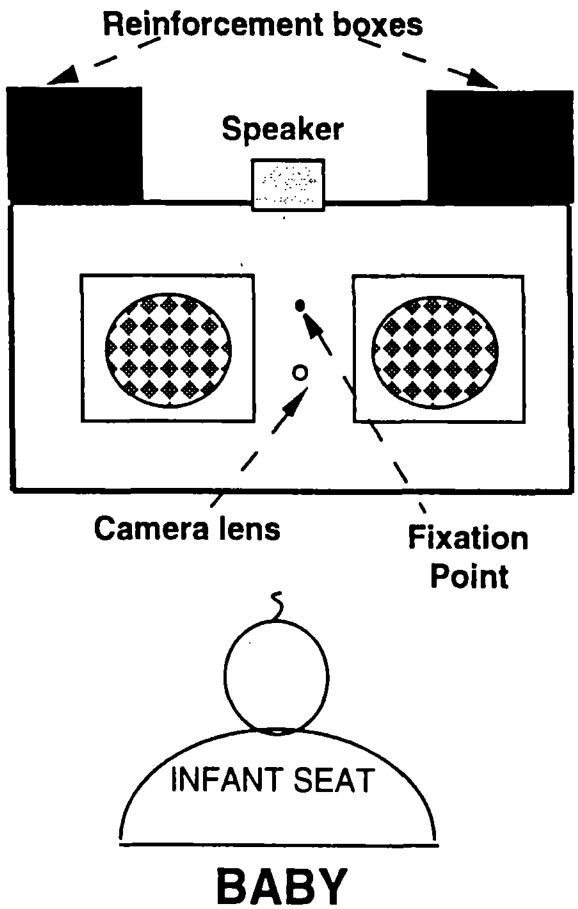
TABLE 4

Pearson Product Moment Correlations for ATP, Habituation, & Recognition Memory Variables in LI Family History Infants

(n = 11)

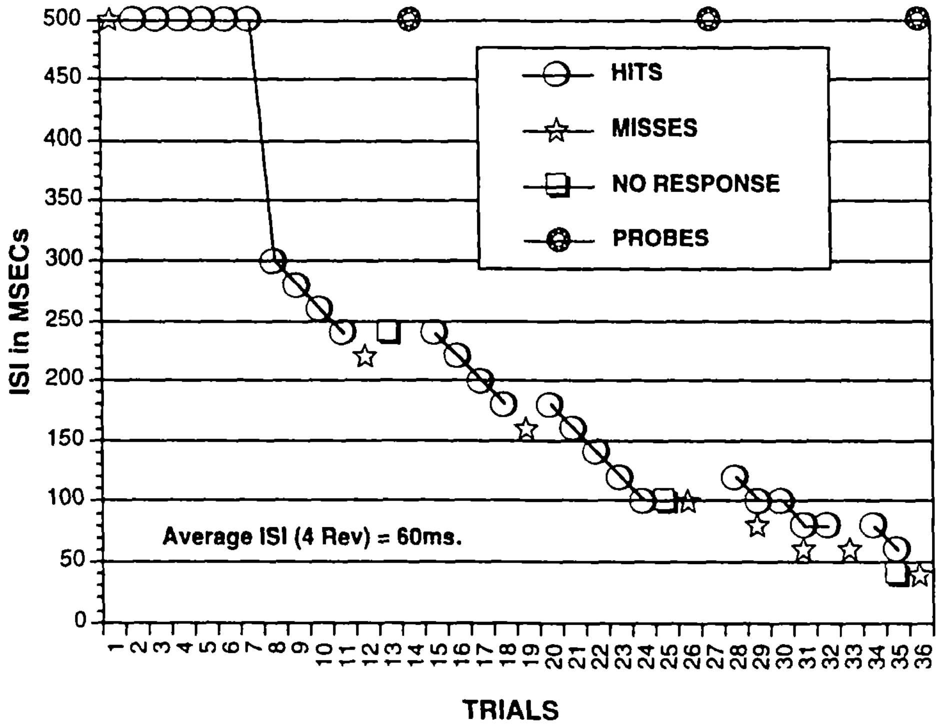
	Auditory Temporal Processing	
Habituation/VRM	Mean ATP Threshold	# of Trials to ATP Criterion
First Look Length	0.41	0.38
Baseline Looking Amount	0.03	0.16
Total Looking Time	0.21	- 0.08
Habituation Slope (real time)	- 0.42	0.28
Habituation Slope (%)	- 0.58*	0.42
# of Trials to Hab. Criterion	0.37	0.33
% Decrement	- 0.37	0.02
% Novelty in VRM Test	- 0.46	- 0.25
Bayley MDI	- 0.04	- 0.21

** p (2-tailed)* **< 0.06**

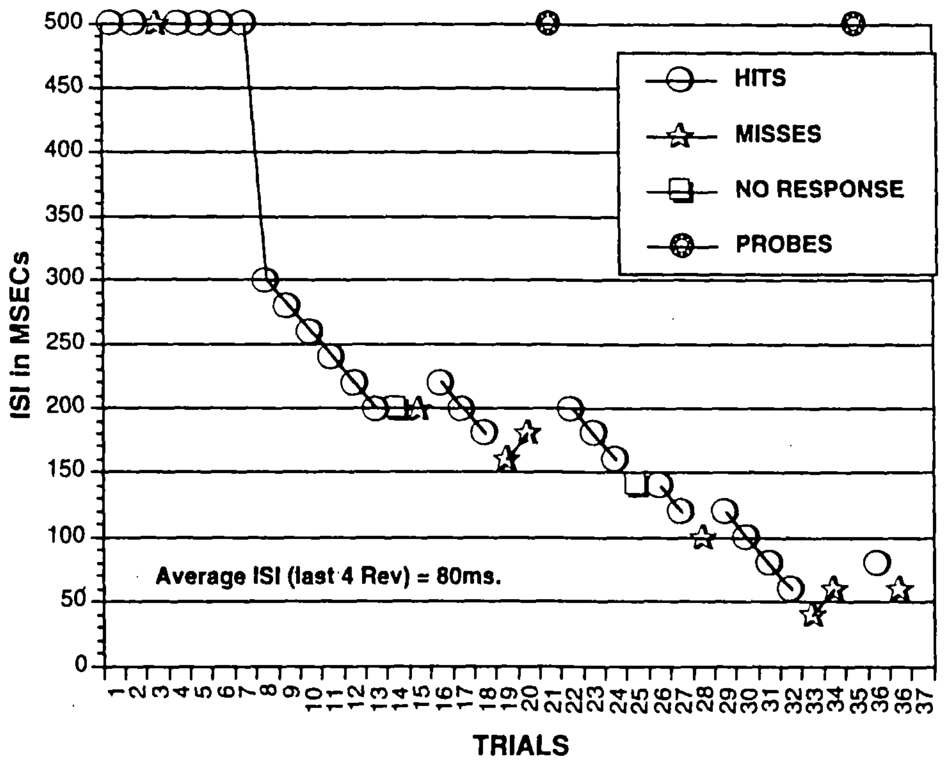


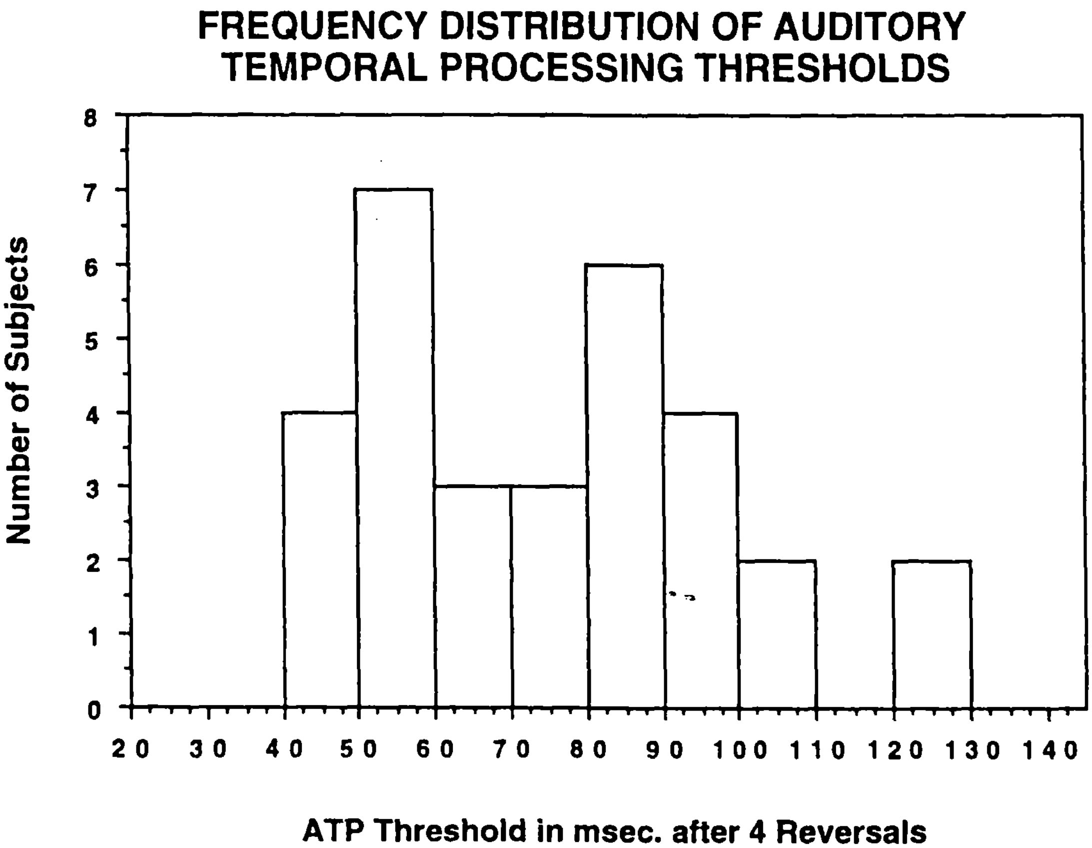
Reinforcement boxes
Speaker
Camera lens
Fixation Point
INFANT SEAT
BABY

TRIAL-by-TRIAL RECORD FROM A 24 WEEK OLD INFANT

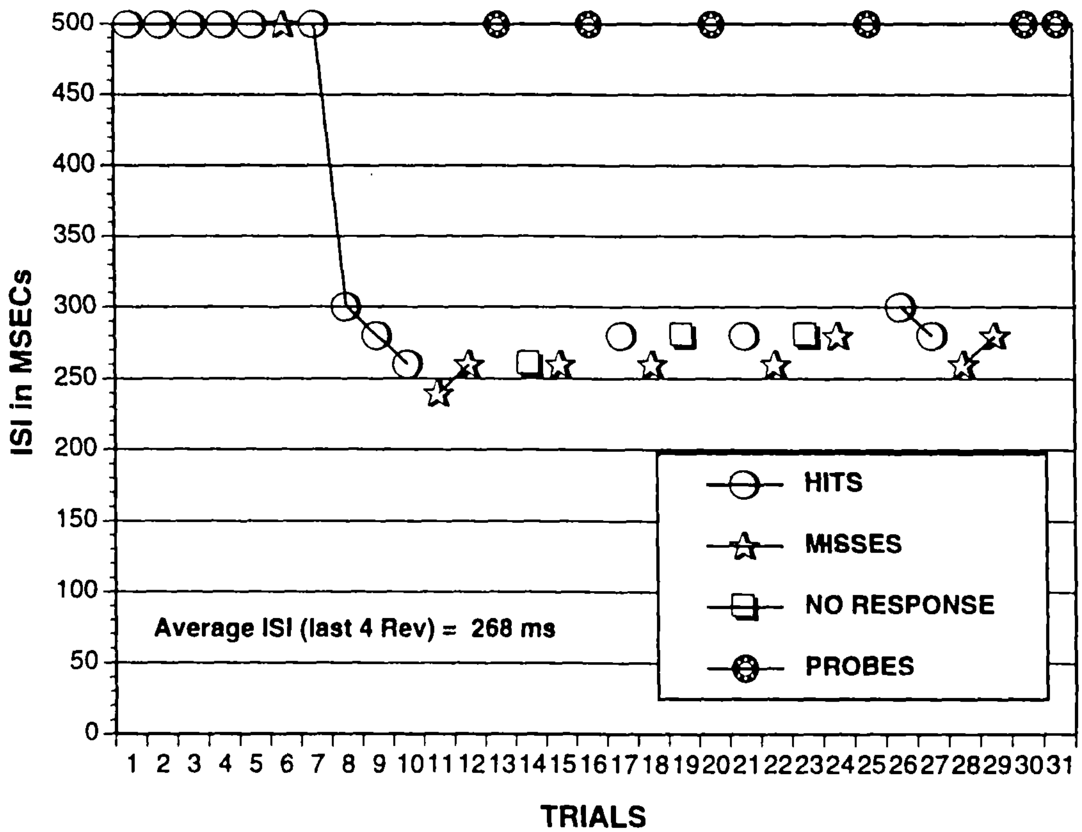


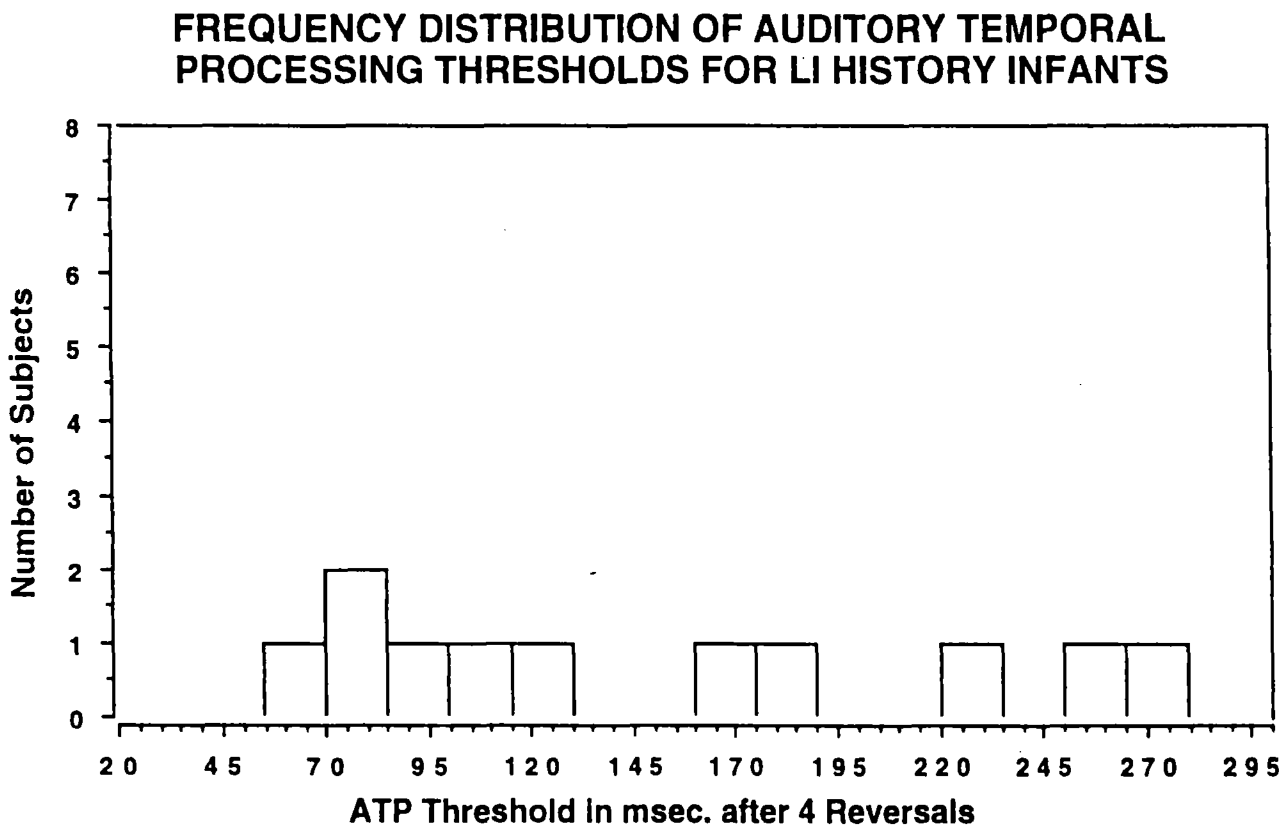
TRIAL-by-TRIAL RECORD FROM A 30 WEEK OLD INFANT



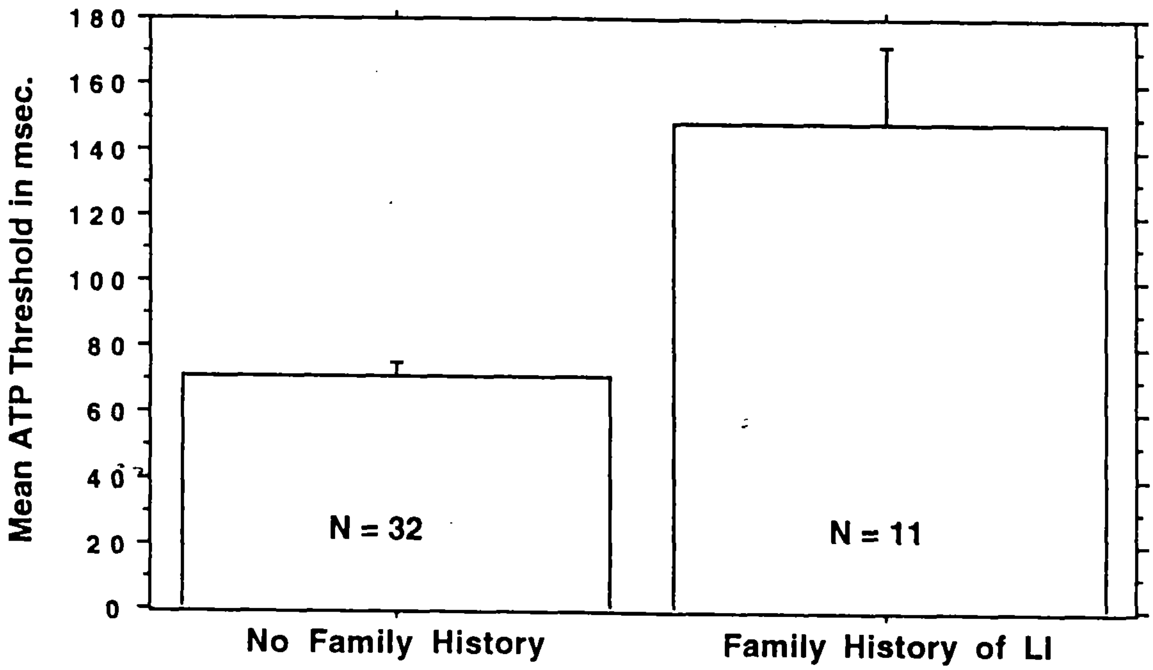

FREQUENCY DISTRIBUTION OF AUDITORY
TEMPORAL PROCESSING THRESHOLDS
Number of Subjects
0
1
2
3
4
5
6
7
8
20
30
40
50
60
70
80
90
100
110
120
130
140
ATP Threshold in msec. after 4 Reversals

TRIAL-by-TRIAL RECORD OF A 28 WEEK OLD INFANT FROM A FAMILY WITH A HISTORY OF LI




FREQUENCY DISTRIBUTION OF AUDITORY TEMPORAL
PROCESSING THRESHOLDS FOR LI HISTORY INFANTS
Number of Subjects
0
1
2
3
4
5
6
7
8
20
45
70
95
120
145
170
195
220
245
270
295
ATP Threshold in msec. after 4 Reversals

Mean ATP Thresholds of Control Infants and Infants with a Family History of Language-based Learning Disorders



Unpaired two-tailed t (41) = -5.04, p < .0001

Cognitive Neuroscience Society Conference
March 26-28, 1995, San Francisco, California

RELATIONSHIPS AMONG INFANT AUDITORY TEMPORAL PROCESSING, PERCEPTUAL-COGNITIVE ABILITIES AND EARLY LANGUAGE DEVELOPMENT.

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We have hypothesized that temporal processing efficiency may underlie the known relationship between "speed of encoding" (as measured by infant habituation and recognition memory) and childhood language and cognitive outcomes. In a previous study using a two-alternative, forced-choice procedure we found that language outcomes at 16 months of age were significantly related to infant auditory temporal processing (ATP) thresholds. However, our completion rate with this procedure was only 68%. Correlational data suggested that habituation, recognition memory, and temporal processing are related and may be tapping similar processes. These findings suggest that poor temporal processing abilities in infancy may serve as a behavioral "marker" of language impairment and could be used in early identification of language impairment.

Auditory temporal processing thresholds were examined at 6 to 8 months of age using a less demanding conditioned head-turn procedure (go/no go) and stimuli blocked by Interstimulus Interval (ISI). Completion rate with this procedure has been 88%. A significant proportion of correct head turns were made to the target tone sequence when the interstimulus interval (ISI) was 500 ms, 180 ms or 70 ms. However, when the ISI was 10 ms, responding fell to chance levels. Correlations among ATP abilities, habituation, and recognition memory were systematic and significant. At 12 and 16 months-of-age language and cognitive development were assessed using the MacArthur Communicative Developmental Inventory (CDI) and the Bayley Scales of Infant Development. Relationships between early ATP and perceptual-cognitive abilities as well as language and cognitive development in the second year will be reported and discussed. In the adjoining poster, Spitz et al. discusses the stability of the CDI scores of this sample over time and their association with nonlinguistic correlates of early language.

INTRODUCTION

We have hypothesized that temporal processing efficiency may underlie the known relationship between "speed of encoding" (as measured by infant habituation and recognition memory) and childhood language and cognitive outcomes. In a previous study using a two-alternative, forced-choice procedure we examined auditory temporal processing (ATP) thresholds in infants from 5 to 10 months of age demonstrating the feasibility of using an infant operant conditioning paradigm to assess auditory temporal processing (Benasich & Tallal, 1993). Average auditory temporal processing (ATP) thresholds were 68.8 (28.6) msec. and latencies for False Alarms were significantly longer than latencies for Hits. Correlations among ATP abilities, habituation, and recognition memory were systematic and significant providing preliminary empirical support for our "speed of processing" hypothesis.

In a follow-up study, we found that language outcomes at 16 months of age were significantly related to infant auditory temporal processing (ATP) thresholds. These findings suggest that poor temporal processing abilities in infancy may serve as a behavioral "marker" of language impairment and could be used in early identification of language impairment. However, our completion rate with this procedure was only 68%. It was difficult to get both ATP tasks administered to the same infants, due mainly to noncompletion of the more rigorous two-alternative forced-choice threshold task. Of the 18 infants who received both procedures, only nine completed both tasks within a three week window. However, the two tests were significantly correlated ($r = 0.79$, $p < 0.01$, 1-tailed).

Using a simpler go/no go operant head-turn procedure and stimuli blocked by interstimulus interval (ISI), auditory temporal processing thresholds were examined in 26 infants at 6 to 8 months of age. Completion rate with this procedure has been 88%. A significant proportion of correct head turns were made to the target tone sequence when the interstimulus interval (ISI) was 500 ms, 180 ms or 70 ms. However, when the ISI was 10 ms, responding fell to chance levels. Correlations among ATP abilities, habituation, and recognition memory were systematic and significant. At 12 and 16 months-of-age language and cognitive development were assessed using the MacArthur Communicative Developmental Inventory (CDI) and the Bayley Scales of Infant Development.

METHODS

Subjects:

Twenty-six subjects were recruited from local (New York City, Newark, and New Jersey suburbs) obstetric and pediatric practices. All infants were full-term, had uneventful pre- and perinatal circumstances, Apgar scores of 9 or 10 and birthweights above 2,500 grams. There was no history of hearing dysfunction and no recent occurences of otitis media.

<u>Total Subjects (N= 26)</u>

Boys	N=14 (54%)
Girls	N=12 (46%)

Mean SES (Hollingshead Index)	56 (9)
Mean Age at First Visit	7.9 (1.5) months
Mean Age at Second Visit	13.0 (1.0) months

Twelve of these subjects have been seen so far for a follow-up visit at a Mean Age of 17.3 (1.8) months.

PROCEDURE

Visit 1 at Mean Age of 8 months:

The infant is seated on the mother's lap (see Figure) in a sound-attenuated experimental room facing one experimenter (E1). To the infant's left, about 90 cm away and at an angle of 60 degrees, are two dark plexiglass boxes and a loudspeaker. Each of these boxes can be illuminated and a moving electrical toy activated to serve as rewards for discrimination learning. The loudspeaker is placed behind the reinforcement boxes.

The experimenter and parent both wear headphones carrying music to mask the nature of the trials presented to the infant. E1 engages the infant with a quiet toy to maintain attention and a foward orientation. A signal light on the parent's shoulder signals the onset and offset of each trial. The infant's looking patterns and direction of gaze are videotaped with a video camera hidden behind the experimenter. The video signal is also displayed on TV monitors in the control room. The infant's head position and central fixations are monitored by another experimenter (E2)in the control room. E2 initiates trials and records responses with a button box interface with the computer.

Proportion of turns on target (change) and no-change trials as well as latency to turn to target and no-change trials are collected for the **Criterion** phase (500mse. ISI) as well as the four **Test** blocks (300, 180, 70,& 10 msec.).

Habituation and Visual Recognition Test

A standard infant-control habituation and recognition memory test was presented using face stimuli (a baby's face for habituation & an adult male's face for the visual Recognition Memory test.

VISITS 2 at 12 months & VISIT 3 at 16 months:

Infants' language and cognitive abilities were assessed using the following measures:

MacArthur Communicative Development Inventories:

Parents completed the MacArthur Communicative Development Inventories (Fenson et. al, 1993) providing receptive and expressive language scores at approximately 12 and 16 months.

Bayley Scales of Infant Development:

All infants were administered the Bayley Scales of Infant Development/Mental Scale (Bayley, 1969) a standardized cognitive assessment at all visits.

DATA ANALYSIS

Looking patterns were scored both in real time and from the videotape by a trained coder blind to type of stimulus presentation; comparisons with online scoring were made for reliability estimates. Proportion of turns on target (change) and no-change trials as well as latency to turn to target and no-change trials. Habituation and recognition memory variables include: First look length in s. (H); Baseline looking amount in s. (H); Total looking time (H); Number of trials to criterion (H); Slope of H function (real time in s.); % Novelty in test (VRM). Correlations among ATP measures, habituation, recognition memory, cognitive and language measures were examined. In addition a stepwise regression examined the relationship among these variables.

RESULTS

- Auditory Temporal Processing thresholds at 8 months predicted Language Comprehension at 12 months and Language Comprehension and Producrion at 16 months.

- A significant proportion of correct head turns were made to the target tone sequence when the interstimulus interval (ISI) was 500 ms, 180 ms or 70 ms. However, when the ISI was 10 ms, responding fell to chance levels.

- Hit versus False Alarm rates were significantly different for ISI's of 500, 180, and 70 ms, but not 10 ms. Thresholds are comparable to those we found using a two-alternative, forced-choice procedure suggesting that this simpler shorter procedure might be used as a screening task.

- Systematic correlations among habituation, recognition memory and language measures continue to be seen suggesting that habituation, recognition memory, and temporal processing are related and may be tapping similar processes.

- A procedure with the potential to identify significant individual differences in temporal processing thresholds early in life would be an important step toward early identification of infants at risk for language-based learning disorders.

Relationships Between Auditory Temporal Processing & Habituation At 8 Months & Language And Cognitive Development At 12 And 16 Months.

- Proportion of Head Turns on target trials at 70 ms ISI at 8 months was significantly correlated with two of four Language variables at 12 months, CDI phrases % ($r = .76$, $p < .0001$), CDI comprehension % ($r = .81$, $p < .0001$).

- Proportion of head turns on target trials at 70 ms ISI at 8 months was significantly correlated with three Language variables at 16 months, CDI phrases % ($r = .64$, $p < .05$), CDI comprehension % ($r = .75$, $p < .01$) and CDI production % ($r = .61$, $p < .05$). We had CDI Words & Sentences assessments on 11 children but much missing data so these relations were not examined at this time.

- At 8 months Habituation Slope and Habituation Trials to Criterion (speed of processing measures) were significantly correlated with Proportion of Correct Head Turns on target trials at 70 ms ISI .

- Bayley scores were significantly correlated with Proportion of Head Turns on target trials at 70 ms ISI at 8 months as well as amount of Habituation (% Decrement). The correlations between Bayley scores at visit 1 and visit 2 was $r = .65$, $p = .003$, and visit 2 and visit 3 was $r = .66$, $p < .01$. Bayley visit 1 and 3 was $r = .34$, ns.

CONCLUSIONS

- Strong relationships were shown between Auditory Temporal Processing Thresholds at 8 months and Language Measures at 12 and 16 months.

- Habituation, recognition memory, and auditory temporal processing were shown to be related and may be tapping similar processes, perhaps speed of encoding.

- Previous studies in our laboratory suggest that Auditory Temporal Processing Thresholds differ in infants from families with a history of language-based learning disorders (Benasich & Tallal, 1992). The data reported here suggests that even in control infants a relationship exists between temporal processing efficiency and language in the second year.

- The ability to assess temporal processing deficits in the first year of life, in conjunction with assessment of perceptual-cognitive abilities, is an important step toward early identification of infants most at risk for language-based learning disorders.

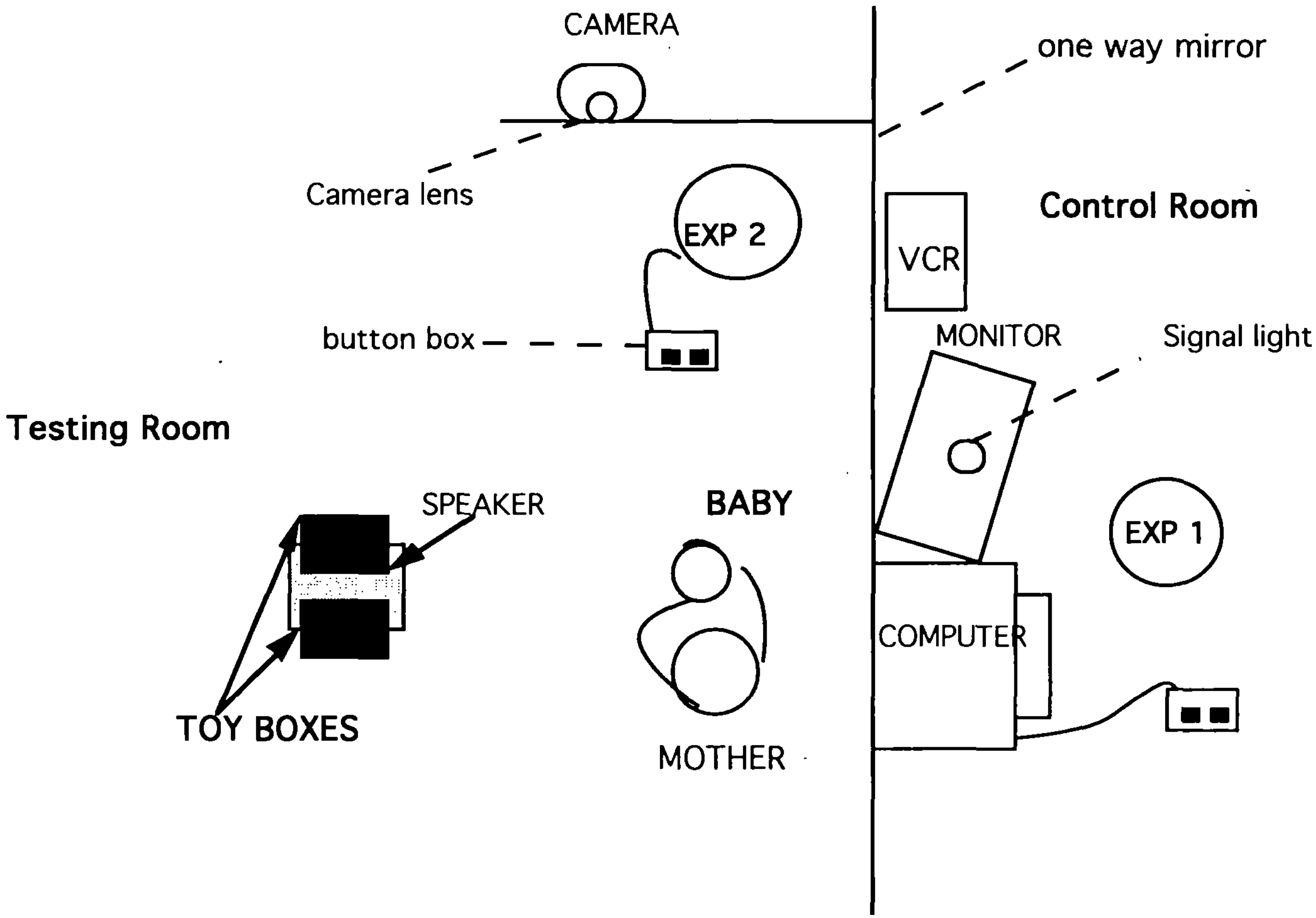
This research was supported by Grant RO1-HD29419 from the National Institute of Child Health and Development to A.A.B. with additional support from the Charles A. Dana Foundation.

See also:

Poster #2: Validation Of 12 Month CDI As An Early Language Measure For Assessing Temporal-Processing-Language Relationships. Spitz, Benasich, & Tallal.

Poster #53: Modification Of Auditory Temporal Processing Thresholds In Language Impaired Children. Miller, Jenkins, Merzenich, & Tallal.

Go/NoGo Headturn Procedure

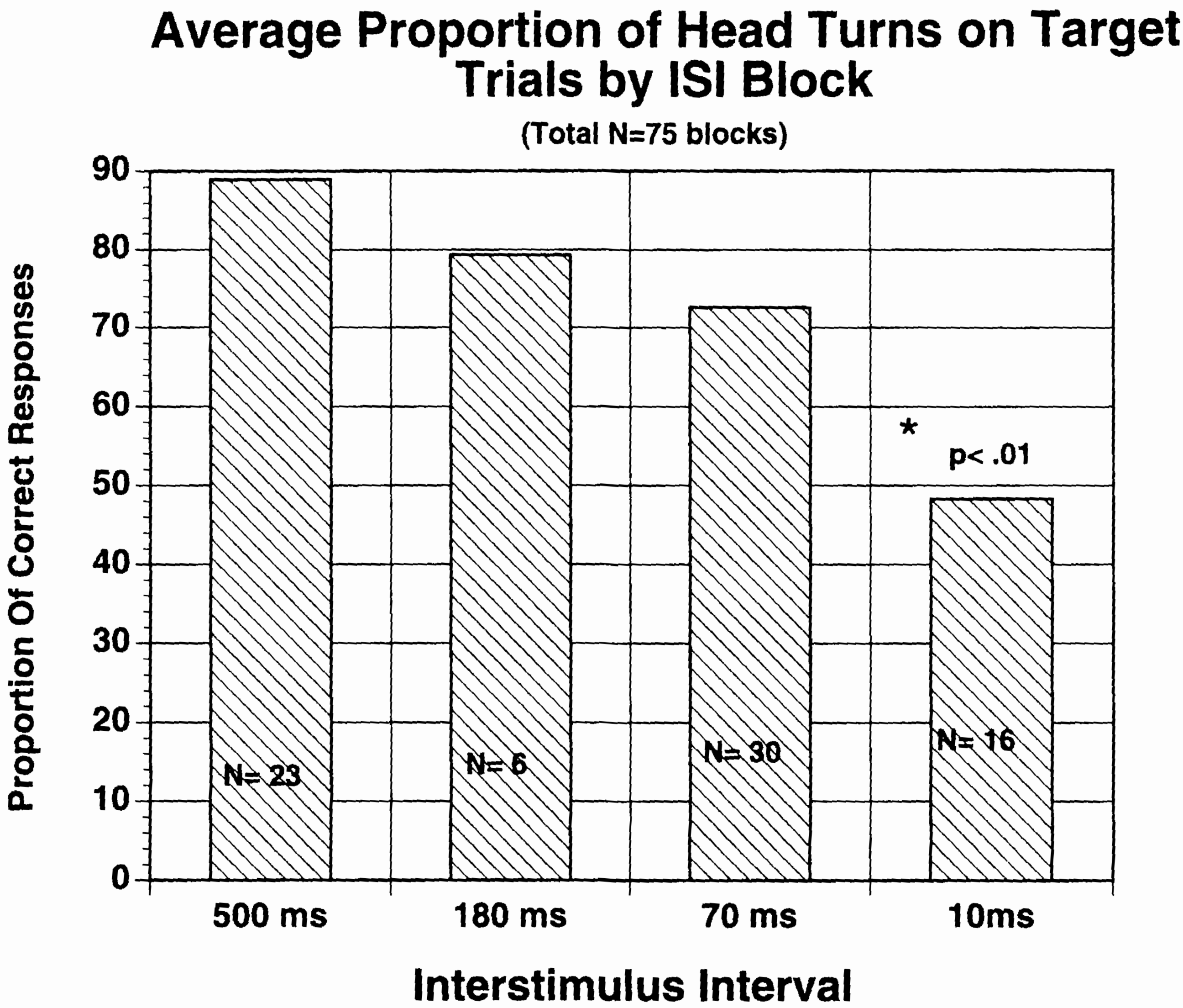


Pearson Product Moment Correlations Among Auditory Temporal Processing, Habituation & Recognition Memory at 8 months and Language Measures at 12 and 16 months.

	Auditory Temporal Processing at 8 m.	Habituation Speed of Processing Variables at 8 m	
Habituation/VRM at 8 months	% Correct Head-turn at 70 ms. ISI	Slope (real time)	Trials to Criterion
First Look Length	-.20	-.36	.17
Baseline Looking Amount	-.17	-.50*	.00
Total Looking Time	.00	-.31	.09
Habituation Slope (real time)	-.44*	—	.34
Habituation Slope (%)	-.38	.73***	.34
# of Trials to Hab. Criterion	-.74***	.44*	—
% Decrement	.09	-.18	.33
% Novelty in VRM Test	.08	.00	-.39
Language at 12 & 16 months			
CDI Comprehension %-12	.81***	-.35	-.59**
CDI Production %-12	.30	.01	-.47*
CDI Phrases %-12	.76***	-.35	-.58**
CDI Gestures%-12	.33	-.15	-.22
CDI Comprehension %-16	.75**	-.62*	-.38
CDI Production %-16	.61*	-.38	-.53
CDI Phrases %-16	.64*	-.22	-.47
CDI Gestures%-16	.41	-.18	-.19

*$p \leq .05$
**$p \leq .01$
*** $p \leq .001$

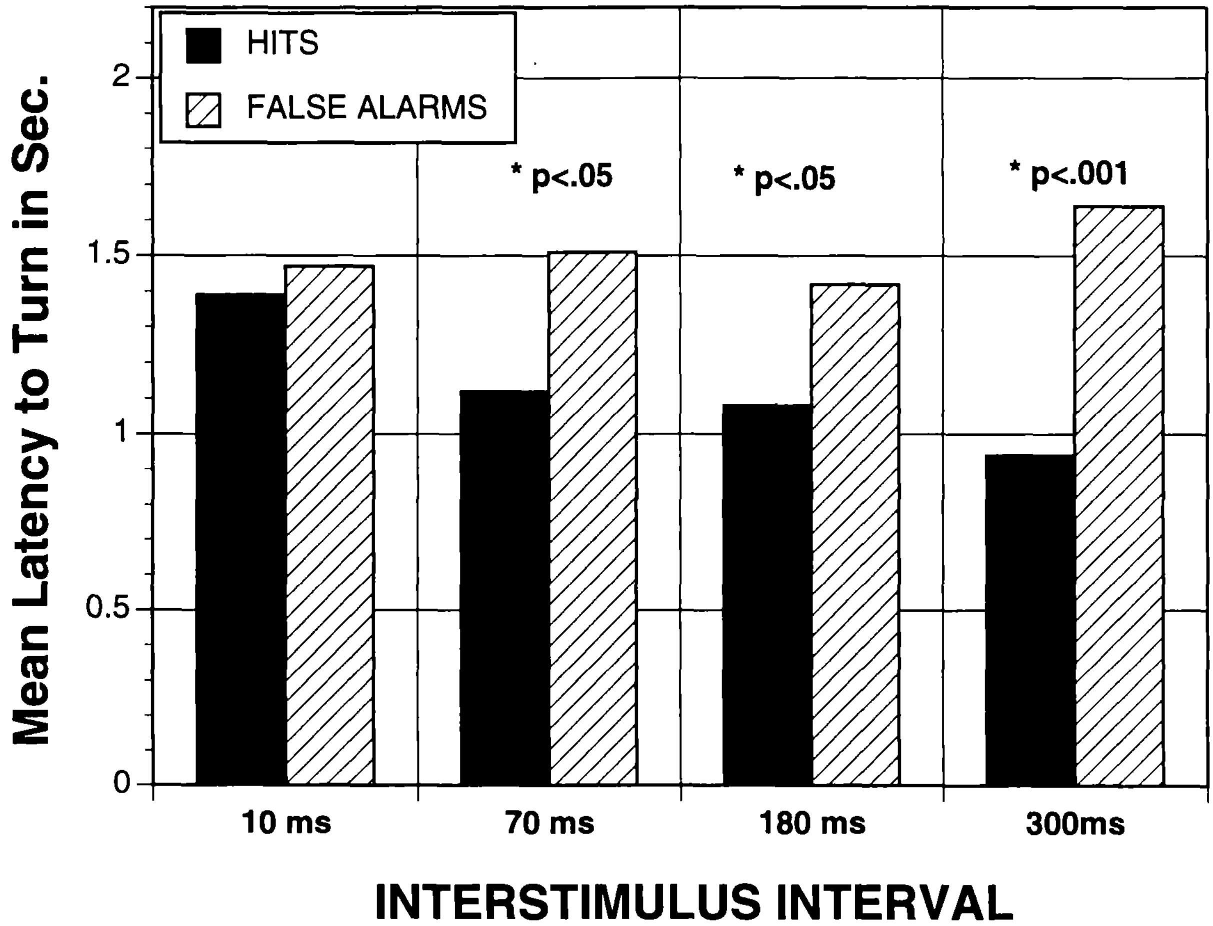
8 month and 12 month Ns = 22; 16 month N =10



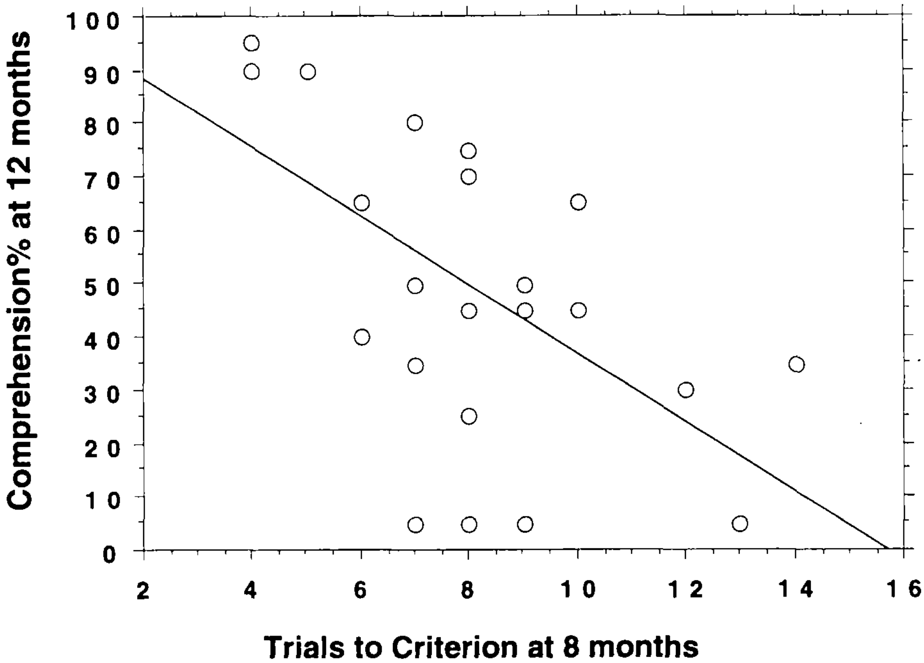
Average Proportion of Head Turns on Target Trials by ISI Block
(Total N=75 blocks)
Proportion Of Correct Responses
90
80
70
60
50
40
30
20
10
0
N= 23
N= 6
N= 30
N= 16
*
p< .01
500 ms
180 ms
70 ms
10ms
Interstimulus Interval

HIT VERSUS FALSE ALARM LATENCY IN THE ATP HEADTURN TASK USING BLOCKED STIMULI

(N = 26)

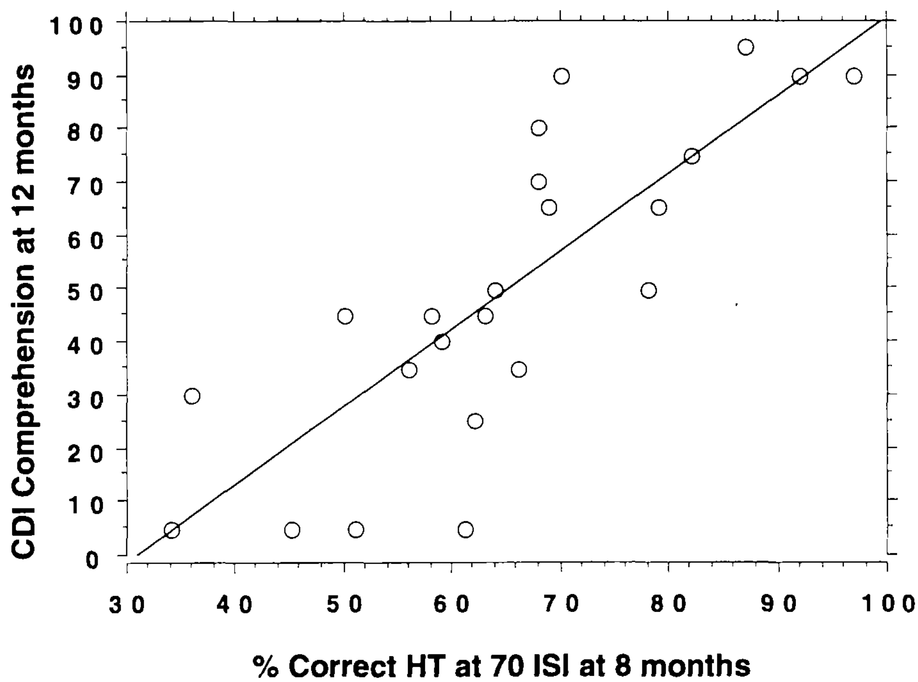


Habituation Trials to Criterion at 8 months and Language Comprehension at 12 months



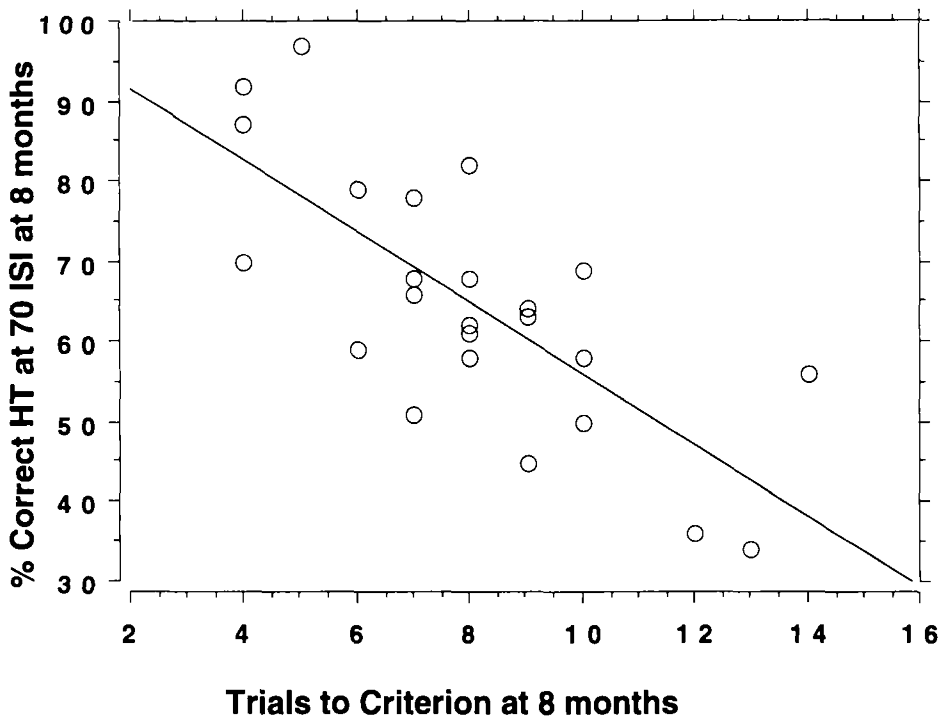
Comp. % T2 = 101.054 - 6.426 * TTC_T; R^2 = .35

% Correct Headturns (70 ms. ISI) at 8 months and Language Comprehension at 12 months



CDI Comprehension = -45.02 + 1.459 * % Correct_70; R^2 = .653

Habituation Trials to Criterion and Auditory Temporal Processing at 8 Months



% Correct_70 = 100.416 - 4.44 * TTC_T; R^2 = .546