NATIONAL SCIENTIFIC COUNCIL ON THE DEVELOPING CHILD

INTERACTION AND THE ARCHITECTURE OF THE BRAIN

By Dorian Friedman

For as long as humans have walked the earth, our interactions with others have helped to shape who we are. But only in recent years have we begun to understand how the most basic forms of human interaction and early experience mold the developing brain's architecture to profoundly influence who we become. The calculus is surprisingly simple, given the complex world of neuroscience: Nurturing, positive interaction releases chemicals in a child's brain that promote its growth and development, while negative influences produce chemicals that weaken its architecture. (For a detailed review of the latter subject, please see the new article, *Stress and the Architecture of the Brain*, on the National Scientific Council on the Developing Child Web site.)

Developmental science teaches us a great deal about the negative consequences for brain development resulting from harmful environments and other conditions that might pose dangers to the growing brain. It teaches much less about how we can alter the natural wiring process of children's brain development. Even so, an ever-growing body of research demonstrates the remarkable extent to which nurturing environments and positive interactions build healthy brain architecture. That research – and the public-policy implications arising from it – animates the work of the new National Scientific Council.

Learning from animal research

Much of what we now know about the powerful links between early experience, interaction, and the developing brain comes from the study of animals. Among the more compelling findings are those from the Council's William Greenough, a veteran neuroscientist at the University of Illinois at Urbana-Champaign. Over the years, Greenough and his colleagues have studied two groups of rats: one group reared alone or in bare cages, the other housed in the "luxury condo" equivalent of a lab cage, containing some combination of play equipment, challenging games and obstacle courses, and – importantly – other animals.

Greenough's team has found that the condo dwellers – those from more complex or "enriched" environments, with lots of opportunity for interaction and new experiences – actually develop *measurably different brains*, with architecture that is both stronger and more intricate. These animals have more neurons, the brain's basic nerve cells, than do rats lacking stimulation. Their neurons sprout more and stronger synaptic connections. And their brains produce more glia (from Greek, for the "glue" that holds things together), which are the brain cells that surround neurons and synapses. Glia carry vital nutrients, blood and oxygen and promote healthy neuronal function. "And that," notes Greenough, "may be the most important point. If the animal's early interaction is happy,

stimulating and nurturing, there will be more of these cells that provide buffering and protective qualities to the brain."

This enhanced brain architecture confers great benefits to the animals that possess them. In lab tests, the "enriched" rats outperformed others on a variety of learning and problem-solving tasks, leading researchers to conclude that a sturdy early foundation for brain architecture – and, specifically, one that produces a multitude of new synapses – supports learning and memory.

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Moreover, research like this offers another important lesson. Everything we know about the brain tells us that it is most malleable (or has the greatest *plasticity*, in the parlance of neuroscience) in the earliest years of life. That fact is demonstrated yet again in these experiments: Rats raised from infancy in the challenging environments showed the fastest and most dramatic gains in brain architecture. However, it wasn't too late for their older peers: Rats moved to the enriched cages as full-grown adults *also* benefited from the extra interaction and stimulation, and had demonstrably stronger brains and better performance levels than rats raised elsewhere. The exciting conclusion, say experts: The brain's capacity to grow and fortify itself in response to new challenges and learning is a lifelong property, not something lost at an early age.

From rat cages to the human brain: How interaction matters

Can the stimulating environments and positive interaction that build brain complexity in lab rats be marshaled to benefit our own children? And what's the environmental equivalent of the rats' luxury condo when it comes to human enrichment? A growing body of science – including the rapid evolution of sophisticated brain-imaging technology – does hint at the amazing ways in which a child's brain architecture grows stronger and more complex, with more neural connections, as a result of exposure to stimulating environments and new challenges. Still, experts caution that much more research is needed before we understand the full causal relationship between early experience and the physiology of the human brain.

But science tells us enough to establish the close link between stimulating early environments and healthy social, emotional and cognitive development of humans. Not surprisingly, one of the most important ways our environments help shape development is through everyday human interaction. It may be useful to think of this interaction as a sort of ***mirroring*** – a back-and-forth, give-and-take process by which adults and babies get *in sync* with each other. This reciprocal exchange, practiced by virtually anyone who has bonded with a young child, is deeply instinctive and happens to a large degree subconsciously. Indeed, "these kinds of behaviors are hard-wired within our species," explains Council chairman Jack Shonkoff, dean of Brandeis University's Heller School for Social Policy and Management, and a pediatrician by training. "It's biologically set

up to happen that way for a very good reason; it's the basis of human development and learning."

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Importantly, experts say, mirroring happens in a bidirectional way – with the child and adult alternating between action and reaction, taking turns in the roles of "subject" or "mirror." Such interaction characterizes the way adults instinctively mimic a baby's facial expressions, coos and gestures, for example. And it can be seen in something as simple as a game of "peek-a-boo," or in silly wordplay, in which children are exercising their innate curiosity and, ideally, getting positive reinforcement from the adults around them.

For Council member Ross Thompson, a developmental psychologist at the University of California at Davis, this style of interaction is best described as an "emotional duet" between the baby and parent or other loving adult. This goes far beyond the act of merely reflecting each other's actions. He likens it to a high-stakes card game in which the players take turns "*upping the ante* by elevating what each other does with instinctive – and enormously valuable – reactions."

In this metaphorical poker game, an infant makes an opening bid by smiling, for example. The attentive caregiver ups the ante by leaning close and smiling wider. The baby responds by reaching out, gently grasping the adult's hair. And so on. The same interactive dynamic is at work months later as rudimentary language skills take shape. The baby utters "kuh," for instance. But more than just mimicking "kuh," the mother or father responds: "Oh, you want a *cookie*?" -- likely repeating the word emphatically, thereby reinforcing language and coaxing the child a little further with each exchange.

Interaction and the development of thought and feelings

Developmental science suggests that interactions like these build and shape the baby's brain architecture in fundamental ways. "It's all happening quite naturally," says Thompson, "but it's providing a really good foundation for the baby's social, emotional, and self-regulatory development." More than that, the research demonstrates how this kind of nurturing from attentive, loving adults is linked to innumerable benefits, ranging from enhanced social competence to stronger language development, sharper cognitive skills, enhanced IQ and greater achievement in school.

Scientists studying early development have turned up other fascinating clues about how social interaction may influence the growing brain. A wide literature on language development, for example, has established that babies start life as "language universalists," able to distinguish the full range of sounds used in the world's many tongues. In fact, they can differentiate very subtle phonemic differences that adults later *can't* distinguish. (Think, for example, of the difficult distinction between "la" and "ra" in Japanese.) "The baby is ready for learning any language at all," says Thompson, which

reflects the developing brain's remarkable adaptive qualities. "But it's not very useful to have that capacity endure if you don't need to speak Swahili," he adds.

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And this is where early interaction is so important. Starting around their sixth month, children become perceptually "tuned in" to the speech they hear in their native language environment. This interaction has a direct effect on the brain by helping the regions governing auditory skills to home in on the sounds and language we need while discarding the ones we don't. This evolution happens quickly: By age 1, children have mainly lost their ability to "hear" universally.

Another way in which interaction builds brain architecture can be seen in experiments testing infants' responses to their own actions. For example, in work by researchers, a string is drawn from a baby's ankle to a colorful mobile above her head. The researcher leaves the room, invariably to be lured back moments later as the infant giggles and coos with delight: she quickly picks up the connection between her actions and the results. "There's nothing more evocative to a baby than to perceive that her action has an effect," explains Ross Thompson. This kind of cause-and-effect interaction with things in their environment – what developmental experts call *reciprocity* – gives children "a sense of agency," says Thompson. "Research tells us it's the earliest form of self-awareness, and a powerful elicitor of positive emotion" in a baby who otherwise feels helpless and passive in the early days of life.

Mothers and others: the interplay of interaction

The science of early childhood development has the most to say about the critical importance of mother-child relationships, but increasingly, evidence supports the great value of a youngster's interaction with a wide range of loving, attentive adults within the family and beyond. (The members of the Council refer to this constellation of supportive caregivers as a child's "environment of relationships.") When these relationships offer warmth, support, and intellectual stimulation, experts say, children develop greater social competence, fewer behavioral problems, and enhanced thinking and reasoning skills in school, among other benefits. Importantly, close attachments like these don't seem to compromise the parent-child bond; young children can instinctively balance these relationships, benefiting from interaction with others while their attachment to their parents remains the most influential and central bond in their lives. *(For more information, see the Council's working paper " Children Develop in an Environment of Relationships".)*

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Similarly, the kind of interaction young children experience with *each other* offers important developmental benefits. Over time, they learn how to share, how to take the

needs and desires of others into account, and how to manage their own impulses. While science doesn't yet have the tools to quantify these benefits or pinpoint their influence on the brain, they are known to be critically important in early development.

Using science to shape public policy

If we, as a society, take seriously the science on interaction and early brain development, we should rethink some of the most fundamental public policies relating to our nation's children, say members of the National Scientific Council. Among them are the following:

***Child care*:** While many communities now enjoy the benefits of top-notch child-care programs, the care across much of the nation is still characterized by high staff turnover, poorly designed programs, or inadequate preparation of caregivers. "We might consider looking at our nation's child-care facilities as *brain-development centers*," suggests Thompson, only half joking. His words reinforce the very real and long-term consequences for society of the care that children get in these earliest years.

Since science tells us that positive interaction is crucial – and that it works best when it's unhurried and comes naturally, notes Thompson – a science-based approach to child care and early education would shift current thinking about how to define the "quality" of that care. For many policy-makers, quality is seen in terms of adult-child ratios, group size, physical facilities, and, more recently, cognitively oriented curriculum. But viewing quality child care through a developmental lens leads us to place more emphasis on ensuring that relationships in child care are nurturing, stimulating, and reliable; strengthening the knowledge and skills of the caregivers; and improving the wages and benefits that affect staff turnover in an effort to assure more consistent relationships between young children and their caregivers.

Moreover, because science demonstrates that the developing brain is most malleable in the first few years, public policies should capitalize on the important window of opportunity represented by the preschool and early-school years. For child care and early grades alike, that means recruiting and training highly attentive caregivers who understand the value of early-childhood interaction and are prepared to "seize the moment" with the kind of valuable, one-on-one interaction children most need.

***Parental leave*:** Similarly, the scientific knowledge we are accumulating about the importance of a close mother-infant bond beginning in the earliest months of life suggests there is a need for a reexamination of today's parental-leave debate. Under current federal law, many Americans may elect to take limited, unpaid time off after the birth or adoption of a child. While the Family and Medical Leave Act was heralded as an unprecedented, pro-family step forward when it was enacted in 1993, it still leaves most parents of young children with few options. More than 40 percent of the workforce is not covered by the law; of those who are, it is mainly high-income families that can afford to forgo 12 weeks of paid work.

Several proposals before Congress aim to improve the options for working parents of young children in various ways: by boosting the number of eligible workers; lengthening

the allowable time off; or by offering a limited amount of *paid* leave. Some states are already innovating in line with the science. California recently became the first state in the nation to adopt *paid* family leave, which provides up to six weeks of partial wage-replacement for workers who take time off to care for a new baby or sick family member. Proposals to enact paid family leave have been introduced in at least two dozen other states.

Education for young children: Incontrovertible evidence on the importance of social and emotional development in the early years would suggest ways to reassess thinking about the education of children who have entered school. In the view of Council members, the current emphasis on reading and skills testing for ever-younger students (as reflected in federal mandates under the *No Child Left Behind* Act) may hold political appeal, but it doesn't adequately reflect what science tells us about the importance of interaction and high-quality relationships in the early school grades. From the perspective of developmental science, a better approach would focus on the "emotional duet" Thompson referenced earlier: the reciprocal bonding and learning interactions between young children and their teachers, and young children and their peers, which have proved to be much more important than rote instruction at young ages. Similarly, early education should take advantage of children's natural interests and intrinsic drive to learn, rather than follow an adult-determined agenda that does not take these qualities into account.

Children in poverty or otherwise at risk: If healthy early development relies on close and loving interaction between young children and adults, such interaction is arguably most critical for our most vulnerable youngsters, such as those living in conditions of poverty. Regrettably, our nation's main safety-net program for poor families — Temporary Assistance to Needy Families (TANF) — focuses more heavily on the need to get mothers back to work than on the needs of their growing children. Currently, federal rules require states to impose work requirements of 30 or more hours per week. Although modifications are permissible, only about half of the states exempt mothers of children under 12 months of age, and some states actually permit mandated maternal employment beginning a few weeks after a baby's birth. This is particularly striking given the fact that the earliest months and years of life offer a highly promising opportunity for attentive and skillful caregiving to promote the building of sturdy brain architecture. Stated simply, science would suggest that breaking the cycle of poverty may be best achieved by thinking long-term, and focusing on equipping the next generation with a solid base for ongoing achievement, beginning in the earliest stages of development.

The TANF program faces long-overdue renewal in Congress, and a number of proposed reforms would further tighten these restrictions, mandating 40 hours of acceptable employment for a greater proportion of adults in the program. A related debate over the adequacy of child care available to these parents has been stalled in Congress for several years.

Without consistent evidence that maternal employment intrinsically helps or hurts children, science has little to add to the ongoing political debate about whether paid work should be mandated for mothers on public assistance. However, emerging data do suggest

that a mother's employment, specifically in the first six months of her infant's life, may be associated with later developmental problems. The research raises serious concerns about the potential harm of mandated maternal employment. Emerging scientific knowledge about how early childhood conditions shape brain architecture offers strong evidence that children from all economic levels, as well as the wider society, will benefit from more thoughtful policies toward early childhood development.

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