Building Better Brains:

New Frontiers in Early Childhood Development

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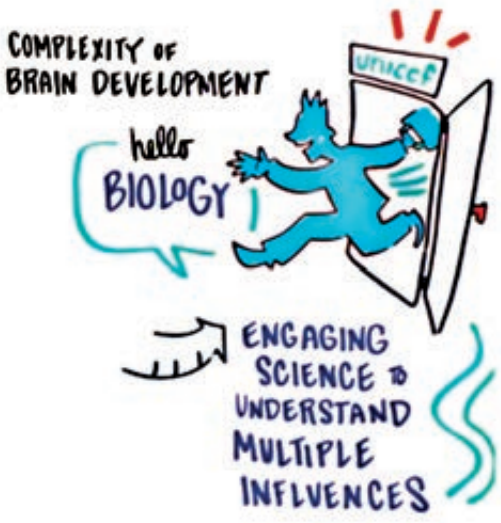
Advances in neuroscience are beginning to drive a revolutionary shift in the way we think about child development, as we learn more about the impact of both positive and negative experiences — and the interplay of experience and genetics — on the developing brain. These developments have significant implications for the future of millions of the world's most disadvantaged children and their societies — and therefore for our work in both humanitarian and development contexts.



The messages presented in this note were generated from a Neuroscience Symposium organized by UNICEF on April 16, 2014, where 16 leading international scientists from different fields of neuroscience presented their latest evidence on the influences of experience and environment on child brain development[1].

1 Please note that this document is not based on an exhaustive review of the literature, but specifically generated from the Neuroscience Symposium. See Annex I for a list of scientists who participated in the Symposium; and Annex II for a list of reference documents that support the messages presented in this note.

We now know that the brain is as influenced by its environment as it is by its genetic blueprint — and that there is an early window of opportunity to provide the nourishment, stimulation, and security children need for their brains need to develop fully — and to help fulfill their own potential. New frontiers of scientific inquiry are also exploring how parenting and caregiving may change the expression of genes in the brain, potentially affecting future generations.

Today, 200 million children under the age of five are not achieving their developmental potential because of multiple adversities — marked by the lack of adequate nutrition, poor health and stimulating, nurturing, responsive, and safe environments.[2] Research shows that investing in early interventions timed to take advantage of crucial phases of brain development can improve the lives of the most disadvantaged and vulnerable children and their societies, helping to break cycles of poverty, violence and despair.

Recognizing the value — and the potential impact — of this science for public health and programming for children in both humanitarian and development contexts, UNICEF convened a symposium bringing together leading scientists from specialized neuroscience disciplines to explore the connections between multiple adversity and early brain development and function. This unprecedented symposium shed new light on how our growing knowledge about early brain development can be applied in new ways to improve the effectiveness of our programming in health, education, nutrition, and child protection — with new implications for protection against violence, neglect, and institutionalization. And the symposium pointed the way to new areas of exploration, including the impact of illness and infections and child health interventions on brain development.

The time has come to redefine early childhood development — linking separate fields of study, translating scientific evidence into practical, integrated interventions across health, nutrition, education and protection, and taking a more holistic approach to drive results for children.

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2 Lancet, 2007

General Messages

The debate over which factor is more influential on brain development — genes or environment — is over.

Once we said nature or nurture; then nature and nurture. Now we know it is nature with nurture, the degree of interdependence is even greater than we ever imagined. They are two parts of a whole, interacting constantly and together playing a singular role in a child's brain development — and a child's future. Genes provide the blueprint for brain development, but the environment shapes it.

The brain develops at its most rapid pace in the first few years of life.

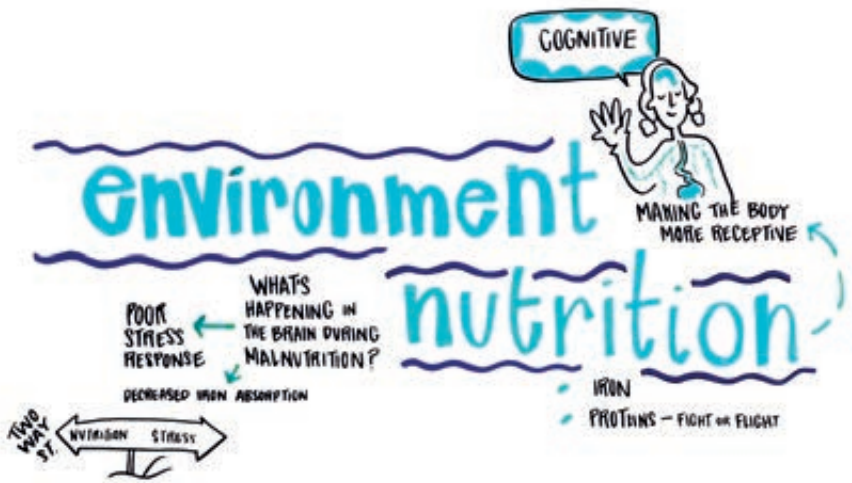
In young children, neurons form new connections at the astounding rate of 700 to 1,000 per second. These early synaptic connections form the basis of neuroplasticity, which underlies a child's physical and mental health, lifelong capacity to learn, adapt to change, and develop psychological resilience. This scientific evidence highlights the importance of caring, good health, nutrition, and stimulation for all young children and especially children facing adversity.

Early intervention is the answer… because it becomes progressively harder to fix problems.

When a child's brain fails to get what it expects and needs, especially during the most sensitive and rapid periods of development early in life, the amount of effort required to set it back on track later in life is enormous and optimal outcomes are far less likely. The extent and severity of problems in later life linked with early deprivation can be remediated through early intervention.

To put this new knowledge to best use, we must learn more about when and how to integrate and deliver interventions in a way that optimizes the period of maximum impact.

The human brain is extraordinarily complex, and it develops from the 'bottom up'. The quality of earlier experiences establishes the foundation for either optimal or suboptimal brain development throughout childhood and adolescence. Brain functions are also highly interrelated, with multiple functions conducted in a coordinated manner. We can maximize the effectiveness of interventions in situations involving multiple adversity if we design them to account for the dynamic pace of early brain development, the complexity and interrelatedness of brain function, and critical windows of opportunity.



Programming Messages

The brain relies on multiple experiences to develop. Nutrition feeds the brain, stimulation sparks the neural connections, positive healthy interactions reduce the impact of illness, and protection buffers the brain from the negative impact of stress. The synergy between adequate nourishment, right kind of positive stimulation and nurturing care, and a sense of safety and security has an effect on the formation and combination of neural pathways — and, as a result, on the brain's ability to develop properly — and on the ability of children to reach their full potential.

Nutrition

Inadequate early nutrition undermines brain development.

In gestation and infancy, the brain is an 'energy hog', consuming between 50 and 75 per cent of all the energy absorbed by the body from food, including fats, proteins, vitamins and minerals. Inadequate nutrition, during that period affects the structure and functions of the brain in ways that are difficult to offset later.

Stress and nutrients interact with each other, affecting how the brain and body absorb nutrients and influence a child's developmental status.

The human body prioritizes how and where nutrients are distributed and absorbed in a complex 'supply' (nutrient availability) and 'demand' (nutrient absorption capacity) system. High levels of stress undermine the body's ability to metabolize key nutrients that support healthy brain development. High stress also affects the absorption capacity of other vital organs, potentially diminishing the effectiveness of nutritional supplements, such as those used to treat children with malnutrition in emergencies. Smarter interventions should therefore link nutrition with stress reduction, simultaneously improving a child's nutritional status and brain development.

Protection

Toxic stress and exposure to violence, abuse, and neglect during early childhood has a lifelong impact.

Stress is experienced at many levels — positive, tolerable and toxic. Toxic stress occurs when an infant or young child experiences violence, abuse, neglect, enduring hunger — deep, chronic, and often multiple adversities. It produces high levels of cortisol, a stress hormone that disrupts the process of brain development by limiting proliferation of brain cells, damaging health, learning, and behavior.

Safety is a pre-requisite for early childhood development.

The autonomic nervous system responds to threats, triggering the stress response and directing energy and nutrients away from the brain. To restore regular brain development, the brain must detect features of safety. Better understanding this "internal" process of risk assessment, known as neuroception, can guide and sharpen our interventions in providing a safe and nurturing environment for children.

Early and Lifelong Learning

Early stimulation and interaction with parents and caregivers jumpstart the journey of brain development — and a lifetime of learning.

Extensive research on infant and childhood stimulation shows that nurturing, stimulating interaction between young children and their parents and caregivers positively and permanently strengthens the ability to learn — and may change brain function for life.

Early childhood learning lasts a lifetime — and yields broad dividends.

The foundation of a brain's network and pathways is established by six years of age. Rigorous economic analyses by Nobel Prize-winning economist James J. Heckman produced the "Heckman Curve", a graph showing that the highest return on investments in education and training is pre-primary learning, from zero to three years of age.

Health

There are many aspects of health that are linked with brain development, not all of which were covered in the Neuroscience Symposium. There are further areas, such as safe deliveries, post-natal care, infections, immunizations, or substance abuse, that are not yet covered by this note but need to be addressed going forward.

Healthy positive interactions between infants and caretakers have a two generational effect.

Strong early attachment and interactions between infant and caregiver stimulate the release of oxytocin. This critically important hormone produces both neural and behavioural effects in the child and the mother, and the effects are interrelated. In mothers, oxytocin may encourage longer breastfeeding, which supports better nutrition and therefore better brain development. And breastfeeding also provides stimulation and nurturing, further strengthening the bond between child and caretaker — all of which support healthy brain development.

Parenting

How children are parented or cared for in the first years of their lives can affect brain function for the rest of their lives — and may even effect future generations.

We are learning more about how early caregiving, socialization and disciplinary practices influence behaviour in early childhood and are also a predictor of adult behaviour, aggression and functioning. These factors can affect genetic predispositions by altering the expression of genes — literally turning the gene and its related function on or off.

Adequate nutrition and consistent, supportive adult caregiving are the best ways to offset the effects of multiple adversity and to support healthy brain development.

The human brain is wired to search for experiences, expecting certain stimuli during time windows — some very short. When the expectation for sensitive and stimulating caretaking is not met, the brain does not know what to do or how to assemble itself, because it relies on the cues from caregiving to create neural connections.

Advocacy Messages

The implications of these new findings for the most vulnerable and disadvantaged children are enormous.

For example, interpreting these new findings can begin to guide advocacy with government partners to decrease reliance on institutionalization and promote more nurturing foster care; to provide more psychosocial support and child-friendly spaces for children living through emergencies; and to focus greater investment in tackling the global problem of violence against children, understanding its profound long-term consequences.

Inequity begins in the first days of life — and so must our efforts to close the gaps that prevent millions of children from realizing their right to develop fully and thrive.

One third of all children[3] are not achieving their development potential, with a profound effect on their lives and long-term consequences for their societies.

3 MICS4

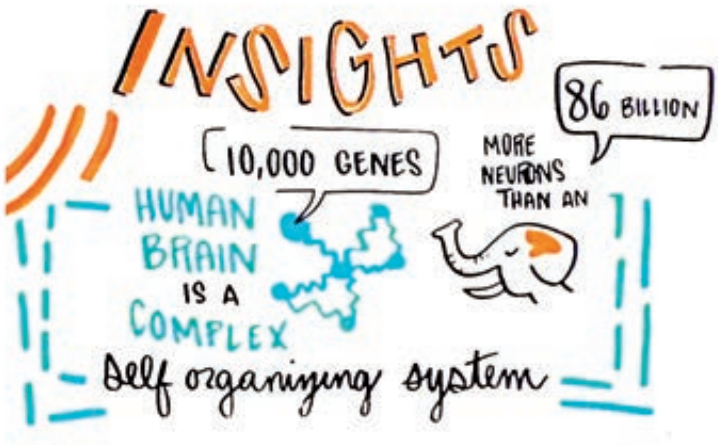
Economists hail investing in early childhood interventions as one the most cost-effective ways to achieve more sustainable growth,

with a high rate of return in learning and earning potential of individuals and higher overall productivity, as well as reduced strain on health, justice, and child and social protection systems, and lower reduced costs to society in lower productivity.

The evidence compels action: Inter-sectoral action is critical to optimize brain development, overall growth, and wellbeing.

As we continue to learn more about the interrelationships between key interventions — nutrition, stimulation, protection, health, support for caregiving and breastfeeding — we can and must begin to interpret and apply these findings today.

The time has come to redefine early childhood development — translating advances in science into results in the lives for the most disadvantaged and vulnerable children.



Key Facts

about the Developing Brain

The blueprint of the human brain includes 86 billion neurons and around one quadrillion synapses (which enable neural connections), coded in only 10,000 genes (Herculano–Houzel, 2009).

During the first years of life, neurons form new connections at an astounding rate of 700 to 1,000 per second (Shonkoff, 2009). Not even a viral tweet from the Oscars moves that quickly.

By the age of 7, neuroplasticity plummets to about 50 per cent of earlier levels (Nelson, 2000).

At 3 years of age, a child's brain is twice as active as an adult brain (Brotherson, 2009).

87% of brain weight is acquired by 3 years of age (1,100 grams; Dekaban, 1978).

50–75% of energy consumption in the first few years of life is allocated to brain development (Steen, 2007).

Of all the human species that evolved through history only we — Homo sapiens — survived because of our adaptive brain development during early childhood (Walter, 2013).

Annex I Neuroscience Symposium: International Scientists

Name	Designation and Institution
Andrea Danese	Senior Lecturer, Institute of Psychiatry, King's College London, UK
Barak Morgan	Neuroscientist, University of Cape Town
Charles A. Nelson III	Professor, Harvard Medical School
C. Sue Carter	Research Professor, University of North Carolina, Chapel Hill Northeastern University, Boston
Francesco Branca	Director, Department of Nutrition for Health and Development, World Health Organization, Geneva
Frank Oberklaid	Foundation Director, the Royal Children's Hospital; Professor, University of Melbourne; Editor-in-Chief, Journal of Pediatrics and Child Health
Judy Cameron	Professor of Psychiatry, Director of Science Outreach, University of Pittsburgh
Jack P. Shonkoff	Professor of Pediatrics, Director of the Center on the Developing Child, Harvard University
Mohamad A. Mikati	Professor of Pediatrics, Professor of Neurobiology, and Chief of the Division of Pediatric Neurology
Michael K. Georgieff	Professor of Pediatrics, Head of Neonatology, and Vice Chair, Department of Pediatrics
Saul Cypel	Professor of Child Neurology, Faculdade de Medicina da São Paulo University; Child Neurologist and former Research Assistant, Institute of Neurology, London University
Stephen Giles Matthews	Professor of Physiology, Obstetrics and Gynecology and Medicine, University of Toronto
Suzana Herculano–Houzel	Associate Professor, the Federal University of Rio de Janeiro, Brazil; Scholar, James McDonnell Foundation; Scientist, Brazilian National Research Council (CNPq) and the State of Rio de Janeiro (FAPERJ)
Stephen Porges	Professor of Psychiatry, University of North Carolina and University of Illinois
William J. Walter (Chip)	Author, educator, filmmaker, former CNN bureau chief and National Geographic Magazine correspondent
Zulfiqar A. Bhutta	Chair in Global Child Health, Hospital for Sick Children, Toronto; Co Director of the SickKids center for Global Child Health, the Founding Director of the Center of Excellence in Women and Child Health, the Aga Khan University

Annex II Reference Documents

Australian Government, Oberklaid, F., Carapetis, J. (2013). A Snapshot of Early Childhood Development in Australia 2012: Australian Early Development Index (AEDI) National Report. Australian Government Department of Education, Employment and Workplace Relations.

Bandeira, F., Lent, R., and Herculano–Houzel, S. (2009). Changing numbers of neuronal and non-neuronal cells underlie postnatal brain growth in the rat. Instituto de Ciencias Biome' dicas, Universidade Federal do Rio de Janeiro, 21941–590, Brazil. PNAS.

Berger, A. (2011). Self-Regulation: Brain, cognition and development. American Psychological Association.

Bhutta, Z. A., Chopra, M., Axelson, H., Berman, P., Boerma, T., Bryce, J. et al., (2010). Countdown to 2015 decade report (2000–10): taking stock of maternal, newborn, and child survival. Lancet, 375, 2032–44.

Britto, P. R., Engle, P. L., & Super, C. S. (Eds.) (2013). Handbook of Early Childhood Development Research and its Impact on Global Policy. New York: Oxford University Press.

Brotherson, S. (2009). Understanding Brain Development in Young Children. Bright Beginnings, NDSU Extension Service, North Dakota State University.

Carter, C. S., Ahnert, L., Grossmann, K. E., Hrdy, S. B., Lamb, M. E., Porges, S. W., & Sachser, N. (Eds.) (2005). Attachment and Bonding: A new synthesis. Cambridge, MA: MIT Press.

Carter, C. S. (2013). Oxytocin Pathways and the Evolution of Human Behavior. Annual Review of Psychology. 65: 17–39

Carter, C. S., Porges, S. W. (2014). Peptide Pathways to Peace. Draft chapter 4–5–2014 for: Raising a Peaceful World: The Transformative Power of Families in Child Development.

Chan, M., (2014). Investing in early child development: an imperative for sustainable development. Annals of the New York Academy of Sciences, 1306.

Cicchetti, D. (2013). Resilience function in maltreated children — past, present and future perspectives. Journal of Child Psychology and Psychiatry, 54, 402–422.

Crudo, A., Petropoulos, S., Suderman, M., Moisiadis, V. G., Kostaki, A., Hallett, M., Szyf, M., and Matthews, S. G. (2013). Effects of Antenatal Synthetic Glucocorticoid on Glucocorticoid Receptor Binding, DNA Methylation, and Genome-Wide mRNA Levels in the Fetal Male Hippocampus. Endocrinology Journal — endojournals.com.

Cypel, S. (2014). Enriching the Brain — From Research to Action. Sao Paulo, Brazil: Faculdade de Medicina da Universidade de São Paulo.

Danese, A., McEwen, B. S., (2012). Adverse childhood experiences, allostasis, allostatic load, and age-related disease. Physiology & Behavior 106 29–39.

De Haan, M., & Gunnar, M. R. (2009). Handbook of Developmental Social Neuroscience. Guilford.

Dekaban, A., S. (1978). Changes in brain weights during the span of human life: relation of brain weights to body heights and body weights. Annals of Neurology, 4(4): 345–56.

Herculano–Houzel, S. (2012). The remarkable, yet not extraordinary, human brain as a scaled-up primate brain and its associated cost. Instituto de Ciencias Biome' dicas, Universidade Federal do Rio de Janeiro, 21941–590, Brazil. PNAS.

Herculano–Houzel (2009 March 31). The human brain in numbers: a linearly scaled-up primate brain. Frontiers in Neuroscience. Retrieved July 7, 2014 from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2776484/

Huffmeijer, R., Alink, L. R. A., Tops, M., Bakermans–Kranenburg, M. J., & van IJzendoorn, M. H. (2012). Asymmetric frontal brain activity and parental rejection predict altruistic behavior: Moderation of oxytocin effects. Cognitive Affective and Behavioral Neuroscience, 12, 382–392.

Kim, P., Leckman, J. F., Mayes, L. C., Newman, M., Feldman, R., Swain, J. E. (2010). Perceived quality of maternal care in childhood and structure and function of mothers' brain. Developmental Science. 13(4), 662–73.

Knudsen, E. I., Heckman, J. J., Cameron, J. L., and Shonkoff, J. P., (2006). Economic, neurobiological, and behavioral perspectives on building America's future. Proceedings of the National Academy of Sciences for the United States of America (PNAS).

McEwen, B., Akil, H., Barchas, J. D., Kreek, M. J. (2011). Social Neuroscience: Gene, Environment, Brain Body (Annals of the New York Academy of Sciences. Wiley–Blackwell.

Meaney M. (2010). Epigenetics and the biological definition of gene x environment interactions, Child Development, 81(1), 41–79.

Mikati, M. A., Holt, R. L. (2011). Care for Child Development: Basic Science Rationale and Effects of Interventions. Pediatric Neurology, Volume 44, No. 4.

Morgan, B. E., Horn, A. R., and Bergman, N. J. (2011). Should Neonates Sleep Alone?. Biol Psychiatry.

Nelson III, C. A., Fox, N. A., and. Zeanah, Jr, C. H. (2013). Anguish of the Abandoned Child: The plight of orphaned Romanian children reveals the psychic and physical scars from first years spent without a loving, responsive caregiver. Scientific American.

Nelson, C. A. (2000). The neurobiological bases of early intervention. In J. P. Shonkoff & S. J. Meisels (Eds.), Handbook of early childhood intervention, second edition (pp. 204–227). Cambridge, MA: Cambridge University Press.

Porges, S. W. (2009). Reciprocal influences between body and brain in the perception and expression of affect: A polyvagal perspective. The Healing Power of Emotion, Affective Neuroscience, Development, Clinical Practice. (2009 in Press). New York: Norton.

Prado, E., & Dewey, K (2012). Nutrition and brain development in early life. Insight: A&T Technical Brief, 4. Washington, DC.

Shonkoff, J. P. & Richter, L., Bhutta, Z. A., van der Gaag, J. (2012). An Integrated Scientific Framework for Child Survival and Early Childhood Development. American Academy of Pediatrics.

Shonkoff, J. P. & Richter, L. (2013). The powerful reach of early childhood development: A science-based foundation for sound investment. In P. R. Britto, P. L. Engle, & C. S. Super (Eds.) Handbook of Early Childhood Development Research and its Impact on Global Policy. (pp 1–23). New York: Oxford University Press.

Shonkoff, J. P. (2009). Investment in early childhood development lays the foundation for a prosperous and sustainable society. Encyclopaedia on Early Childhood Development [online]. Montreal, Quebec: Centre of Excellence for Early Childhood Development and Strategic Knowledge Cluster on Early Child Development. Retrieved July 7, 2014 from http://www.child-encyclopedia.com/documents/ShonkoffANGxp.pdf

Steen, G. (2007). The Evolving Brain: The Known and The Unknown. Amherst, New York.

Stenberg, K., Axelson, H., Sheehan, P., Anderson, I., Gülmezoglu, A. M., Temmerman, M., Mason, E., Friedman, H. S., Bhutta, Z. A., Lawn, J. E., Sweeny, K., Tulloch, Jim., Hansen, P., Chopra, M., Gupta, A., Vogel, J. P., Ostergren, M., Rasmussen, B., Levin, C., Boyle, C., Kuruvilla, S., Koblinsky, M., Walker, N., de Francisco, A., Novcic, N., and Presern, C., Jamison, D., Bustreo., on behalf of the Study Group for the Global Investment Framework for Women's and Children's Health (2013). Advancing social and economic development by investing in women's and children's health: a new Global Investment Framework. The Lancet: Health Policy.

Suomi, S. J. (2005). Genetic and environmental factors influencing the expression of impulsive aggression and serotonergic functioning in rhesus monkeys. In R. Tremblay, W. W. Hartup & J. Archer (Eds.), Developmental origins of aggression. New York: Guilford, pp. 63–82.

UNICEF (2012). Committing to Child Survival: A Promise Renewed. New York.

UNICEF (2011). Multiple Indicator Cluster Survey (MICS) 4

Wachs, T. D., Georgieff, M., Cusick, S., and McEwen, B. S. (2013). Issues in the timing of integrated early interventions: contributions from nutrition, neuroscience, and psychological research. Annals of the New York Academy of Sciences Issue: Integrating Nutrition and Early Childhood Development Interventions.

Walter, C. (2013). Last Ape Standing. New York: Walker and Company.

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2014