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The Long Reach of Early Childhood

The roots of an individual's health, behavior, learning and socioeconomic capability in adulthood are formed in early childhood. The convergence of independent research in neuroscience, developmental psychology, epidemiology, population health, molecular biology and economics is remarkable and it all concludes that the earliest experiences of children reach long into adulthood.

Experience-based brain development

The exponential growth in new knowledge from research in the neurosciences and biological sciences provides evidence of "how" the social environment of early life gets "under the skin" in the early years of life, shaping learning, behaviour, and health throughout the life cycle.

All the neurons in the head have the same genetic structure (DNA) but they all develop specific functions. The stimuli that gets under the skin can, through biological processes, regulate the expression of DNA in nerve cells. Thus, identical twins with exactly the same gene structure can show a 20-30% variance in behaviour as adults. This is because they do not have an identi-

cal experience in early development, leading to some variation in gene function: they can have a different phenotype although they have the same genotype. Thus, experience in early life sets the architecture and function of the neurons in the brain.

Brain development begins soon after conception and continues after birth. The changes that take place in the brain in the early years of life ensure that an infant becomes highly attuned to the environment into which he or she is born. An infant reared in perilous surroundings — whether a dysfunctional home or a war-torn urban jungle — will develop brain connections and chemical responses that are highly sensitive to signs of danger. Early brain development is for the long-term. It assumes the environment into which an infant is born will not change significantly over the span of his/her lifetime; hence the brain connections or chemical tendencies laid down in a dangerous environment at the beginning of life become entrenched. Even if an individual finds him or herself in a safe and secure environment in adult years, his/her brain is likely to stay on constant lookout for the slightest signs of danger, to the detriment of health, well-being, ability to cope and competency throughout life. On the other hand, an infant born into nurturing surroundings experiences very different sensory stimulation and the brain develops connections and chemical reactions that support more optimal development and better health, well-being, and competency.

Scientists are now able to study the extensive neuron connections that form in the first six years of life. At birth neuronal connections are few. The process of building neuron pathways intensifies after birth. By six years the numbers of neurons are the same as at birth, but connections amongst the neurons are far more numerous. By 14 years of life, the neuron connections that are not frequently used have been eliminated through a process called "pruning". Connections between neurons and neural pathways are strengthened with use; repeated use leads to strong connections.

Four fundamental neural pathways, very much interconnected and established early in life, form a neural foundation for higher cognitive functions. The formation of neural pathways is hierarchical: the pathways that develop early are crucial for the next stage of neural pathway development. Sensory neural pathways set most of the brain's ability to interpret the signals and

pathways that govern or control intellectual, emotional, psychological, and physical responses to stimuli.[1] Coping pathways also develop early and support higher level language and cognitive pathways.[2] Visual and auditory areas of the cortex and limbic system pathways precede receptive language systems, which in turn precede speech. So early experiences have a powerful influence on the neural pathways that underlie humans' capacity to use language, become literate, and understand the complexities of their environments. In some parts of the brain neural circuits continue to renew and develop throughout life.

Neuroscientists have begun to understand in much greater detail what sorts of experiences are important for optimal brain development, why some experiences are more beneficial than others, and why certain kinds of experiences can damage how the brain develops.[3] Indeed, we are now entering the stage where we can understand why changes that happen in the brain in the early years of life are so important for how well a child speaks, how she performs in school, her skills in math or music, her ability to form friends or to enjoy life and become a responsible and productive member of the community.

Primary caregivers, usually parents, are crucial in providing the early stimulation that drives the function of the neural pathways. The quality of experience or sensing stimulation with adults (particularly parents or other primary caregivers) and other children in the very early years of life has a major effect on neuron function and brain development. The signals from the sensing pathways affect how neurons function and the formation of neural pathways for coping, language, and understanding.

Poor caregiver-infant interactions compromise the formation of neural circuits and pathways. A series of studies over two decades show that neglect, abuse, or parenting compromised by depression or substance abuse influences the development of the child's brain and biological pathways. Children who experience parental abuse and/or neglect are more likely to show poor outcomes that carry forward into adult life.[4] These children are more likely to show problems with emotional regulation, self-concept, social skills and academic motivation. Over time, studies have reported that individuals who experience abuse often show serious learning and adjustment problems, including aca-

demic failure, severe depression, aggressive behaviour, peer difficulties, substance abuse, and delinquency.

The long reach of early childhood on health, behaviour, and learning

We have outlined how early experiences establish the architecture of the brain and the developmental trajectories for the learning, behaviour, and health of individuals and populations. Coping abilities, competencies, health, and well-being are strongly influenced by the neural circuitry that develops as a result of the intricate interaction of genes and early environments and experiences. The remainder of this article details the long reach of early childhood throughout life and how an individual's health, behaviour, and learning are interconnected manifestations of social and economic circumstances in early life.

The developments of neuronal and biological pathways in the prenatal period and in the early years affect physical and mental health, learning, and behaviour in adult life.[5] The evidence from studies of the social determinants of health and well-being in humans, monkeys, rats, and other mammals show that the effect of the social environment on brain development and function in early life contributes to physical and mental health problems throughout life. The LHPA pathway established in utero and in early childhood is linked to hormone and immune systems that have an impact on the body's tissues and organs. The functioning of this pathway is implicated in adult health and disease. Children brought up in adverse environments are predisposed to coronary health disease, hypertension, type II diabetes, substance abuse, and mental health problems.

Behaviour problems, such as attention-deficit hyperactivity disorder (ADHD), antisocial behaviour and autism, are manifestations of brain function influenced by early development. Experience-based **gene activation, differentiation of neuron function, and synapse formation in the early years can set a dysfunctional pattern leading to behavioural problems.** The evidence from behaviour studies is compatible with the concept that vulnerability in gene structure combined with a poor environment for early child development can lead to significant behaviour problems in later life. Children who do not

experience behaviour problems, in spite of adverse early experiences, may be resilient because of their genetic structure.

The differentiation of neurons to detect different sounds for language also shows that trajectories for language and literacy performance tend to be set in infancy. The data from longitudinal studies and the few randomized early intervention programs also indicate **the early years are when the brain is most receptive to the development of verbal skills and language**. In developed countries there is a relationship between poverty and literacy. In the American study of adult literacy, about 22% of the population was at Level 1 (low) and about 27% of the population is at Level 2. Forty percent of the population at Level 1 were classified as living in poverty and more than 20% were living in poverty at Level 2. Less than 5% with high performance in literacy lived in poverty. International studies by the OECD also demonstrate a strong correlation between equity in literacy and equity in incomes.

Whatever it is about the social environment that affects health, learning, and behaviour, it reaches all social classes, but all are not equally influenced. Outcomes in all population-based research appear as a gradient when plotted against the social and economic status (SES) of the sample studied. Members of the low SES group are more likely to have poor outcomes but there are fewer numbers of people in the low group. Likewise, members of the highest SES group are less likely to face challenges (although some do), but there are few numbers in this group. Thus, the largest number of individuals affected by factors influencing health, learning, and behaviour are in the two middle groupings, or as often referred to, the middle-class.[6] In Canada this represents about 75% of the total population.

Early experiences can make a difference

Children's earliest experiences have far-reaching and solidifying effects on the development of their brains, and health, learning and behaviour throughout the life cycle. There now is strong evidence that the early period of human development has profound effects on the function of the brain throughout life. The Romanian orphanage studies show clearly that strong support for early child development programs have major effects on the later stages of child development.

Researchers have long identified the **crucial role that the primary caregiver** plays in the infant's development.[7] Over the past eight years, neuroscience has begun to shed light on the neurological processes underpinning these phenomena.[8] Neuroscientists are discovering that human brains are specialized for receiving and understanding stimulation from other people[9] and the kinds of early experiences that are necessary for the optimal functioning of these neural pathways.[10] Caregivers exhibit a number of behaviours that suggest humans are pre-adapted to nurture our infants. Mothers can hear their infant crying in very noisy environments, reliably distinguish between the crying of their own infant and other infants, distinguish between their own infant's smell and that of other infants, and they unconsciously fine-tune their behaviours in order to help their infant master verbal, social, and cognitive skills.

Play engages a young child and promotes learning.[11] Play is how children make sense of the world and is an effective method of learning for young children. Play is a form of problem-based learning which is one of the best ways to learn. Ideas and skills become meaningful tools for learning are practiced, and concepts are understood. Play engages children's attention when it offers a challenge that is within the child's capacity to master. The qualities developed through play are the same required to succeed in school. Children who enter Grade 1 with strong oral communication skills are confident, able to make friends, are persistent and creative in completing tasks and solving problems, and excited to learn and have pathways set for academic success.[12]

The acquisition of literacy skills begins long before Kindergarten. It starts at birth through everyday interactions like talking, singing, sharing books, telling stories, or pointing out and naming objects. Painting, drawing, or picking up things also serve a purpose. These activities help develop hand muscles and coordination — skills necessary for learning how to write. Children begin to take meaning from printed text by combining a growing sense of story and the structure of language with the idea that print represents spoken language and thoughts. Children's ability to derive meaning from print text is further enhanced with greater understanding of letter-sound relationships and word recognition.[13]

Numeracy begins with the three-year-old understanding she is taller than her one-year-old brother, that she gets two cookies because she is bigger and he gets one because he is smaller. Relationships between objects (big-small, long-short, etc.) and object classifications are the foundation to numeracy. To develop an understanding of the meaning of numbers, children count objects one by one, pointing to them as they say the numbers in the sequence. And children must also grasp the concept of cardinality — that the last number in the sequence tells how many objects there are. Play consolidates understanding about numbers and children can then begin to use number sequences that is a prerequisite for addition, subtraction, multiplication, and division.[14] Play that involves games that use a number line, one-one correspondence, and counting help children master and integrate understanding about numbers.

Inquiry or scientific reasoning begins in infancy.[15] Babies through problem-based learning see how objects move and behave, gather information, build patterns of expectations about the world around them, and form general categories. Toddlers experiment with tools and learn to manipulate objects. They learn to solve simple problems they encounter in their environment, such as how to get an object out of reach or how to make their desires understood. Preschool children use methods of inquiry including data collection, predicting, recording, and talking about findings. Problems to be solved emerge in preschool pretend play.

High quality early childhood development works

The evidence related to early child development programming is compatible with the evidence from the biological and neurosciences that the critical and sensitive periods for brain and biological development are significantly influenced by experience in the early years beginning with pregnancy. A substantial investment in an early child development system is necessary to improve the competence, health, and well-being of populations throughout the world.

Starting Strong II, a review of early childhood programs in 18 countries for the Organization for Economic and Cooperative Development (OECD), recommended a more systemic approach across early childhood programs and the integration of tradi-

tional care and education sectors.[16] Its review of Canada recommended bridges between existing early childhood programs with the aim of integration at both the ground level and at policy and management levels. Nine OECD countries have now integrated their entire early childhood systems for children from birth to age six under one government department. They regard early childhood programs as an essential part of the preparation of children for public school, as an important component of the supports for families, in particular for those with employed parents, and finally, as a venue for identifying children and families who will need special services.

Other comprehensive early intervention studies (Abecedarian and Perry Preschool for example) offered integrated programming that combined health, early childhood education, nonparental care, home-visiting, and parenting supports to participants. In fact, a comprehensive, integrated approach is a common characteristic of effective early interventions.

To work, programs must be universal

As we saw earlier, vulnerable children are found in all SES groups but vulnerability is not evenly distributed between groups. The largest numbers of vulnerable children overall are found in the middle SES groupings. The lowest SES groupings have a greater percentage, but a smaller number, of vulnerable children. Conversely, children in the middle SES groups are less likely to be vulnerable, but because of the size of the group, this is where the most vulnerable children are found. Restricting programs to the most vulnerable children in the lowest SES groups therefore misses the majority of children experiencing difficulties.

Any program to improve the competence and well-being of populations should therefore be available for all families with young children. While such initiatives will have the greatest impact on children in the lowest socioeconomic groups, they will influence outcomes for vulnerable children in all social classes, thus addressing issue of vulnerability for the entire population.[17]

Interestingly, it is not wealth, but equality, that produces healthy populations. Consistently, countries demonstrating high health and literacy outcomes show a fairly flat socioeconomic gradient. Countries with healthy, more literate populations also invest heavily in young children and their families.

Internationally, the top scorers on early child development indices provide quality, universally-accessible early childhood programs for their youngest citizens.[18] At present, there is very limited evidence that special education programs improve the performance of children once they are in the school system to the same extent that good preschool programs do.[19] To achieve high population performance and equity in outcomes (and reduce the incidence of anti-social behaviours and to improve the mental and physical health of their populations), it appears that societies will have to make a substantially larger investment in early child development programs than they have to-date.

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ENDNOTES

[1] Hebb, 1949; Sternberg, 2000; Nelson, 1999; Kandel, 2001; McEwen, 2002; LeDoux, 2002a; Knudsen, 2004; Fields, 2005.

[2] McEwen, 2002.

[3] Greenspan & Shanker, 2004.

[4] Bolger & Patterson, 2001; Shonkoff & Cicchetti, 2001; Maughan & McCartney, 1997.

[5] Barker, 1989, 1998; and Gluckman and Hanson, 2004.