Focus on Zero to Three (Part 1) Brain research—what's new?

ARTICLE

Recent advances in brain research have given us new insight into how the human brain - the most immature of all organs at birth - continues to grow and develop during the first years of life. This growth was once thought to be determined by genetics, however scientists now know that it is also highly dependent upon the child's experiences. Research shows that interactions with other people and objects are vital nutrients for the growing brain in just the same way as protein, fat and vitamins.

We know that a child's ability to understand language, solve problems and get along with other people is strongly influenced by experiences as an infant and young child. These very early childhood experiences impact on the way that genes are expressed in the developing brain.

> *'Early care and nurture have a decisive, long-lasting impact on the way people develop, their ability to learn and their capacity to regulate their own emotions'.*[1]

Much of the information and new knowledge generated by the last decade of brain research will not surprise, or even seem very new, to caregivers as it revolves around the primacy of interactions and attachment. What is new is the scientific research base that underpins our knowledge of early Child Care and development together with the widespread publicity and implications of this information. Table 1. (page 2.) simplifies and summarises our present understanding about brain development.

This article will provide information for caregivers to assist you to provide high quality Child Care that is a positive experience for infants and young children. It is not intended to tell you all there is to know about brain research – but to get you thinking about how to use this information in your own care giving practices and in the wider community. It will also give you information to answer the questions that parents ask about early care and child development. In this way you can help to spread awareness about the crucial importance of the child's early years.

Why are we hearing so much about children's brains these days?

As a result of new technologies, including powerful brain scans and imaging techniques, scientists are able to form a much clearer picture of the brain's inner workings. These technologies have allowed new insights into early development. How we think, learn and develop has always fascinated people. In particular, many parents and caregivers are eager to understand the role they play and how they can enhance children's brain development in the crucial early years.

What have scientists discovered that we didn't know before?

Scientists have made discoveries about how a child's earliest experiences affect the way the brain is organised. Some of the neuroscientists' findings simply confirm what many caregivers already intuitively believed. For example, researchers now confirm that the way we interact with children and the experiences we provide or encourage have a big impact on emotional development, learning abilities and the way children function in later life. Scientists are learning more about the biological processes that underlie development.

They are finding that the kind of care giving that children receive has an even greater effect on brain development than previously suspected. In order for children to thrive, they must be loved, held, talked to, read to and allowed to explore. Of course, heredity also plays a role. We know that a complicated mix of heredity and experience shapes brain development. Our genetic inheritance establishes our potential, but our daily experiences determine just how this potential is expressed. Because most of children's brain development takes place after birth and experience shapes the developing structure of the brain, caregivers have the opportunity, every single day, to contribute to healthy development. In order to understand how this happens, we need to understand a bit about how the brain works.

[1] Shore, R (1997) Rethinking the Brain, New Insights into Early Development. Families & Work Institute, New York. p. 27

The human body is entirely made up of cells, and the brain is no exception. These cells are not yet connected into networks as they will be when the brain is mature. These **networks** are crucial - they allow thinking and learning to take place. Given their importance why do we begin life without them? One answer is that an 'unfinished brain' allows babies to form networks of brain cells in **direct response** to their world. The brain's ability to develop and change in response to the demands of the environment is referred to as **plasticity**.

From the infant's viewpoint – their caregiver **is** their world. They experience the way you look into their eyes, they see the expressions on your face; they hear you cooing, singing, talking and reading; they feel you holding or rocking them; they take in your familiar smells. They often experience the taste of your skin as well as their own.

These primary sensations – touch, taste, sight, smell, sound and movement are what developmental neurobiologist, Dr Bruce Perry, refers to as the '**somato-sensory bath**'[2] – provided by high quality carer-child interactions.

> *'These primary sensations play a major role in providing the patterned, repetitive sensory stimulation and experiences that help organise the child's developing brain.'* [3]

The daily interactions between the caregiver and the child are the keys to the way in which the child's brain forms connections.

HOW DOES THE BRAIN DEVELOP?

The brain is made up of distinct regions, each devoted to a specific function, such as identifying what we see, processing spoken language, or assessing whether we are in danger. Within each of these brain areas are millions of **neurons, or nerve cells,** which are connected to each other by **synapses.** These trillions of synapses and the pathways they form make up the 'wiring' of the brain. They allow all of the various brain areas to communicate and function together in a coordinated way.

Old Thinking	New Thinking
How a brain develops depends on the **genes** you were born with.	How a brain develops hinges on a complex **interplay** between the **genes** you're born with and the **experiences** you have.
The **experiences** you have before age three have a **limited impact** on later development.	Early **experiences** have a **decisive impact** on the architecture of the brain, and on the nature and extent of adult capacities.
A **secure relationship** with a primary caregiver creates a favourable **context** for early development and learning.	**Early interactions** don't just create a context; they **directly affect** the way the **brain is 'wired'**.
Brain development is **linear:** brain's capacity to learn and change grows steadily as an infant progresses toward adulthood.	Brain development is **non-linear;** there are **prime times** for acquiring different kinds of knowledge and skills.
A toddler's brain is much **less active** than the brain of a college student.	By age three, children's brains are **twice as active** as those of adults. Activity levels drop during adolescence.

TABLE 1: RETHINKING THE BRAIN [4]

[2] From presentations by Dr Bruce Perry during his 2000 tour of Australia and audiotaped Keynote Address, NAPCAN Conference, New Zealand (1998)
[3] From presentation "Principles of Neurodevelopment" Dr Bruce Perry, 2000.
[4] Table reproduced from Shore, R (1997) op cit. p18.

The number and organisation of connections in the brain influence everything from the ability to recognise letters of the alphabet to managing complex social relationships.

Neurons develop rapidly before birth, but after birth no new neurons are formed. Instead, brain development consists of an ongoing process of wiring and rewiring the connections among neurons. New synapses between cells are constantly being formed, while others are pruned or broken. During the first eight months after birth, connections are formed more quickly than they are broken, so that at age eight months a baby has an astounding 1,000 trillion synapses in his brain. After the first year, synapse pruning occurs more rapidly than synapse formation until at age ten, when a child has about 500 trillion synapses – roughly the same number as the average adult.

Early experiences can have a dramatic effect on this brain wiring process, causing the final number of synapses in the brain to increase or decrease by as much as 25 per cent.[5]

HOW DO BRAINS FORM CONNECTIONS?

Brain cells are designed to make connections. Each cell sends signals out to, and receives input from, other brain cells. The signals, in the form of electrical impulses, travel down the length of the nerve cell (or **neuron).** With the help of special chemicals (neuro-transmitter substances such as serotonin) the signals travel from cell to cell, creating connections. Repeated activation of networks of neurons strengthens these connections.

HOW DOES THE BRAIN 'KNOW' WHICH CONNECTIONS TO KEEP?

When a connection is used repeatedly in the early years, it becomes permanent. In contrast, a connection that is not used at all, or often enough, is unlikely to survive. The brain operates on a **use it or lose it** principle: only those connections that are frequently activated are retained. Other connections that are not consistently used will be pruned so that the active connections can become stronger. For example, a child who is rarely spoken to or read to in the early years may have difficulty mastering language skills later on. By the same token, a child who is rarely played with may have difficulty with social adjustment as he or she grows.

DOES IT MATTER WHEN CONNECTIONS ARE FORMED?

No complex building process happens all at once and different parts of the job get top priority at different times. It's the same for brain development. For example, in very early pregnancy, the cells that make up the cortex – the part of the brain that allows thinking – have to travel to exactly the right place at the right time. This is a **'prime time'** for brain development. During this prime time, it is particularly dangerous for an expectant mother to take drugs or come into contact with radiation. If cells get side-tracked in their journey up the cortex wall, the baby's brain development may be jeopardised.

There are other prime times both before and after birth. Some of them are relatively short. For example, if the brain is not exposed to visual experiences in the first years of life, then the child will not be able to see. Other prime times can last a decade or more. For example, for the first dozen years of life, children can learn languages easily, as opposed to later in life. Our goal must be to:

> *'provide the right experiences in the right amounts at the right time in the life of the child. Few infants will benefit from a linear algebra lecture – and few adolescents need to be held for hours, rocked and breastfed.'* [6]

Whenever these prime times are discussed, it is essential to keep in mind that, whilst we advocate for early childhood intervention, it is never too late to help children learn and develop – although it can be more costly and time-consuming than in the early years of life.

THE EFFECT OF ABUSE OR NEGLECT ON BRAIN DEVELOPMENT

At the CIVITAS Child Trauma Programmes at Baylor College of Medicine, Dr Bruce Perry and co-workers have studied the impact of trauma/neglect on the neurobiology of over 1,000 abused or neglected children. In one study, 20 children who had been raised in impoverished, under-stimulating environments – children who were rarely touched or spoken to and who had little opportunity to explore and experiment with toys – were examined with sophisticated brain imaging techniques and other measures of brain growth. These children were found to have brains that were physically 20 to 30

[5] Starting Smart: How Early Experiences Affect Brain Development. An Ounce of Prevention Fund (1996) p3 . Website reference http://www.childtrauma.org/ctmaterials/caregivers.asp
[6] From presentation "Principles of Neurodevelopment" Dr Bruce Perry, 2000.

per cent smaller than most children of their age and, in over half of the cases, parts of the children's brains appeared to have wasted.[7]

The effects on children of abuse and neglect result in 'under-development' of parts of the brain associated with (amongst other things) anxiety, impulsivity, self-regulation, managing emotions and possibly even such skills as problem solving and empathy. Abused or neglected children miss out on the somato-sensory bath provided by high quality carer-child interactions. These experiences provide the major sensory cues responsible for organising key areas of the brain. Lack of specific sensory input during development results in abnormal development in those brain systems that sense, perceive, process, interpret and act on information related to that specific sensory system.

WHAT DOES THIS MEAN ABOUT INTERACTIONS WITH CHILDREN?

Scientists have found that your relationship with a child affects his or her brain in many ways. By providing warm, responsive care, you strengthen the biological systems that help him handle his emotions.

Research also shows that a **strong secure attachment** with the child helps him withstand the ordinary stresses of daily life – not just today, but in the future as well. A strong bond doesn't just reassure him, it actually affects the biological systems that adapt to stress. Scientists have shown that in stressful situations, children who have experienced a secure attachment are more adaptive and produce less cortisol – the stress hormone that affects metabolism, the immune system and the brain. Excessively high levels of cortisol alter the brain by making it vulnerable to processes that destroy brain cells, and just as importantly, reduce the number of connections in certain parts of the brain.

Consistent and responsive attention to a crying baby helps the infant to build the neurobiological capacity to tolerate future stress in a positive manner. You cannot 'spoil' a baby by responding to them – instead, you help them become resilient. Babies require very different experiences than toddlers or older children. The key to expressing the genetic potential of a child is to provide experiences matched to the developmental needs of the child. This research finding is consistent with high quality Child Care provision.

SOME SPECIFIC EXAMPLES

Language Skills

When an infant is three months old, his brain can distinguish several hundred different spoken sounds. Over the next several months, his brain will organise itself more efficiently so that it only recognises those sounds that are part of the language he regularly hears. For example, Japanese babies can distinguish between 'r' and 'l' sounds at six months of age but lose this ability by twelve months of age. By then, the distinction has been ignored by their brain structure because it isn't used in the Japanese language. During early childhood, the brain retains the ability to relearn sounds it has discarded so young children typically learn new languages easily and without an accent.

The Spoken Word

Researchers found that when mothers frequently spoke to their infants, their children learned almost 300 more spoken words by age two than did their peers whose mothers rarely spoke to them. However, exposure to language through television or adult conversation not directed at the child had little benefit. Babies need to directly interact with others to gain maximum developmental benefit. They need to hear people talk to them about what they are seeing and experiencing, in order for their brains to fully develop language skills.

Vision

Wiring for vision takes place in the first few months. A baby whose eyes are clouded by cataracts from birth will, despite cataract surgery at age two, remain blind. However, an adult who grows cataracts later in life and who has them removed will regain vision. This is because the adult's circuits were already 'wired' - an example of the use it or lose it principle in early childhood!

Creating One Stable Bond/Primary Caregiver

Researchers who examine the life histories of children who have succeeded despite many challenges, have consistently found that these children have had at least one stable supportive relationship with an adult early in life.

[7] Starting Smart: How Early Experiences affect brain development. An Ounce of Prevention Fund, 1996.Website reference http://www.childtrauma.org/ctmaterials/cargivers.asp

WHAT'S HAPPENING IN AUSTRALIA?

NIFTeY

In Australia**, NIFTeY (The National Investment for The Early Years) emerged out** of a meeting of academics, practitioners and government officials held in Canberra in March 1999. These people, from many sectors, concerned about the wellbeing of children within the context of their families and communities, endorsed a proposal that a major initiative focusing on the first three years of childhood be launched to coincide with the new millenium. One of their guiding principles[8] is that early brain development is strongly influenced by the nurturing environment and security of relationships that surround the young child, that sets a base for learning, behaviour and health for life. In Western Australia there is a State Branch and RUCSN maintains an active involvement in this local organisation. Meetings are held every six weeks and are open to anyone with an interest in early childhood issues. Attendees include paediatricians, therapists, nurses, early childhood educators, and representatives of the Department of Community Development. More information about NIFTeY can be sourced at its website: www.niftey.cyh.com.

Government Policy

The **Commonwealth Child Care Advisory Council** provides advice to the Minister for Family and Community Services on Child Care issues. Their new initiative is **Child Care Beyond 2001** - to share ideas and hear the views of anyone with an interest in Child Care and the 'big picture' issues that will shape its future.

> *'The recent announcement of the **Stronger Families and Communities Strategy** by the Prime Minister on 16 April 2000 provides a timely opportunity to consider the potential role and options for Child Care in family and community life.'* [9]

The Government demonstrates an awareness of the crucial importance of the early childhood years for long term well being, development and health. They also recognise that quality Child Care provides important social and learning opportunities for children and that caring for children is a skilled role:

> *'There is a wealth of new thinking and recent research into early childhood. There is also substantial expertise and experience in our communities. We have the tools to maximise the early experiences of our children. The challenge is to share these tools and develop the skills of everyone involved in Child Care both in and out of the home.'* [10]

IMPLICATIONS FOR CHILD CARE

Brain development is non-stop. It continues around the clock – when the child is with her parents, and also when she is not, for example, when in Child Care. That's one reason why high quality Child Care is so important. Warm, responsive care giving not only meets an infant's basic day to day needs for nourishment and warmth, but also responds to their preferences, moods and rhythms. This kind of consistent care giving plays a vital role in healthy development. Caregivers help to shape the experiences that allow the brain to develop. From the child's perspective, every important caregiver is a potential source of love and learning, comfort and stimulation.

Children need experiences with important caregivers who are sensitive to their emotional and physical needs. By providing consistent and responsive care giving, you can ensure that children have the best opportunity for healthy emotional and social development. Every important caregiver has the potential to help shape a young child's future.

> *'Child Care is more than a service that holds daily schedules intact. It is a place where children build their brains'.* [11]

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[8] The guiding principles were determined in July 1999 and were based on research evidence and adapted from the Ontario Report (Mustard and McCain (1999) *The Early Years – Reversing The Real Brain Drain*.

[9] Commonwealth Child Care Advisory Council (May 2000), *Child Care Beyond 2001*, cover page.

[10] Commonwealth Child Care Advisory Council (May 2000), op cit, pg 3.

[11] Website reference: http://www.news-observer.com/2little2late/stories/day1-main

THINGS FOR CAREGIVERS TO CONSIDER

- Consistent staffing – rostering, relief in the babies' room, allocation of primary caregiver.
- Encourage attachment[12]– allow yourself to get close and be involved.
- Provide information for parents on the importance of the early years.
- Think of ways to increase opportunities for the somato-sensory bath – experience and interactions.
- Allow time to 'be with' babies and learn their needs and respond to them.
- Make time for talking.
- Respond to babies' needs – they are supposed to cry and we are supposed to soothe them.
- Create a stress-free environment [13].

INFORMATION ON THE INTERNET

A recommended website

There is a wealth of information available for caregivers who want to know more about current information and research. It can be hard, however, to know where to start and you can easily waste time and resources looking for the 'right' website.

To guide your search, RUCSN recommends that you begin with the following site as it contains information specifically developed for Child Caregivers together with lots of 'parent information' that you can download and distribute to parents who use your service. This is my favourite starting point for clear and useful information.

http://www.zerotothree.org/brainwonders

Brainworks is a collaborative project of the Boston University School of Medicine, Erikson Institute and ZERO TO THREE. It has been developed to provide user friendly information about how the brain develops within the context of relationships from conception to the three year stage. It contains separate sections for Parents, Child Care Providers, and Paediatricians. (Although it's helpful to look across all of the areas). The section designed for caregivers looks at different age groups and at relevant areas of brain development. For example, the age span 'newborn to two months' looks at

- vision, hearing and touch
- crying
- breast feeding and brain development.

It answers specific questions in these areas and provides information about what caregivers can do to enhance children's development and most sections contain a reference and further resource list.

SUPPORT FOR CAREGIVERS

If you are having difficulties including all children in your care environment, consider discussing any issues and problems with your Regional Inclusion Support (SUPS) Team. They have a wealth of experience and are able to offer practical advice, suggestions and information about local resources. They can also help with information about referral procedures for children with additional needs. If you are unsure which SUPS Team covers your service, contact RUCSN. Inclusion Support teams and RUCSN can offer staff training if skill enhancement is required.

GLOSSARY

Cerebrum

The large, rounded structure of the brain that includes the cortex. The cerebrum controls and integrates motor, sensory and higher mental functions including thought, reason, emotion and memory. It is divided into two hemispheres, the right and the left.

Cortex

(Technically the cerebral cortex.) The neuron-rich, furrowed, outer portion of the cerebrum. The cortex controls higher mental functions such as thinking, planning, remembering and analysing.

Networks

Groups of connections (see neural pathways) between brain cells that are created and maintained by particular experiences. They allow brain areas to communicate with one another in a coordinated way. Each neuron can connect to as many as 15,000 other neurons.

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[12]Dockett, S, Caring Adults – A Necessity for Optimal Brain Development Every Child Vol 6, No 1, Autumn 2000, pp 12-13

[13] Lawrence, M, Stress Free Environment – Providing Healthy Brain Development Every Child Vol 6, No 1, Autumn 2000, pp10-12

Neuron

A cell that is part of the brain or central nervous system.

Neural pathway

A series of synapses (connections) that forms a network in the brain. These pathways can be activated by a particular experience.

Neurotransmitters.

Chemical substances, such as serotonin or dopamine, that enable electrical impulses to pass across a synapse from one neuron to another.

Plasticity

(Technically, neuroplasticity.) The capacity of the brain to change or adapt in response either to experience or to damage.

Pruning

A term used to describe the selective elimination of synapses (connections).

Somato-sensory bath

Carer-child experiences and interactions which 'immerse' the infant in the primary sensations of touch, taste, sight, smell, sound and movement.

Synapse

A link (connection) between two brain cells (neurons).

Wiring

The organisation of connections and networks in the brain. The brain's 'circuitary'.

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