

Engaging Families in the Early Childhood Development Story

A National Project conducted on behalf of the Ministerial Council for Education, Early Childhood Development and Youth Affairs

Neuroscience and early childhood development:
Summary of selected literature and key messages for parenting



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EXECUTIVE SUMMARY

This paper reports on recent neuroscience research in English-speaking countries into early brain development and the implications of these findings for the development of babies and young children.

The paper consists of a literature search summary and a set of key messages with suggestions for positive parenting to maximise the contribution parents can make to their children's development.

The survey is a component of the MCEECDYA project *Engaging Families in the Early Childhood Development Story*. The purpose of the strategy is to maximise the potential for families to positively support their children's early social, emotional and intellectual development. The value of this paper lies in its demonstration of the growing convergence between current neuroscientific findings and past and present psychological and social observations of babies and young children.

Neuroscience is confirming the following factors as being vital in early childhood development:

- The first five years last a lifetime
- Good nutrition, health, and exercise are critical
- Children are born ready to learn
- The best learning happens in nurturing relationships
- The brain develops through use
- Children's wellbeing is critical to brain development and learning
- Children learn through being engaged and doing
- Children learn from watching and copying
- Children's self control is critical for learning, responsibility and relationships
- Children learn language by listening to it and using it
- Children are born ready to use and learn mathematics.

There is, however, a note of caution in this report. While the neuroscientific data mark great and expanding breakthroughs in our understanding, it is important to remember that neuroscience is one element in the social and psychological environment of developing babies and young children. It provides an indispensable tool, but not the whole answer, for meeting the challenges faced by parents, educators and policy makers in striving for an optimal setting for children's learning and emotional and social development.

The first five years matter and last a lifetime

- Neuroscience (the scientific study of the nervous system) provides compelling evidence that **early experiences impact on brain development**, and can have a long-term effect on wellbeing (this includes physical and mental health, learning and behavior).
- The US National Institute of Child Health and Human Development concluded that **parenting is the primary influence on children's development**.
- The first three years are the period of the most rapid growth during which there are specific sensitive periods for optimal learning in particular areas. A large proportion of human brain development takes place after birth as a result of interactions with the environment – the **impact of early experience has a greater influence on development than heredity**.
- By the time a child is three years old, 90% of their brain has been developed – the **quality of relationships and learning environments** for babies and toddlers is critically important.

- **Early experiences either enhance or diminish innate potential**, laying either a strong or a fragile platform on which all further development and learning of the person, the body and the mind is built. The longer children spend in adverse environments, the more pervasive and resistant to recovery are the effects.
- Very important to expressing the underlying genetic potential of each child and therefore, optimal brain development and function, are **good nutrition** (pre- and post-natal), and **experiences that are repeated, consistent, predictable and nurturing**.
- A **lack of positive relationships**, inadequate supervision of and involvement with children are strongly associated with children's increased risk for behavioural and emotional problems. It is the 'poverty of the parent-child experience... that leads to poor child outcomes rather than poverty of a material kind'.
- Parenting practices such as reading to children, using **complex language**, **responsiveness**, and **warmth** in interactions are all associated with better developmental outcomes.
- The findings of neuroscience should, however, be interpreted with some **caution** – it is easy to simplify or overstate findings, which can result in a sense of determinism and giving up, of having missed the critical period, of having to excessively stimulate or 'hot house' children and burdening parents with guilt.
- The **key message for parents** is to include children in everyday, nurturing life, where they are loved, talked with, played with and are well nourished; where they can socialise and explore and are kept safe from chronically chaotic or abusive environments.
- Neuroscience currently confirms that:
 - the first five years last a lifetime – children's wellbeing, good nutrition, health, and exercise are critical to brain development and learning
 - children are born ready to learn, and the best learning happens in nurturing relationships – children learn language by listening to it and using it – children are born ready to use and learn mathematics
 - children learn through being engaged and doing, watching and copying.

INTRODUCTION

This summary aims to document for policy makers the important information from the neuroscience evidence base about brain development in the early years, so that key messages can be shared with parents to support their children's development. It is a component of the Ministerial Council for Education, Early Childhood Development and Youth Affairs (MCEECDYA) project *Engaging Families in the Early Childhood Development Story*, which is a part of the Council of Australian Governments' National Early Childhood Development Strategy. *Engaging Families in the Early Childhood Development Story* aims to better inform parents, carers and the community about the evidence provided from the neurosciences about the critical importance of factors that impact on early childhood development. It is proposed that this is achieved by:

- framing and communicating key messages about brain development that are universal, consistent and based on evidence
- identifying ways to effectively incorporate these messages into existing and emerging services provided through health, care, education and community service settings.

Engaging Families in the Early Childhood Development Story is also closely aligned with one of the guiding principles of the draft National Quality Standard, *The role of parents and families is respected and supported*.

For the purpose of this report, a number of key words or phrases have been used and are defined in Appendix 1.

The review process

The review of literature for this summary was desk-based and drawn primarily from current, publicly available material. It was a targeted search to gather evidence from neuroscience relevant to the review's purpose and the following questions that the review set out to address:

- 1. What is the impact of brain development upon early childhood development?**
- 2. What are the key messages to be shared with parents and carers?**

The review is not exhaustive. It was selective and undertaken within the context of what neuroscience has to say about early brain development and the implications for early childhood development with a focus on early learning. There are a range of other evidence bases that were not the subject of this review.

Evidence in this review has been mainly drawn from secondary sources of English language empirical studies and reviews, reported in books, journals, reports, conference proceedings and websites, with an emphasis on material published during the last 10 years. Three primary sources of neuroscience findings were particularly important to the two main review questions. These three sources are comprehensive and cited frequently by other authors.

- *Understanding the Brain: the birth of a learning science* (OECD, 2007)
- *From Neurons to Neighbourhoods: the science of early childhood development* (Shonkoff & Phillips, 2000)
- *Early Years Study 2: putting science into action* (McCain, Mustard & Shanker, 2007).

Much of the reviewed literature emanates from the United States, so translating the findings into the Australian context needs careful consideration.

Neuroscience also is revealing much about the correlation between brain development and developmental disorders. It is beyond the scope of this review to address the relationships between neuroscience and developmental disorders.

In reviewing neuroscientific/biological material an interactionist approach was used to understand the importance of the environment and synthesise messages to be shared with parents and carers. In addition, the analysis of material was influenced by a rights-based approach – where children are viewed as active social agents, who must not suffer discrimination, who have a right to survival and development in all aspects of their lives, where their best interests are the primary consideration in all decisions or actions that affect them, who are active participants in all matters affecting their lives and who can be free to express their opinion, and have their views heard and taken seriously (United Nations Convention on the Rights of the Child, 1999).

The increasing amount of evidence from neuroscience gives us the opportunity to support more equitable development and better health and social outcomes – better lives – for individuals, families, community and the next generation.

Neuroscience provides compelling evidence that early experiences impact on brain development and can set long-term effect trajectories for wellbeing (this includes physical and mental health), learning, behaviour and social development. Changing the course of these trajectories takes more resources, more time and is potentially less effective, the longer children spend in unfavourable environments.

The human brain is a 'work in progress', beginning before birth and continuing through the lifespan. However, neuroscientists have found that the first three years are the period of the most rapid growth during which there are specific sensitive periods for optimal learning in particular areas. A large proportion of human brain development takes place after birth as a result of interactions with the environment (Shore, 2001). The brain develops and organises its function in direct response to the pattern, intensity and nature of sensory and perceptual experiences. As a consequence, it is now understood that the impact of early experience has a greater influence on development than heredity (Shore, 2001). By the time a child is three years old, 90% of their brain has been developed (Perry, 2000). The implications of the findings from neuroscience, therefore, place a premium on the quality of relationships and learning environments for babies and toddlers.

Some words of caution

Understandings of brain development through neuroscience have increased exponentially over the last 20 or so years and it is prudent to remember that understandings can change with the rapid expansion of knowledge. Caution is needed when drawing conclusions and promoting key messages.

It is also useful to remember that correlation does not mean causation. Caution is required to ensure that the substantial evidence base of social, psychological, behavioural and health research is not overlooked when focusing on the messages from neuroscience. We need to be vigilant that we don't confuse biology with culture.

A body of Australian and international research has found correlations between poverty and behaviour, concluding that being born into deprived circumstances has negative effects on child outcomes and life chances (see for example Bor, 1997; Mitchell, 2009; Shonkoff & Phillips, 2000; NICHD, 2005). Lexmond & Reeves (2009) clearly point out that it is not poverty *per se* that makes the difference, but family characteristics correlated with income and parenting style (related to warmth/responsiveness, attachment and discipline), confidence and self esteem. Scott (in Lexmond & Reeves, 2009: 36) eloquently summed up this notion in stating *...it seems to be poverty of the parent-child experience... that leads to poor child outcomes rather than poverty of a material kind.*

Shonkoff and Phillips (2000) noted that the 'striking' differences connected with levels of household wealth and status predict how well children develop and succeed. They conclude from hundreds of research studies that non-genetic influences are the main reason for differences among adults and that interventions to help shape children's brain development and function are critical. There is consistent agreement in the neuroscience literature, from a range of investigations, that brains at birth are much the same but can be dramatically different by the age of two.

Parenting consistent with the messages of neuroscience cannot alone compensate for the socioeconomic environments that disadvantage children. We need to proceed with caution when promulgating the messages from neuroscience to parents who are already under-resourced and socially and economically challenged.

The motivation to attend to messages and take action takes strength, energy, will, time, an understanding of their importance and encouragement to engage in family enhancing behaviour. From a social justice perspective, the issue of the quality of early learning experiences is bigger than parent messages and has implications for the positioning of children as a social or a private responsibility – being mindful of the maxim that *it takes a village to raise a child!* One might ask as Fairclough (in Wall, 2004:46) did: Are we constructing social problems as problems for individuals? *Early disadvantage, such as the impact of poverty, ill health and other adversities, can have a significant influence on children's future progress, and are more often than not beyond the control of individual families* (Siraj-Blatchford & Woodhead, 2009:4).

As with any theory, it is wise to interpret the findings of neuroscience with some caution. Neuroscience is in its infancy and is constantly being reviewed, challenged, modified, strengthened, and complemented. In this iterative process new evidence sometimes proves early hypotheses and assumptions invalid.

However, the understandings can be persistent and difficult to dispel. It is also easy to misuse, simplify or overstate findings and translate them over zealously or make questionable interpretations and hence we see the rise of some 'neuromyths'. In the case of neuroscience, this can result in pushing rote learning, a sense of determinism and giving up, having missed the critical period, burdening parents with guilt, diverting funds from older children's programs and the production of expensive programs and products with the aim of accelerating children.

Neuroscience says much about conditions that negatively affect the developing brain with the assumption that more of the opposite will lead to enhanced or accelerated brain development. There is some compelling evidence that impoverished environments inhibit neural development, but there is also a strong theme in the literature that there is little or no evidence that enriched environments enhance it (TLRP, 2007:8; Bruner in Wall, 2004:43), or that unusual types or excessive amounts of stimulation will increase intellectual capacity (Halfon et al., 2001:6).

With the proliferation of writings promoting evidence for neuroscience there has been a commensurate proliferation of 'brain-based' education programs (for example Brain Gym) which too often 'do not survive scientific scrutiny' (TLRP, 2007:15). It has been asserted that *there are no credible scientific data to support claims that specialised videos or particular music recordings... have a positive, measurable impact on developing brain architecture... and ... statements about the superior brain-building impacts of expensive 'educational' toys and videos for infants and toddlers have no scientific support. Similarly, didactic instruction in skill areas that are developmentally inappropriate is an exercise in futility* (NSCDC, 2007b:5).

Blakemore and Frith (2005:32–33) assert that a child, in a 'normal' child oriented environment is unlikely to be deprived of sensory input. Hall (2005:3) has also stated that *any normally stimulating human environment ...will be sufficient for normal human infant development...* Hence, a question that needs further exploring arises: *... Is there a threshold of quality for optimal development?* Blakemore and Frith (2005:32–33) suggest there is a threshold of 'richness' below which a deprived environment could harm a baby's brain development. They also suggest that it might be inaccurate to suggest that extra stimulation (ie, the richer the better) leads to increased synaptic connections. Over-stimulating babies has been found to have the opposite effect (Mitchell, 2009).

Neuroscience gives us a significant evidence base to support the development of policies, resources and optimal environments for children, while being mindful of other evidence bases that recognise the combined responsibilities of family, community and governments to promote the healthy development of all young children.

The key message for parents is to include children in everyday, nurturing life, where they are loved, talked with, played with and are well nourished; where they can socialise and explore and are kept safe from chronically chaotic or abusive environments.

Neuroscience – the early childhood development story

Neuroscience, by definition, is the scientific study of the nervous system, a field that deals with its structure, function, development, genetics, biochemistry, physiology, pharmacology, and pathology. It has many branches including social neuroscience (study of the relationship between biological neural and social processes, Cacioppo et al., 2003:650) and cognitive neuroscience (study of the relationship between biological neural and behavioural processes, Bruer, 2006:106).

Neuroscience, still in its infancy, is one of the many sciences currently contributing to our understanding about the influences on early learning and development and subsequent relationships, behaviours, health, achievements and success in life. While neuroscience is providing more and more evidence about brain architecture and development – which provide the platform for learning and development – cognitive and social scientists and learning theorists are providing greater understanding of the importance of the social context and meaning making to learning. Understandings and findings from psychology are often used to bring the biological, cognitive and social scientific fields together. Focusing on neuroscience reminds us that *all behaviour, from learning and memory to controlling our moods and emotions, is mediated through the brain* (Levitt, 2007:1).

Many of the assertions of neuroscience are deductions made from scientific experiments on animals, from case studies and descriptive studies of children who have suffered from deprivation and/or been institutionalised, and from neuroimaging and electroencephalograms (EEGs) done on adult brains.

The findings strongly suggest that when early life neglect is characterised by a low level of sensory input (for example, relative poverty of words, touch and social interaction) there will be underdevelopment of the brain (Perry 2002:92). It has been demonstrated that the development of the brain and its functions are actually compromised in an environment that is not appropriately stimulating (Bloch, 1991; Kotulak, 1998; Carnegie Task Force, 1994; Willer, 1990; Perry, 2000; Shonkoff & Phillips, 2000; Fancourt, 1999; Shore, 1997). From the studies it has been concluded that the longer children spend in unfavourable environments, the more pervasive and resistant to recovery are the detrimental effects.

While no one science or theory alone can explain the complicated nature of learning and development, new, relevant, hard scientific data collected through brain imaging technology is constantly being published and conceptualisations and understandings are continually being modified, refined and built upon. Many of the neuroscience findings are complementing what many have understood and theorised from experience and observation, over many years.

There has always been debate about whether nature (genetic endowment) or nurture (experience) has the greater influence on children's learning, development and longer term outcomes.

It is now generally accepted that it is the dynamic interaction of nature and nurture that brings about changes in children's brain growth, function and capacities. That is, children's environments and experiences mediate (either enhancing or diminishing) the potential with which children are born. In the past, it was commonly thought that intelligence was 80% genetic and 20% environmental. Current thinking reverses the balance, that is, it is now thought to be 20% genetic and 80% environmental (Westwell, 2009), with genes and experience being interdependent. Shanker (cited in McCain et al., 2007:13) states that *genes are part of fully co-actional developmental systems involving everything from a mother's nutrition and well-being to how caregivers interact with a baby or how a society supports child-rearing.*

Neuroscience has highlighted the fundamental importance of early experiences on the developing brain and the associated risks of poor-quality experiences and environments during the early years, particularly, the first three years. It provides a scientific argument for the nurturing that most parents are able to provide for their young children.

Neuroscience is providing evidence that brain development in the first three years of life is more extensive, more vulnerable to environmental influences and has a longer-term impact than was previously thought. There is evidence that during the first three years of life, children's long-term capacities to trust, to empathise and feel concern for others, to think, understand and construct are being fundamentally shaped. Early experiences either enhance or diminish innate potential, laying either a strong or a fragile platform on which all further development and learning of the person, the body and the mind is built.

While neuroscience cannot provide *all* the answers for optimal early development and later learning and success, a combination of knowledge from the neurosciences, cognitive sciences, social sciences and psychology can provide rich deductions and understandings, and in particular, broaden the understanding that learning is not just about intelligence. Social cognition, emotion and behaviour are also part of brain architecture and function (Cacioppo et al., 2003).

Very important to expressing the underlying genetic potential of each child and therefore, optimal brain development and function, are good nutrition (pre- and post-natal), and experiences that are repeated, consistent, predictable and nurturing (Perry, 2000; Shore, 1997:1). With the new technologies, neuroscientists are able to study the composition, the activity, the chemicals and the response of the brain, and have made conclusions from the evidence that early experiences influence brain architecture, function and capacities by:

- affecting gene expression and neural pathways
- shaping emotion, regulating temperament, coping and social development
- shaping perceptual and cognitive ability
- shaping physical and mental health, activity, performance, skills and behaviour in adult life
- shaping language and literacy capability (Mustard, 2008).

While there are consistent understandings in the literature that brain adaptation and learning is lifelong, there is still a confident assertion that *the child's capacity to learn when she enters school is strongly influenced by the neural wiring that takes place in the early years of life* (Shanker, in McCain et al., 2007:13) ... and that *brain and biological pathways in the prenatal period and in the early years affects physical and mental health in adult life* (McCain et al., 2007:33).

This provides us with a very good reason to attend to the messages about early learning environments but also not to be fatalistic about them.

Engaging parents – the early childhood development story

'Engaging parents' as a notion and a strategy is based on the assumption that parenting matters. This assumption reflects a dynamic systems approach that conceives of development as being located within the relationship between a child and parent. This relationship has been found to show a range of bidirectional and interactive effects between characteristics of the child and parenting behaviour (Zubrick et al., 2008). The evolution of this relationship brings changes in both parent and child over time and those changes are greater than either one could achieve alone.

There is little argument now in the literature that development is shaped for better or worse by relational, social and cultural contexts. Contexts such as temperament, peer group and neighbourhood have been found to mediate or moderate parenting and its effects (Zubrick et al., 2008). The very significant US National Institute of Child Health and Human Development (NICHD) study (cited in Russell, 2008) concluded that parenting is the primary influence on children's development. A major UK longitudinal study, the *Effective provision of pre-school education* (EPPE, now EPPSE 16+), found that for cognitive outcomes, the effect sizes for preschool childcare are only about a half to a third as large as those for parenting (Melhuish et al., 2008).

The strength and quality of the relationship between parents (and close family) and their children is being seen as fundamental to the effective development of children's brain architecture, functions and capacity (Fogel et al., 2009). Specifically, a lack of positive relationships, inadequate supervision of and involvement with children are strongly associated with children's increased risk for behavioural and emotional problems (see for example Shaw et al., 1996; Frick et al., 1992; Patterson et al., 1992 in Oates, 2007). Bradley (2002) too found that parenting practices such as reading to children, using complex language, responsiveness, and warmth in interactions are all associated with better developmental outcomes.

Halfon et al. (2001), quoting from a significant American survey, assert that 46% of parents (57% of fathers) did not understand that the first three years are potentially the most critical and the greatest amount of brain development occurs in this period. The survey also found that lower socio-economic status (SES) was associated with less awareness.

However, there is not agreement in the literature about the effect of SES on parenting skills. A large body of compelling and significant research literature is showing that the development of skills which powerfully predict later success (including literacy, numeracy and character capabilities) are influenced by socio-economic background, (see for example Kagan, in European Commission, 2009:36) and the home learning environment, (see for example Sylva et al., 2004). Melhuish et al., (2008:96), have attempted to explain the links between SES and developmental outcomes, *in that higher SES parents use more developmentally enhancing activities. Stimulating activities may enhance development by helping children with specific skills (e.g., linking letters to sounds), but also, and perhaps most important, by developing the child's ability and motivation concerned with learning generally. Additionally, it is possible that a feedback loop is operating whereby parents are influenced by the child's level of attainment, which would lead to children with higher ability possibly receiving more parental stimulation.* (Melhuish et al., 2008:97).

The National Institute of Child Health and Human Development Early Child Care Research Network (2005), concludes that parenting varies with SES. Lexmond and Reeves (2009) provide evidence that half the gap (measurable from an early age) between children from affluent and poorer households can be explained by home environments and the quality of parenting.

The Longitudinal Study of Australian children (LSAC), specifically designed to examine neighbourhood effects on children (see Sanson et al., 2002), found that children living in the most disadvantaged neighbourhoods have lower social/emotional and learning outcomes than children living in more affluent neighbourhoods even when family income, parents' employment status, mother's education were controlled for in the analyses (Edwards, 2005:41). Sameroff (in Halfon et al., 2001:12) found that it is a combination of risk factors (depressed mothers, mother's low educational attainment, lack of social support) rather than one factor alone, that has negative effects on children's outcomes.

Another body of literature is equivocal about the effect of SES. The EPPE study has found that, rather than SES, it is experiencing a better early years home learning environment (what parents do with children) that is correlated with a significant positive long term impact after controlling for other influences such as parents' qualification levels, family SES and income (Sammons et al., 2008). The EPPE study has also found that mothers' highest qualification levels, the early years home learning environment (measured at age 3–4) and continued support with English as an additional language are the most important background predictors of English and mathematics attainment and self-regulation in Year 6. The study found that the home learning environment is only moderately associated with parents' educational or occupational level and was more strongly associated with children's intellectual and social development than either parental education or occupation. Children whose parents engaged regularly in home learning activities were found to be less likely to be at risk for special educational intervention.

The EPPE researchers strongly conclude that poor mothers with few qualifications can improve their children's progress and give them a better start at school by engaging in activities at home that engage and stretch the child's mind. The EPPE index used to measure the quality of the home learning environment includes activities that parents undertake with preschool children which have a positive effect on their development such as reading with the child, teaching songs and nursery rhymes, painting and drawing, playing with letters and numbers, visiting the library, teaching the alphabet and numbers, taking children on visits and creating regular opportunities for them to play with their friends at home (Sylva et al., 2004).

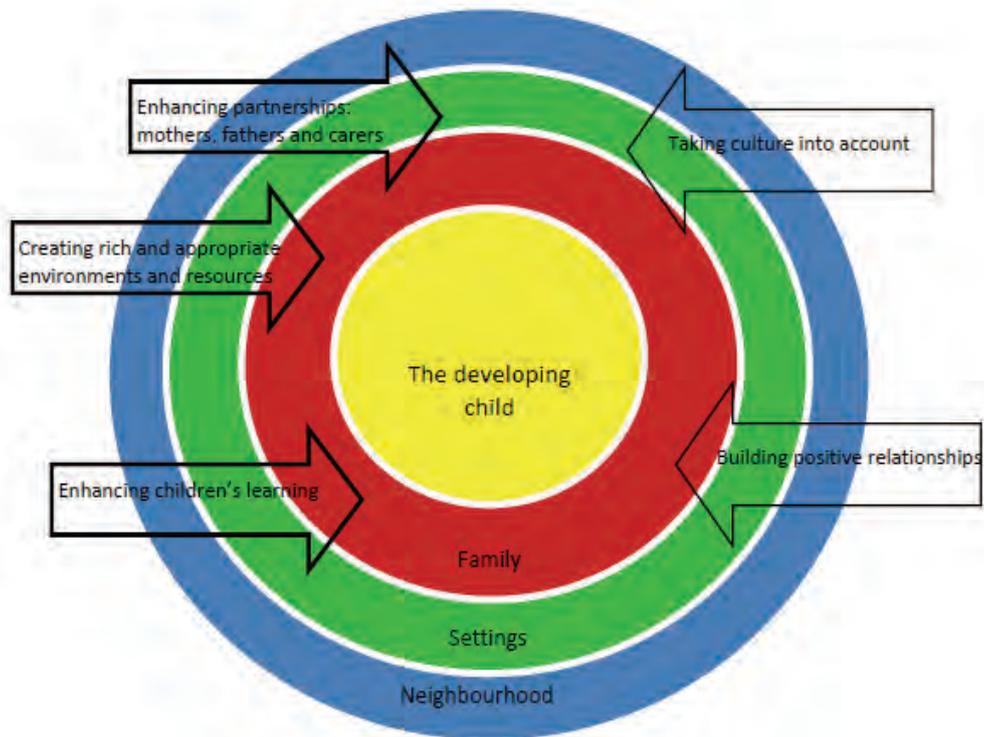
These activities which were all associated with higher intellectual and social/behavioural scores can be correlated with the messages from neuroscience for effective early development.

Two significant Canadian national surveys undertaken in 2002, also found that family practices were not strongly related to SES or family structure. It was found that less than 10% of variance in childhood cognitive and behavioural problems (risk factor predictors) could be explained by SES. The surveys found that positive parenting practices were strong predictors of children's cognitive and behavioural outcomes (Russell, 2008).

It is useful to be cognisant that many of the findings reported above emanate from social and behavioural science research, rather than brain science research.

However, for young children (and their families) who face significant adversity early in life, the *Engaging Families in the Early Childhood Development Story* strategy provides an opportunity to draw on the current, rich evidence base to support and complement parents' strengths and resources for improvement in children's capacities, wellbeing and outcomes and for community health and wellbeing.

The contexts of children's development



Source: University of Oxford, 2009

REVIEW OF THE LITERATURE

The first five years matter and last a lifetime

The development of our brain (neurodevelopment) determines who we become and how we behave. It is dependent upon the presence, pattern, frequency, quality and timing of experiences, good and bad. Although all brains have similar basic structures, the size, organisation and functioning varies and changes over one's lifespan, according to each individual's genes, environment and experience.

Examination of infants' brains shows that they are extremely similar. Adult brains, however, are extremely different (OECD, 2007). It has been found that there is no essential biological difference at birth between a boy brain and a girl brain (OECD, 2007; Westwell, 2009). The brain remains plastic (flexible and able to adapt to and learn from environmental stimuli) throughout life, learning being a lifelong activity (OECD, 2007).

While genes determine some neural connections (a process called 'spontaneous neural activity'), the development of the brain is generally 'use dependent' – a process called 'sensory-driven neural activity' (Halfon et al., 2001:4). Neuroscience is providing unequivocal evidence that the brain physically changes, increasing and strengthening the neural connections through repetitive experience (McCain et al., 2007:19).

However, the relative influence of experience versus genes differs depending on function; for example, breathing, heart rate and temperature regulation are mostly genetically determined and relatively developed at birth, while emotional regulation, social skills and problem solving are modified by experience. Through epigenetics, the study of how genes can be turned on or

off by environmental factors (McCain et al., 2007:29) scientists can explain how experiences and environments determine how a child's genetic potential is expressed (or not).

At birth, babies have approximately the same number of neurons as an adult but approximately 10 times fewer connections (synapses). Brain development related to experience involves the growth of axons (transmitters), dendrites (receptors) and synapses connecting neurons and neural networks. The making of the synapses is called synaptogenesis. This occurs in different parts of the brain at different times, happening rapidly in the first years of life until a child has more synapses than they can use.

All being well, as a result of experience, from birth to age three the number of neural connections multiplies by 20 (Lexmond & Reeves, 2009). A process of 'pruning' selectively eliminates those connections that are not used (Perry, 2002; Bruer, 2006). The process of pruning helps to structure the brain's architecture into organised networks, resulting in every child's brain being unique depending on that child's individual experiences.

Two other important brain development processes occur concurrently – *myelination*, the insulation of the axons by myelin, making their connections more efficient and the transmission of neural signals faster (McCain et al., 2007; Halfon et al., 2001), and the *growth of glial cells* (nerve tissue which provides nourishment, support and insulation for neurons).

Because of the brain's plasticity during the early period of rapid development, the younger the child the more vulnerable is their developing brain to the effects of the environment. Adverse environments can be particularly harmful and have long lasting effects, altering the developmental trajectory of a child's learning (Goswami, 2008).

Good nutrition, health, and exercise are critical

When the brain is relatively immature, it is particularly vulnerable to the adverse environmental impacts on its developing architecture and functions, resulting in permanent impairment with lifelong adverse effects on health (physical and mental), behaviour and learning. Disruption to the pattern, timing or intensity of the genetically or environmentally determined messages the developing brain receives can result in malorganisation and diminished functional capabilities in the specific neural development that has been disrupted, (Perry, 2002). Neuroscience is suggesting that the contribution a healthy pregnancy makes to brain development is as great as the interactions a parent and child have in early childhood (Halfon et al., 2001).

A number of significant studies over the last two decades (see for example Meyers et al., 1989; Wesnes et al., 2003) demonstrate that having good nutrition (including a good breakfast) with adequate intakes of vitamins, minerals and essential fatty acids can improve learning capacity and reduce antisocial behaviour.

The health and nutrition of the pregnant mother influences genes while they are laying the foundation of the brain's structure (Levitt, 2007), including affecting cell migration in the developing brain (Lally, 1998). Before the end of the first year of life, children's developing brains do not have the protective barrier of cells that restrict the entry of toxins from the blood stream into the brain cells, hence, pre- and post-natally, the brain is extremely sensitive to many chemicals (NSCDC, 2006). Doses of toxins that are tolerated with no adverse effects on adults can have devastating effects on developing children (NSCDC, 2006).

Maternal inadequate nutrition and exposure to harmful pollutants and toxins (such as, pesticides, viruses, prescription medication and recreational drugs including nicotine and alcohol) impact significantly on the developing brain, causing brain cells to acquire abnormal properties and make aberrant connections with other brain cells (Levitt, 2003; NSCDC, 2006).

Neuroscientists are beginning to draw positive links between breast feeding and neurodevelopment outcomes, in particular higher scores on intelligent tests (see for example the meta-analyses conducted by Anderson et al., 1999 and Perez-Escamilla, 2005) and on

psychosocial development (see for example Perez-Escamilla 2005), through the milk's bioactive compounds that are crucial for brain development and maintenance and motor development (Vestergaard et al., 1999). However, some of the findings should be treated cautiously as there are many potentially confounding variables (such as SES, maternal education) in the research studies.

A baby's searching for 'the breast' enhances her olfactory (smell) learning, stimulating the serotonin receptor genes which have an organising effect of the development of the brain and later health and behaviour (OECD, 2007).

Some emerging research is beginning to suggest that there is a positive link between exercise, brain development and learning (see for example Hillman et al. and Winter et al., in Howard-Jones, 2008). A study by van Praag et al. (cited in Blakemore & Frith, 2005) found the number of brain cells in the hippocampus (one of the regions of the brain responsible for memory and learning) in rats that exercised was almost double the number in inactive rats and the synapses were more efficient.

Neuroscience is providing evidence that sleep is a period of considerable neurologic and physiologic activity (Zee & Turek, 1999 in Davis et al., 2004), involving higher cortical functions (Horne in OECD, 2007; Dahl, 1998, in Davis et al., 2004). Sleep is believed to play a role in learning and processing of memory, and central nervous system repair (Zee & Turek, 1999 in Davis et al., 2004). During sleep, neurotransmitters maximise consolidation of what has been experienced during wakefulness and memories are consolidated, helping to remember and use the memories to generate new insights when awake. Inadequate sleep quality or quantity can have a negative impact on the ability to pay attention and concentrate (Chervin et al., 2002 and Chervin et al., 1997 in Davis et al., 2004) and cognitive, behavioural, and emotional functioning (Dahl, 1996 and Weissbluth, 1987, in Davis et al., 2004).

Children are born ready to learn

Brain development begins soon after conception, develops sequentially and cumulatively. It is integrated and continues throughout life.

Neural systems are created, organised and changed in response to experience through the lifecycle, beginning soon after conception (Perry, 2002). This helps to explain why different children will master different skills at different ages.

The in-utero period is critical for the development of neuron function and pathways. At birth, the vast majority of neurons used for the remainder of life are present (Perry, 2002:82). Through experience, before and after birth, the neurons specialise and connect to organise into functional systems. Between birth and about age three, children's brains are more malleable than they will be at any other stage in life, and the brains of very young children whose development is already compromised through genetic or environmental circumstances are more vulnerable than those of children growing up in stable, healthy environments (Lexmond & Reeves, 2009). Compromised brain development in the early years increases the chances of later difficulties (NSCDC, 2007a:5).

Different areas of the brain evolve in a predictable sequence (University of Maine Cooperative Extension, nd: 2). Brains develop from bottom up. The lowest part (the brain stem) which controls automatic, regulating functions and responses (such as heart rate, body temperature, fear) develops first. The brain stem must be organised by birth for survival.

This is followed by development of the higher parts – the midbrain, which mediates sensory motor integration, the limbic, where a lot of emotional information is stored, and the prefrontal cortex and neocortex, which control abstract thought and cognitive memory. The neocortex continues to organise into adulthood (Perry, 2000).

Higher level development builds on lower level development. To develop and function well, the higher levels of brain development depend on precise and reliable inputs from lower

levels (Knudsen, 2004). Higher level adaptation is more difficult if lower level has been compromised – ‘skill begets skill’ (Perry, 2000).

The evidence of hierarchical development means that neural circuits that process low-level information will develop before networks that develop more sophisticated and complex information (Shonkoff et al., 2005). This means that children’s interpretation of what they perceive will change with time and experience, from simple to more sophisticated judgements, reasoning and analysis. The impact of any experience is moderated by what brain circuits are forming at the time, with different circuits maturing at different times (NSCDC, 2007b).

Experiences that are in sync with the neurodevelopmental process have greatest impact (Perry, 2000). Hence, for new babies, sensory, social and warm emotional experiences are essential to optimise lower level brain development. As children mature, more sophisticated and diverse experiences are essential to optimise development of higher levels (NSCDC, 2007b).

The higher level of development includes the development of executive functions in the cerebral cortex (regulation of cognitive processes that include the ability to control impulses and self-regulate emotions and physical behaviour, interact socially, direct and sustain attention, hold an idea in your head, plan, map, use memory, recall, flexibly problem solve and reflect). Some recent work by Temple and Posner (cited in Goswami, 2008:6) suggests that developmental differences in task performance could be related to executive functions, such as response organisation, rather than cognitive understanding. This is early and very interesting research that may provide further evidence of the integrated nature of brain development and function and how best to support early childhood development.

Memory is an important part of learning, the processes of it being embedded in the network of interconnecting neurons. Understanding the way memory works is one of the current challenges for neuroscience.

There are two types of memory (short-term or working memory and long-term). Short-term memory is used for temporarily storing and manipulating information, while long-term memory stores information as meaning (OECD, 2007). Through a process of consolidation new information is transferred from short-term memory, organised and restructured and stored as persistent long-term memory and then revisited and added to or altered through additional experience through a process known as reconsolidation (Maxwell et al., 2009:2). This can happen long after the original acquisition of the memory providing the new learning is in the same spatial context as the original learning. If the context is new, a new episodic memory is created (Hupbach et al., 2008).

Emotional context also influences memory. It has been found through neuroimaging that words that are stored in a positive emotional context are remembered better than words stored in a negative emotional context (Erk et al., 2003).

The best learning happens in nurturing relationships

The active ingredient for brain development is the nature of children’s engagement in relationships with nurturing parents and carers in their family and community.

Responsiveness and sensitivity of care of very young children has been found to be a major predictor of effective brain development and social emotional functioning (Shonkoff et al., 2005; Sroufe et al., 2005; NSCDC, 2007a; Perry, 2002). The characteristic way in which a close adult behaves will especially influence the child’s emotional behaviour. This is implicated in establishing the individual patterns of brain development, setting up increasingly common pathways of expectation which lead to the way a child typically responds to the environment (Perry & Pollard, 1997; Kotulak, 1998).

Children will reach out and explore when they feel safe. Their sense of safety comes from a nurturing, predictable, calm environment, where adults are attentive and attuned to children's bids for attention and their basic needs for shelter, warmth, comfort and love are met (Cacioppo & Berntson, 2004).

There is a body of research which shows that young children in loving, caring relationships have a lower stress response than children in less secure relationships (for summaries of this work see McCain et al., 2007; van Ijzendoorn, 2005; Shonkoff & Phillips, 2000; Shore, 1997). Secure attachment plays a pivotal role in the regulation of stress responses in times of distress, anxiety and illness (van Ijzendoorn, 2005).

Children exposed to consistent, predictable nurturing and rich experiences will develop neurobiological capabilities that will increase the child's chance for good, long term health, happiness, productivity and creativity. On the other hand, if early nurturing relationships are absent, it has been asserted that long-term major deficits in neurodevelopment can occur (see for example Perry, 2002; Rutter, in Perry, 2002).

Babies with strong, positive, affective bonds to their caregivers (attachments) have been found to have consistently lower levels of cortisol (a stress hormone) which in elevated levels disrupts brain development and function (University of Maine Cooperative Extension, nd).

If a child experiences persistent chaos and unpredictability the developing neural systems and functional capabilities will reflect the disorganisation (Perry, 2000). Unpredictable environments, and finding ways to adapt to them, cause stress for young children which affects the growth and development of the brain and emotional development (Cacioppo & Berntson, 2004). Children who chronically experience abusive environments develop neural networks needed for survival in adverse situations and are constantly vigilant to negative situations and have well developed abilities to recognise anger and become defensive with less provocation than children nurtured in a safe environment. This may result in the children having difficulties in acting appropriately in play with other children (Levitt, 2003).

The connections between neurobiology and psychology (that is the physical and the emotional development of the brain) are still being explored. However, it is known that one of the best predictors of social and emotional functioning and outcomes for a young child is their attachment to a primary carer (Sroufe in Halfon et al., 2001). The inclination to become attached is innate and universal (Ijzenadoorn et al. in Oates, 2007). Brain imaging research suggests there is a neurological basis to the human ability to establish secure attachments with others (OECD, 2007) and these relationships are a significant part of a nurturing environment (Cacioppo et al., 2003).

It has been found that when first-time mothers look at their infants' faces, the reward areas of their brains are activated (Strathearn et al., 2008). Hormonal changes associated with pregnancy and childbirth prime mothers to respond in this way, but their neurochemical responses to their babies are also shaped by the actual experience of caring for their infants (Kringelbach et al., 2008).

This same process allows biologically based attachment relationships to develop between infants and non-maternal carers including fathers, grandparents, foster parents and child care workers (Sims, 2009).

However, it has been argued that a parent with poor attachment capabilities is rarely able to pass on healthy attachment to his/her child, and this can be exacerbated if the parent is experiencing preoccupying life experiences such as unemployment or domestic violence (Perry, 2000).

Caregiving is thought to function as a regulator of the stress response (Gunnar & Quevedo, 2008; NSCDC, 2005:3), with the caregiver-child relationship seen as a stress buffer. Consistent and responsive attention to young babies helps build the neurobiological capacity to tolerate future stress (Perry, 2000). Attachment to a carer in a secure relationship provides

a sense of safety and elicits particular biological responses to stress and is critical for forming neural connections related to feeling a sense of belonging and confidence in self and developing a sense of the needs and feelings of others (Fancourt, 2000:24), social relatedness, access to autobiographical memory, and the development of self-reflection and narrative (Siegel, in Derrington et al., 1999:9).

Children learn to regulate their own emotional responses to people and experiences by watching and perceiving their carer's responses. A sensitive carer helps a young child regulate their response and, over time, the child begins to self-regulate. Without a secure attachment relationship, a child may experience prolonged periods of unregulated stress resulting in long-term exposure to elevated levels of stress hormones and physical changes in the brain. This may measurably alter developmental trajectories, including emotional development and social cognition (Halfon et al., 2001; Goswami, 2008).

If children's attachments are not secure or are disorganised, the lower-brain responses become dominant and the cognitive regulating structures do not develop to their full capacity, limiting the development of self regulation, social cognition and empathy (Kraemer, in Child Welfare Information Gateway, 2001).

The brain develops through use

The development of the brain is use/experience dependent and use/experience expectant. It relies on sensory bathing.

At birth, most of a person's neurons have been generated, but most are not connected in networks. Brain development is about forming and reinforcing the connections (Shore, 1997). By the age of four years, a child's brain can be 90% adult size. It is an ever-changing biological system, although no part of the brain will change unless it is activated by stimulation from the environment (Perry, 2000). The brain is most sensitive to environmental input while it is developing and therefore variance in experience at an early age has more impact than later in life.

The brain's ability to adapt in response to environmental stimuli, throughout life, is termed plasticity, of which there are two types – use/experience dependent (genetically inclined structural modifications, typical species wide development, such as vision and speech, requiring relevant experience at an optimal, sensitive stage of brain development) and use/experience expectant (structural modifications as a result of exposure to environments throughout life, resulting in individual differences in brain development).

At birth, the brain has developed to the point where environmental cues mediated by the senses play a major role in determining how genes are expressed, that is, how neurones will adapt and function (Perry, 2002; NSCDC, 2007a). Genes determine when specific brain networks are formed, while individual experience (which provides sensory input) shapes what that form is like. Connections that are used repeatedly and often become permanent while those that have little stimulation will not develop. If there is little stimulation, new ones will not develop and therefore learning will not occur.

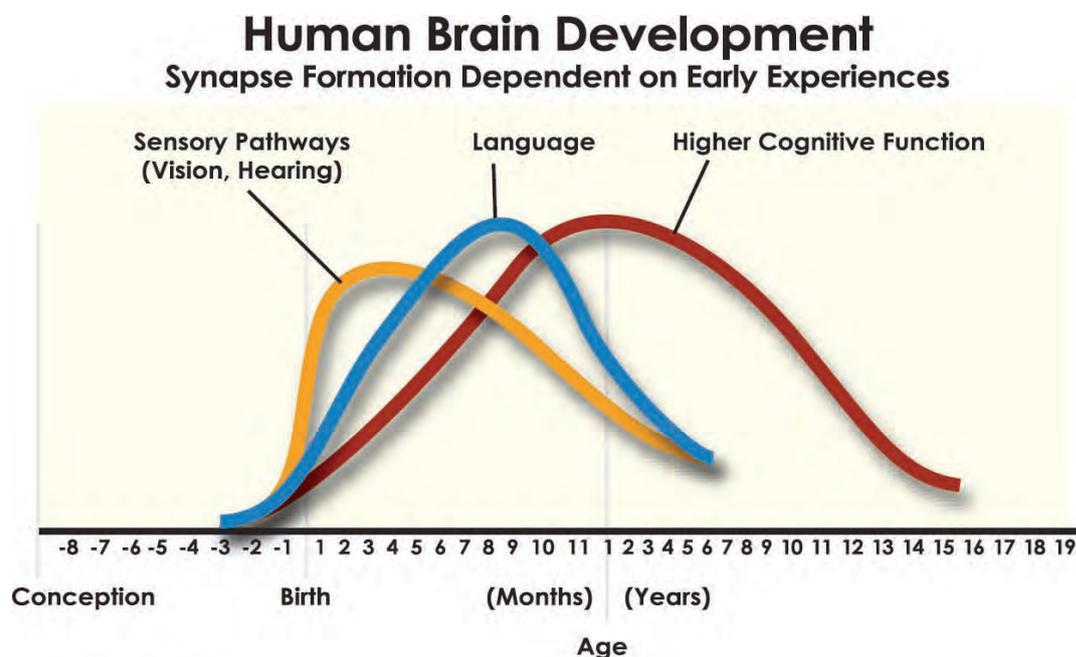
Because different regions of the brain develop, organise and become fully functional at different times, there are periods, especially early in life, where particular experience is more effective to facilitate development in the specific region. Lack of a specific sensory input during developmentally sensitive periods can result in atypical development of the brain systems which sense, perceive, process, interpret and respond to information related to that specific sensory system (Perry, 2000).

A few of these periods have been found to be more time-limited and shorter than others and have sometimes been referred to as 'critical'. These periods are related to some skills and abilities which naturally evolve with sensory stimulation (experience-expectant, sensory-driven neural activity such as vision, hearing, language). Many more developmentally receptive periods (such as for musical abilities) have been found to be sensitive for longer

(experience dependent) (Halfon et al., 2001). These periods have sometimes been referred to as Windows of Opportunity. The development of culturally transmitted knowledge systems is less prone to specifically sensitive periods (Hall, 2005). The corollary of the extremely receptive periods is that, at the same time, the same areas of the developing brain are more vulnerable to adverse experiences, with the risk of altering the function and architecture of the specific neural networks (NSCDC, 2007b).

While many of the so-called 'critical periods' fall within a child's first three or four years, their fixed or rigid nature is now being questioned. Additionally, some neuroscientists are beginning to challenge the term 'critical' as the research that led to the notion involved studies on animals, it related to the sensory system only and the correlation between critical period and maximum learning is an assumption which hasn't been proven (Hall, 2005).

There is always the possibility of some later development, although it may not be as effective (TLRP, 2007), since, with increasing age, there is a decrease in the speed of learning processes and in plasticity (Spitzer in OECD, 2002).



Source: Nelson (2000) in Shonkoff & Phillips (eds), 2000

Sensory stimulation, especially touch, is critical for the development of brain structure and function in very young children. Children's sensory experiences (sight, hearing, touch, taste, smell, and movement) stimulate neural activity that differentiates and creates the complex nerve networks that are key for optimum development in early life (Cynader & Mustard, 1998), (Mustard, 2008). During the first six months of life, touch is critical to mother-baby interaction, (Kaye & Fogel; Tronick in Amelie et al., 2009) and to the baby's communicative skills (Lamb et al.; Stern, in Amelie et al., 2009).

Touch stimulates the limbic hypothalamus pituitary adrenal (LHPA) or allostatic pathway. The pathway acts as a stress, emotion and behaviour 'thermostat' and its development and function affects cognition, emotion and behaviour and health. It is vital for everyday existence (Mustard, 2008:12). Correlations have been made between early life development of the LHPA pathway and later health problems including obesity, memory loss, cardiovascular disease, mental ill health (Mustard, 2008b:14; Gunnar et al., 2009:3). When the infant's/child's

emotional-social senses of body touch, movement and smell are not sufficiently stimulated during the formative periods of brain development, atypical brain development can result in a range of personally and socially challenging behaviours (Perry, 2002; Prescott, 1996).

One of the contemporary, popularly promoted learning theories about different sensory stimulation and individually preferred learning styles (visual, auditory, kinaesthetic) is being challenged by findings of neuroscience (Westwell, 2009a). Geake (2009) asserts that no improvement in learning outcomes has been found from teaching that focuses on different learning styles. Now the understanding is that different types of information will be learned in different areas of the brain and these will be interconnected to form a mental representation. This means that multi sensory stimulation and input will be more effective and should lead to multiple representations which in theory should strengthen learning (Goswami, 2008:7).

Children's wellbeing is critical to brain development and learning

Wellbeing incorporates the integration of physical, social, emotional, cognitive and spiritual aspects of development. Neuroscience is now providing evidence of the interrelatedness of emotion (complex reactions which arise from cerebral processes) and cognition, which provides the platform for wellbeing. Social and emotional capacities are being recognised as equally as important as cognitive capacities as indicators of healthy brain development and as predictors of academic achievement (Halfon et al., 2001:17).

Wellbeing includes good physical health, feelings of happiness, satisfaction and successful social functioning (Mayr & Ulich in Winter, 2003). It is highly complex and the characteristics associated with it, identified by Laevers (1999), have all been recognised by neuroscience as indicators of healthy brain development and function. The characteristics include being at ease, spontaneity, openness to the world, inner rest, vitality, self confidence, in touch with oneself, and the enjoyment of life.

The development of emotion and cognition both rely on the emergence, maturation, connection and change in the complex neural networks in multiple areas of the brain (NSCDC No 2, 2004b; OECD, 2007). This integration of different areas of the brain results in more efficient functioning and strengthens the argument that wellbeing is necessary for learning. Neuroscience is able to demonstrate how the connections between emotions, memory and attention improve problem solving and self control, and how chronic stress can raise chemical levels of stress hormone that interfere with memory, attention and learning (Thompson, 2008).

Other evidence from neuroscience that links wellbeing with learning is the identification of the cognitive characteristics of executive function (discussed above), which very much match the behavioural characteristics of those with sound wellbeing. The neural networks associated with executive function have been found to be highly interactive with those involved with regulation of emotion. Geake (2009) has also illuminated the complex nature of wellbeing and the associated strong connections between emotion and cognition in his discussion on humour and positive feelings (engendered through feedback) and how they enhance learning through the release of endorphins (neurochemicals that contribute to feeling positive and optimistic).

Toxic stress can damage the developing brain. Sensitive and responsive caregiving is a requirement for the healthy neurophysiological, physical and psychological development of a child (NSCDC, 2004a, 2004b, 2008; Richter, 2004; Siegel, 1999). Children who experience abuse and neglect may have lifelong problems with emotional regulation, self concept, social skills and learning. This can lead to decreased academic achievement, early school drop-out, delinquency, drug and alcohol problems and mental health problems (Anda et al., 2006; Perry, 2000). Young children who have been exposed to violence will not necessarily grow up to be violent but they will be at greater risk because of the adverse effects on their early brain development. With early, reliable, nurturing relationships with supportive caregivers, outcomes can still be good for them (NSCDC, 2004b).

Stressful experiences can be beneficial or harmful to the developing brain. The outcome will depend on the body's response, based on past experience and availability of support. Positive, tolerable stress (which includes such time-limited events as a meeting new people, having immunisations, making transitions, serious illness or death of a loved one, a parent separation, a natural disaster, a frightening injury) is part of life and is compatible with normal child development when it occurs in the context of a supportive relationship. It generally results in coping and mastery. However, it has the potential to disrupt brain architecture unless there are supportive, attentive and sensitive adult relationships that facilitate adaptive coping (Shonkoff et al., 2005; Gunnar et al., 2009).

Chronic, extreme, stress (toxic stress) either during foetal or post-natal development has been found to lead to smaller brains (NSCDC, 2005), dysregulation of the stress response system, disruption of neural plasticity and atypical synaptic connectivity, amongst other things (Gunnar et al., 2009). Toxic stress in young children (strong, frequent, overwhelming, prolonged adverse experiences such as extreme deprivation, repeated abuse, neglect, exposure to violence) without supportive adult relationships, can lead to changes in the physical structures and the functioning, including chemical responses, of the brain, impairing cell growth, changing the kinds of proteins and other molecules produced by the brain, death of neurons, interference with the formation of healthy neural networks (Levitt in NSCDC Perspectives, 2006; University of Maine Cooperative Extension, nd; Shonkoff et al., 2005).

Prolonged stress leads to an elevated level of noradrenalin, a hormone that increases arousal and aggression as well as lowering the levels of serotonin (mood regulating hormone that affects learning and memory), which can result in depression and low impulse control (Lally, 1998). These effects of prolonged stress, ie the persistent altered levels of the impulse modulating and stress hormones serotonin, cortisol and noradrenalin, can become a 'typical' process affecting response and behaviour regulation. This state will be characterised by hyper-sensitivity to signs of danger, including hyper-vigilance and a short fuse for the body's stress response and 'alarm' systems which can lead to lifelong problems in learning, behaviour, and both physical and mental health by changing brain chemistry (NSCDC, 2005; Perry & Pollard, 1997; Kotulak, 1998; Shanker in McCain et al., 2007), as well as interfering with attention and memory (Geake, 2009).

Children learn through being engaged and doing

Emotions, learning and memory are closely linked. Children need sound wellbeing, motivation and self esteem to engage in experience and become competent through attention and practice. Attention drives both learning and memory (Rushton et al., 2003:18). Emotions influence a person's capacity to attend, to be involved and to take action, all of which are essential for learning (OECD, 2007:64). Children's motivation and endeavour are underpinned by having a sense of security which develops in nurturing relationships, (NSCDC, 2007a).

On the other hand, if children feel excessively stressed, fearful or anxious, maintaining engagement can be difficult and neural processes are compromised (Erk et al., 2003). It has been found that anxiety produces a cognitive style that facilitates the execution of simple learned routines rather than being engaged in creative or complex innovation and problem solving which leads to deeper learning. When there is no anxiety, the mind is open and able to focus and create new solutions. This has implications for the emotional context of parenting, both for parents' own engagement in their role as parents and for children.

All experience (cognitive, emotional, social, physical) allows the brain to create an internal representation of the external world (Perry, 2000). The development of maps of representations in particular areas of the brain depends on experience. Experience that is repetitive, patterned and consistent will be represented by strong neural connections (Spitzer in OECD, 2002).

Shared attention between a baby and their carer is a fundamental element of early engagement in learning. In nurturing relationships, babies soon begin to follow the gaze of the carer. This is important in helping them engage in worthwhile experiences by attending and putting *their learning energies into matters that the people around them consider important, rather than paying equal attention to both important and unimportant things*. This helps them to reduce confusion and make sense of their world (Mercer, 2009).

Play, more than any other activity, promotes healthy development of children. All learning (emotional, social, motor and cognitive) is accelerated by play. Children's natural curiosity, a neurobiological feature, drives exploratory play. Exploratory play expands children's experience, stimulating neural activity and changes in the neural networks and their sophistication. Play is usually an enjoyable activity and hence encourages engagement and repetition leading to mastery and a sense of accomplishment and confidence. Play engages children's attention, providing challenge, observation and opportunities for practice and success in the development of skills, creative problem solving, concepts and relationships (Perry, 2000). It is likely that 'pretend play' engages many areas of the brain because it involves emotion, cognition including executive functions, language, and sensorimotor actions and hence it is suggested that it promotes the development of dense synaptic connections (Bergen & Coscia in Bergen, 2002).

Children learn from watching and copying

Neuroscientists assert that children learn skills through two main strategies: practice (trial and error) and observation (imitation).

Learning through observation and imitation is made possible by an action observation/execution matching system, or mirror neuron system which is a neurophysiological mechanism (Blakemore, Winston & Frith, 2004; Rizzolatti & Craighero, 2004). A mirror neuron is a neuron which fires both when a person performs an action and when the person observes an action performed by another (Iacoboni et al., 2005). The mirror neuron system is implicated in a range of important cognitive processes including social cognition and interaction, language, art, action understanding, observational learning, theory of mind and empathy (Chong et al., 2008; Oberman et al., 2006; Iacoboni et al., 2005; Rizzolatti & Craighero, 2004).

Neuroscientists have found that repeated observation of actions (either passive or active with the intention to reproduce the action) increases brain activity and can result in experience-dependent changes (Chong et al., 2008). Hence, it is asserted, that it is through the mirror neuron system, that children develop the ability to understand the actions of others, to imitate and to teach others (Blakemore et al., 2005). Because mirror neurons are used to learn and feel from what is observed, they allow learning through imitation, rather than having to use trial and error (Geake, 2009), meaning that demonstrations can be very effective in helping children learn (Chong et al., 2008).

Meltzoff et al. (in Mercer, 2009) state that the ability to imitate is present in the first hours after birth, when a newborn can imitate facial movements like opening the mouth and protruding the tongue, as these are demonstrated by an adult. The ability and tendency to imitate helps young children learn many things by observation, without the need to be instructed. Mercer (2009) asserts that young children become selective in their imitation, stating that they do not imitate everything they see. If a person they are watching makes mistakes or stops before completing an action, toddlers imitate what they think was intended to be done, not what was actually done. By the time children are toddlers, they understand the relationship between observed actions and effects and they benefit from observation of others' actions to organise their own (Fattori et al., 2000). Because children learn through imitation, antisocial models and events (such as portrayed in the media) are also powerful sources of observational learning (Frey & Gerry, 2006; Iacoboni et al., 2005).

The mirror neuron system plays a critical role in social learning (Geake, 2009), an important aspect of which is empathy. Empathy is the capacity to understand the perspectives and actions and be affected by and/or share the emotional state and feelings of another. It is fundamental to interpersonal sensitivity and successful human relationships (Gordon, 2009). Evidence of this is often seen in children's pretend play when acting out family roles. It has been argued that children are born with the capacity to empathise. However, like other learning, they have to experience empathy to establish strong neural networks for it. An early secure attachment relationship between a baby and their primary carer, where there is emotional attunement, provides a baby with experiences to do this (Fattori et al., 2000).

The identification of the mirror neuron system, like much of neuroscience, validates what many have understood through experience, observation and other sciences – that is social aspects of the environment can affect biological functions such as gene expression (Gottlieb, in Goswami, 2008). While an increasing number of researchers agree in the literature about the existence and function of mirror neurons and some consider that they are one of neuroscience's most important, recent findings providing scientific evidence for the theories of social interactionists (such as Bandura and Vygotsky), there is still some speculation and scepticism regarding the claims that mirror neurons explain empathy and theory of mind (see for example Dinstein et al., 2007; Dinstein et al., 2008; Lignau et al., 2009).

Children's self control is critical for learning, responsibility and relationships

Self regulation is the ability to regulate or adapt one's behaviour, emotions and thinking according to the situation. It includes the abilities to start or stop doing something even if one does not want to do so (Maxwell et al., 2009:2). It is the cornerstone of early childhood development. It cuts across all domains of behaviour (Shonkoff, & Phillips, 2000) and is a key feature skill of being an effective learner by either directing or disrupting attention, problem solving and relationships (Cole et al. in OECD, 2007). Self regulation is critical to being able to create and maintain positive relationships (OECD, 2007). It begins to develop with brain architecture and function from a very young age, with long lasting effects on children's life chances (Lexmond & Reeves, 2009).

The research of Shanker (in McCain et al., 2007) shows that learning self-regulation is a primary task of newborns and is only possible in nurturing relationships. By providing appropriate and changing stimulation in response to a baby's states, moods, and interests, parents help the baby manage their level of arousal and build the networks for self regulation (Sroufe et al., 2005).

When a baby is born, the brain is relatively undeveloped with few emotional circuits (fear, rage, love and curiosity) and little or no ability to control them. Control is learned from those with it. In nurturing relationships, a baby's parents or caregivers provide an environment and experiences that build pathways of neural connections through one-on-one stimulus and response. If this process is interrupted, for example by stress, hunger, or the caregiver's inadequate responses, the neural connections may not be strong, which in turn compromises the child's ability to self regulate (Sroufe et al., 2005).

Self regulation is a process of executive function. Executive function processes have consistently been ranked by first years of school teachers as the most critical aspect of 'school readiness' (Bodrova in Zaslow & Martinez-Beck, 2005; Shonkoff & Phillips, 2000) and have been directly linked to academic achievement (Bull et al., 2008) and social and emotional development (Hughes, 1998; Howard-Jones, 2008). It has been found that more than half of children entering school do so without sufficient levels of social-emotional and cognitive self regulation (Bodrova in Zaslow & Martinez-Beck, 2005).

Children learn language by listening to it and using it

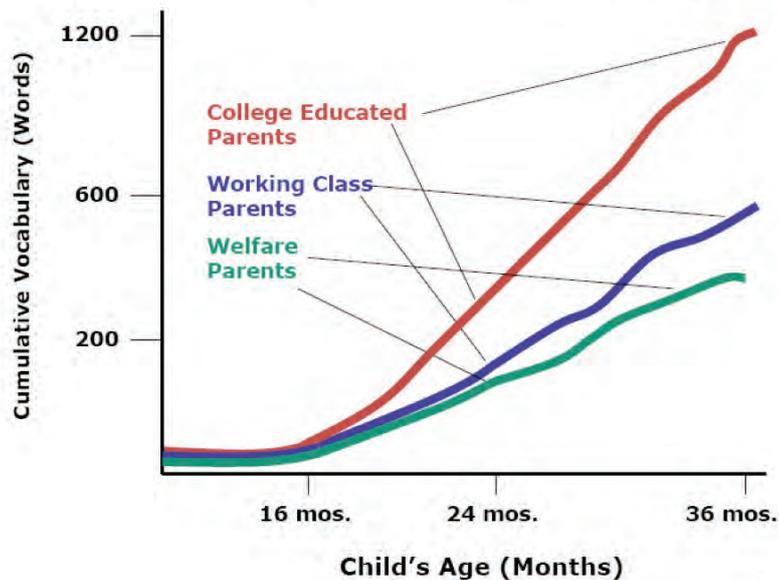
Experience is the catalyst for language acquisition. The brain is biologically primed to acquire language (OECD, 2007). It has been found that the acquisition of speech sounds begins around (or prior to) birth (OECD, 2007) and that babies begin to differentiate between sounds of their home language as early as their fourth month of life (Society for Neuroscience, 2000).

Experience with a particular language in the first 10 months triggers the brain's sensitivity to sounds particular to that language (OECD, 2007). As with other learning, patterned repetitive activity (repeated exposure to language in meaningful contexts) results in patterned neural activity that reinforces pathways and changes the brain (that is, hearing language helps to develop speech and language capabilities), leading to ongoing language learning and automaticity (Westwell, 2009; University of Maine Cooperative Extension, nd). With neuroscience providing evidence that very young children have particularly sensitive periods for learning many aspects of language, it is now thought that second language learning is easier and more effective the younger the age of exposure, as long as the language learning is in an age appropriate context (OECD, 2007:15).

There is strong evidence that reading and talking in early childhood has a significant effect on language skills at later stages of development (Brewin in McCain et al., 2007; Hart & Risley, 2003). Geake (2009:129) asserts that for 95% of infants, it is children's linguistic environment that makes the difference in verbal abilities in their early years. Similarly, Mustard (2008) reports that the extent of children's language exposure in the early years has a significant effect on the verbal skills of children by age three. Hart & Risley (2003) have found huge differences in the vocabulary size of young children related to social class correlated with the quantity of early family language experience (the amount and frequency of interaction between parents and children). These early differences translated into striking disparities in the children's later vocabulary growth rate, vocabulary use, and IQ test scores all of which are critical for success at school and in the workplace. These findings concur with the assertion of Snow (2006) that vocabulary is one of the most robust long term predictors of good literacy development.

Literacy is not language and there is no current evidence that there are specific brain structures for literacy learning. Cumulative neural modifications, through experience, create the capacity for literacy by building neural networks for skills required to be literate (processing of visual and sound input, acquisition of vocabulary, semantic retrieval, phonological processing, grammar). Children deprived of early language experiences, may well have insufficient structures on which to build their literacy (OECD, 2007:86).

Disparities in Early Vocabulary Growth



Source: Hart & Risley (1995)

Children are born ready to use and learn mathematics

As is inferred for literacy development – that *language structures provide scaffolding for literacy to be constructed in the brain* (Vygotsky in OECD, 2007:87), there are similar findings from neuroscience for numeracy. Being numerate depends on a combination of biology and experience and the coordination and building of neural networks to perform numerical functions. Neural networks not specifically destined for mathematics can be shaped by experience, a process called ‘neural recycling’ (Dehaene in OECD, 2007:98).

Hence, being numerate is a result of a combination of genetically specified quantitative structures and experience-dependent biologically compatible structures. There is evidence that babies have a quantitative sense (Ferguson et al., 2004 & Wynn, 1998 in OECD, 2007), can discriminate between numbers with high ratios and perform mathematical operations including approximate calculations (McCrink & Wynn, in OECD, 2007), leading to the conclusion that babies are born with an intuitive inclination to use number to understand their world. The implication of this is that for strong numeracy development we need to keep this disposition alive and expanding.

Neuroscience is providing evidence that mathematical abilities are distributed in different parts of the brain and can be dissociable from other cognitive domains, with the implication that young children who may have deficits or talents in one domain may not have deficits or talents in other domains, so it is important that they are provided with multiple ways to experience and acquire mathematical understandings (OECD, 2007). The research of Dehaene (in OECD, 2007) has led to the suggestion that the functions of number and space are intertwined and young children may have a biological predisposition to associate the two. Therefore concrete experiences combining the two may lead to powerful learning.

Through functional magnetic resonance imaging, it has been found that young children’s fingers have a role in their mathematical development, and rather than seeing using fingers to support calculation as a weakness, it has been identified as a strong predictor of mathematical ability (Noel in Howard-Jones, 2008), providing children with concrete opportunities to be intimately involved with their developing ‘number sense’ (Howard-Jones, 2008). Delazer et al. (in OECD 2007) found that neural pathways underlying drill learning are

less effective than the neural pathways underlying strategy learning and hence, learning by strategy resulted in greater accuracy and transferability than learning by rote. The implications for parents is that children benefit from many and varied experiences that provide opportunities for them to experiment and use mathematical concepts in the context of play and relationships, including counting games and rhymes using fingers.

CONCLUSIONS AND KEY MESSAGES

Certain major themes consistently emerge from the neuroscience literature, the analysis of which in relation to early childhood development has led to the following key messages for policy makers to consider for parenting to support early learning:

- The first five years matter and last a lifetime.
- Good nutrition, health, and exercise are critical.
- Children are born ready to learn.
- The best learning happens in nurturing relationships.
- The brain develops through use.
- Children's wellbeing is critical to brain development and learning.
- Children learn through being engaged and doing.
- Children learn from watching and copying.
- Children's self control is critical for learning, responsibility and relationships.
- Children learn language by listening to it and using it.
- Children are born ready to use and learn mathematics.

Neuroscience is providing compelling evidence that the prior-to-school years are critical to the long-term outcomes for children as the rapidly developing brain is building its architecture and the way it functions, both of which may be difficult to change as they become less flexible with age. However, compromised early learning is not irredeemable.

Nurturing relationships (attachment and consistent warm, loving behavior) have been found to be critical for optimal brain development. Persistent neglectful and negative relationships and environments damage the developing brain with long-term effects.

The strength and quality of the relationship between parents (and close family) and their children is fundamental to the development of children's brain architecture, function and capacity with long term influences on who children are, how they behave and who they become.

Children's brains are changed by experience. Good experiences are required for good brain development and expression of genetic potential. Most of the brain's development after birth is dependent on experience, which needs to be repetitive, consistent and in a context of emotional and social security.

Literacy and numeracy development relies on quality and quantity of early language and mathematics experiences.

KEY MESSAGES FROM NEUROSCIENCE AND THE IMPLICATIONS FOR PARENTING, CARE AND LEARNING

All behaviour is mediated through the brain – our brain determines who we are, and controls what we think, feel and do.

- Children’s brains are changed by experience. Good experiences are required for good brain development.
- Early experiences shape physical and mental health, activity, skills and behaviour in adult life.

KEY MESSAGE FROM NEUROSCIENCE		PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK
The first five years matter and last a lifetime.	<p>The development of our brain determines who we become and how we behave. All babies’ brains are much the same at birth. The presence, pattern, frequency, quality and timing of early childhood experiences, (good and bad) makes them all different and affects our success in life, in relationships, in school and in work.</p>	<p><i>Nurture and comfort and keep safe; communicate and play with your baby and young child; respond calmly, take joy in being a parent, encourage and help your baby and young child find out how the world of people and things work.</i></p> <p><i>Be a good role model, be gentle, establish predictable routines and provide clear guidance about caring for self, others, things and places.</i></p>	<p>BELONGING BEING & BECOMING (Commonwealth of Australia 2009)</p> <p>PRINCIPLE 1 Secure, respectful, reciprocal, relationships</p> <p>PRACTICE 2 Responsiveness to children</p> <p>OUTCOME 1 Children have a strong sense of identity</p> <p>OUTCOME 2 Children are connected with and contribute to their world</p> <p>OUTCOME 4 Children are confident and involved learners</p>
Good nutrition, health, and exercise are critical.		<p><i>Have a healthy life so children can learn from you.</i></p> <p><i>Eat well with your children.</i></p> <p><i>Have a good breakfast and lots of fresh fruit and vegetables.</i></p>	<p>OUTCOME 3.2 Children take increasing responsibility for their own health and physical wellbeing</p>

KEY MESSAGE FROM NEUROSCIENCE	PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK	
	<p>Smoking in pregnancy can lead to aggression in young children.</p>	<p><i>When pregnant, avoid exposure to harmful pollutants and toxins (such as drugs, including nicotine and alcohol).</i></p> <p><i>Avoid exposing children to harmful pollutants and toxins (such as drugs, including nicotine and alcohol).</i></p>	
	<p>Breast feeding is good for brain development.</p>	<p><i>Breast feed for at least the first six months, if you can.</i></p>	
	<p>Exercise is beneficial for learning and health (physical and mental).</p>	<p><i>Be active, give babies daily tummy time and opportunities to roll and rock, reach, grasp; give them rattles, spoons etc.</i></p> <p><i>Be physically active and safeguard children from physical and emotional harm. Provide lots of opportunities to practise physical skills – visit playgrounds, parks, walk rather than take transport. Encourage children to help you with physical tasks like getting dressed, sweeping floors, leaves, hanging out clothes.</i></p> <p><i>Provide older children with safe opportunities to run, play ball games, climb, jump, skip.</i></p>	<p>OUTCOME 3.2 Children take increasing responsibility for their own health and physical wellbeing</p>
	<p>Regular and sufficient sleep is critical to learning. Sleep helps to lay down and consolidate memories so they are more robust and accessible.</p>	<p><i>Establish good sleep routines. Help your baby/child learn to sleep independently. Maintain a regular routine that takes into account your baby or young child's need for sleep.</i></p>	<p>OUTCOME 3.2 Children take increasing responsibility for their own health and physical wellbeing</p>
<p>Children are born ready to learn.</p>	<p>Early experiences matter as the brain is developing rapidly. Early experiences, coupled with genes, shape how the brain grows, learns and functions.</p>	<p><i>From birth provide baby with sensory, social, warm emotional experiences, share gaze, vocalisations, touch. Play games with baby that help establish self regulation (peek a boo, sensory, tactile games, rocking, talking, singing, picture and word books).</i></p>	<p>OUTCOME 4 Children are confident and involved learners</p>

KEY MESSAGE FROM NEUROSCIENCE		PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK
	<p>Learning and development is cumulative. Early experiences lay the foundation for what follows. New, more complex learning builds on previous learning.</p>	<p><i>For toddlers, large and fine sensory-motor experiences – listening and moving to music, movement, walking, running, balancing, climbing, rolling, balls, push/pull toys, books.</i></p> <p><i>For preschoolers, games that strengthen social/emotional development and abstract thought – pretend and role play, group, turn taking, humour, language, drawing, ball games, rhyming and word games, stories.</i></p>	<p>OUTCOME 5.1 Children interact verbally and non-verbally with others for a range of purposes</p> <p>PRACTICE 7 Continuity of learning and transitions</p>
	<p>There are prime times for specific types of learning.</p> <p>Prior to age 3: vision, habitual ways of responding, emotional control, language, and symbols.</p> <p>Prior to age 6: peer social skills, relative quantity.</p> <p>Children become more rational as they develop. When they are very young the way messages are given to children is more important than the content as they are learning what they are like as a person and a learner.</p>	<p><i>Check sight and hearing early so if intervention is required it can be done early.</i></p> <p><i>Establish routines and rituals and rhythms for the day (sequences, rather than timed).</i></p> <p><i>Recall and retell stories and events.</i></p>	
<p>The best learning happens in nurturing relationships</p>	<p>Healthy brain development relies on loving, caring, stable, supportive relationships with important people who respect children. Children’s brains adapt to the environment in which they find themselves.</p>	<p><i>Babies depend on you for comfort in all forms – food, warmth, love, protection, connection. Respond to baby’s cries consistently, warmly.</i></p> <p><i>Be attentive and in tune with your child’s bids for attention and communication; establish predictable daily routines.</i></p>	<p>PRINCIPLE 1 Secure, respectful, reciprocal, relationships</p> <p>PRACTICE 2 Responsiveness to children</p> <p>PRACTICE 5 Learning environments</p>

KEY MESSAGE FROM NEUROSCIENCE		PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK
	<p>Babies with strong, positive, affective bonds to their caregivers (attachments) have been found to learn better and cope better with stressful situations.</p> <p>Children are social beings who learn most effectively in socially sensitive and responsive environments through their interactions with caring adults and other children.</p> <p>Aim for warm and responsive relationships/secure attachments.</p> <p>You can't spoil a baby in their first year. Babies have to learn to trust. They do this by feeling safe, by you being predictable and available when they need you, by you encouraging their curiosity.</p> <p>For toddlers, it's about being available when they want you. As children get older, establish rules that allow children and adults to share their lives together reasonably peacefully. Warm, sensitive interactions are more effective at promoting brain development than a toy, CD, DVD or TV.</p>	<p><i>Special educational equipment (such as flash cards, computer programs) is not needed for babies and young children. You are their best toy.</i></p> <p><i>Play with baby; make sounds, facial expressions and gestures for baby to copy e.g. blow 'raspberries', smile, wave.</i></p> <p><i>Hold, cuddle, caress, affirm, talk, sing, touch your baby.</i></p> <p><i>Maintain a positive emotional relationship with your child – look into their eyes, reflect their smiles, share a cuddle, play in the bath water.</i></p>	<p>OUTCOME 1.1 Children feel safe, secure and supported</p> <p>OUTCOME 1.4 Children learn to interact in relation to others with care, empathy and respect</p>
<p>The brain develops through use.</p>	<p>The brain changes in response to stimulation from the environment.</p>	<p><i>Provide children with companionship and experiences that match their development and their interests – not too easy, not too difficult, lots of</i></p>	<p>PRINCIPLE 3 High expectations and equity</p>

KEY MESSAGE FROM NEUROSCIENCE		PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK
	<p>Babies' brains at birth are similar. It is experience (good and bad) that makes the difference.</p> <p>Good experiences are kind, affectionate, consistent, predictable.</p>	<p><i>encouragement and opportunities to practise as they try and master new skills and learning.</i></p> <p><i>Include children in day-to-day experiences, such as helping maintain the home and family routines, and using what is in the local community to expand language, knowledge and concepts for literacy, numeracy, science, history and social understandings.</i></p> <p><i>Provide lots of safe opportunities and choices to explore and play.</i></p> <p><i>Share point and talk picture books for babies and toddlers; longer story books for preschoolers.</i></p> <p><i>Play memory games.</i></p> <p><i>Ask children open ended questions, what they think...</i></p>	<p>PRINCIPLE 4 Respect for diversity</p> <p>OUTCOME 5.2 Children engage with a range of texts and gain meaning from these texts</p>
	<p>Sensory stimulation is critical, especially touch for very young children.</p>	<p><i>Make sure children have lots of sensory experiences including touch (cuddling, rocking, rolling, lap play, stroking, massage), taste, sound, sight, smell and movement.</i></p>	<p>PRINCIPLE 1 Secure, respectful, reciprocal relationships</p>
<p>Children's wellbeing is critical to brain development and learning.</p>	<p>Social emotional development is connected to and is as important as intellectual development.</p> <p>Grow the heart and mind.</p> <p>All areas of learning and development are connected and depend on each other.</p>	<p><i>Look for the strengths in your child and affirm them.</i></p> <p><i>For very young children touch is very important (e.g., holding, rocking, cuddling).</i></p> <p><i>Make opportunities for children to form relationships with other children and adults.</i></p> <p><i>Say hello and goodbye when picking up and leaving children, practise with children to do the same.</i></p> <p><i>Create experiences for children where they can interact with people and the environment, with lots of talking, listening and responding to each other and</i></p>	<p>PRINCIPLE 1 Secure, respectful, reciprocal relationships</p> <p>PRACTICE 1 Holistic approaches</p> <p>OUTCOME 1.3 Children develop knowledgeable and confident self identities</p> <p>OUTCOME 3 Children have a strong sense of wellbeing</p>

KEY MESSAGE FROM NEUROSCIENCE		PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK
		<p><i>each other's feelings; share family activity that is positive for all.</i></p> <p><i>Talk with your child's carers/teachers and share what you know about your child so it can be included in the plans for your child's learning and development.</i></p> <p><i>Join a group of other parents where you can become part of a network to support each other, share the joys and challenges of parenting and maybe some of the responsibilities.</i></p>	<p>OUTCOME 3.1 Children become strong in their social and emotional wellbeing</p> <p>PRINCIPLE 2 Partnerships</p>
	<p>Chronic stress in a mother during pregnancy can raise her blood levels of chemicals which can harm a baby's developing brain. Adverse environments can be particularly damaging for very young children when their developing brains are very vulnerable. The effects can be long lasting.</p> <p>Chronic, toxic early stress is harmful to brain development. Certain chemicals in the body affect the brain and help or hinder learning.</p> <p>Chronic and/or intense stress (physical / emotional) releases hormones that impair cognitive ability by slowing or disrupting the transfer of information, the laying down of memory and social responses.</p>	<p>LOOK LISTEN LOVE. <i>Be observant, warm and responsive – comfort, soothe, feed, clean and calm baby gently, attentively and timely.</i></p> <p><i>Comfort baby quickly when they are distressed.</i></p> <p><i>Avoid environments where there is antisocial and aggressive behaviour.</i></p> <p><i>Do things together. Prepare meals, walk around the block, to the shops, to care/preschool.</i></p>	<p>OUTCOME 3 Children have a strong sense of wellbeing</p> <p>OUTCOME 3.1 Children become strong in their social and emotional wellbeing</p> <p>PRINCIPLE 1 Secure, respectful, reciprocal relationships</p> <p>PRACTICE 2 Responsiveness to children</p> <p>PRACTICE 5 Learning environments</p> <p>OUTCOME 1.1 Children feel safe, secure and supported</p> <p>OUTCOME 3 Children have a strong sense of wellbeing</p>

KEY MESSAGE FROM NEUROSCIENCE		PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK
	<p>Anxiety destroys curiosity and exploration and can lead to inattention, poor impulse control and lack of resilience.</p> <p>Positive and tolerable stress (which includes time limited events such as a serious illness, injury or death of a loved one, a parent separation, a natural disaster) helps children learn to cope as long as there is a supportive, attentive and sensitive adult relationship.</p> <p>Toxic stress (which includes strong, frequent, overwhelming, prolonged adverse experiences such as extreme poverty, repeated abuse, neglect, exposure to violence without supportive adult relationships) can disrupt brain development and increase aggression.</p>		<p>OUTCOME 3.1 Children become strong in their social and emotional wellbeing</p>
<p>Children learn through being engaged and doing.</p>	<p>Children are active, not passive, learners who acquire knowledge by examining and exploring their environment.</p> <p>Young children learn most effectively when information is embedded in meaningful contexts rather than in artificial contexts that foster rote learning.</p>	<p><i>Join children in chains of communication. Use vocalisations, gestures, expressions, body movements for baby to connect with you and imitate.</i></p> <p><i>Encourage children to choose and direct their own activities.</i></p> <p><i>Make sure children have a balance of quiet and active experiences and choices. Be observant for signs that a child is either not interested or very interested, and is exploring how something works (trial and error), what makes something happen.</i></p>	<p>PRACTICE 3 <i>Learning through play</i></p> <p>PRACTICE 5 Learning environments</p> <p>OUTCOME 4 Children are confident and involved learners</p> <p>OUTCOME 4.1 Children develop dispositions for learning such as curiosity, cooperation, confidence, creativity,</p>

KEY MESSAGE FROM NEUROSCIENCE		PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK
	<p>Babies reach out for attention and social contact through facial expressions, movement patterns, gestures, vocalisations.</p> <p>There is no evidence that excessive stimulation and ‘pushing’ a young child to learn beyond their interest, capabilities and developmental maturity will increase their intellectual capacity.</p>	<p><i>Provide opportunities for children to talk about and represent their ideas, drawing, painting, play, constructions with boxes. Help children stay engaged through asking open questions, giving them choices.</i></p> <p><i>Provide plenty of opportunities for children to explore things by themselves and engage in self-directed play (alone and with others) as alternatives to expensive programs and products promoted to increase intellectual ability.</i></p>	<p>commitment, enthusiasm, persistence, imagination and reflexivity</p> <p>OUTCOME 4.2 Children develop a range of skills and processes such as problem solving, enquiry, experimentation, hypothesising, researching, and investigating</p> <p>OUTCOME 4.4 Children resource their own learning through connecting with people, place, technologies and natural and processed materials</p>
	<p>Play helps children develop the skills they need to do well later. Play mirrors and facilitates the development of the brain.</p> <p>The repetitive nature of play helps shape and builds networks in children’s brains which they will use for other things.</p> <p>Children learn through play that involves them doing things themselves – using and expanding the knowledge they have through trying, working out problems, imagining, pretending and making up, talking and negotiating with others, reasoning and explaining.</p>	<p><i>The best toy is a caring adult who pays attention to a child’s cues, and engages with them, plays with them using words, songs, touch and smiles.</i></p> <p><i>Provide lots of uninterrupted time and space for safe play and materials for different kinds of play (it doesn’t need to be expensive toys and equipment).</i></p> <p><i>Encourage children to explore and experiment how things works, how they go together, what you can do with them using toys, puzzles, materials.</i></p> <p><i>Encourage pretend play with household items such as boxes, clean sand, pots, pans, dress ups.</i></p> <p><i>Enjoy humour and jokes together.</i></p>	<p>PRACTICE 3 Learning through play</p> <p>PRACTICE 5 Learning environments</p> <p>OUTCOME 1.3 Children develop knowledgeable and confident self identities</p>

KEY MESSAGE FROM NEUROSCIENCE		PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK
	There is little evidence that television viewing before age 3 increases later learning. Over-scheduling of educational/structured activities limits children's natural curiosity which drives their learning through their explorations.		OUTCOME 4.2 Children develop a range of skills and processes such as problem solving, enquiry, experimentation, hypothesising, researching, and investigating
Children learn from watching and copying.	Babies are very good at attending to faces. They mimic facial expression from a very early age activating parts of the brain.	<i>Play games and make gestures with children that they can copy like smiling, blowing kisses, waving bye bye, clapping hands.</i> <i>Be a good model. Avoid exposing children to watching antisocial models, actions and events.</i> <i>When children are struggling, show them how to do things.</i>	PRACTICE 4 Intentional teaching
	Empathy, the capacity to understand and be affected by the actions and feelings of others, is learned by watching and experiencing it. It is a very important part of successful human relationships. Young children need experiences of empathy to learn it.	<i>Respond sensitively to your child's bids for attention.</i> <i>Engage in to and fro communication.</i> <i>Talk about feelings, name them, model and include children in concern and care for others.</i> <i>Provide experiences to help express feelings like drawing, painting, music, playing with sand.</i> <i>Talk about pictures and read stories about feelings.</i> <i>Talk about how you understand what is happening and encourage children to share their ideas.</i> <i>Model caring ways to respond to others.</i>	OUTCOME1.4 Children learn to interact in relation to others with care, empathy and respect OUTCOME 2.2 Children respond to diversity with respect OUTCOME 2.3 Children become aware of fairness

KEY MESSAGE FROM NEUROSCIENCE		PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK
<p>Children's self control is critical for learning, responsibility and relationships.</p>	<p>Children learn self control and manage their feelings by modelling the behaviour of their parents and adults around them.</p> <p>The development of executive function (the ability to organise and manage your thinking, emotions and actions) including self regulation and direction is critical to early school success.</p> <p>This includes being able to sustain attention, try new activities with curiosity and enthusiasm, inhibit impulsive behaviour, follow directions, take turns and show concern for others.</p> <p>The more nurturing and responsive a baby's environment is and the more attuned carers are to a young child's needs, the stronger the baby's sense of empathy (concern for others) will become.</p> <p>If children don't learn to regulate use of aggression prior to school, aggressive behaviour can be longstanding.</p>	<p><i>Regulate your own behaviour so children learn from good models.</i></p> <p><i>Be emotionally available.</i></p> <p><i>Allow young children to experience tolerable frustrations and gradually experience some supported delays in gratification.</i></p> <p><i>Establish purposeful routines, directions and boundaries. Play memory and association games, encourage children to make choices, such as having toys accessible to children so they can make choices and be responsible for putting them away.</i></p> <p><i>To help reflection (self appraisal and self monitoring), give children feedback focusing on effort rather than the success of a product. Encourage children to pretend/role play with others. Include children in the planning of family events, excursions, outings, visits, making of shopping lists, mapping journeys.</i></p> <p><i>Model positive social, emotional and cognitive problem solving and encourage children to be cooperative, socially responsible, self regulating. Create opportunities for children to take age appropriate responsibility. Reinforce good self regulation and responsible behaviour.</i></p> <p><i>Play games with children, such as 'Simon Says', which helps children pay attention and improves motor control and control of impulses.</i></p> <p><i>Have reasonable expectations and provide non-harsh, clear, consistent guidance.</i></p> <p><i>Be assertive (not aggressive), and reason with and support rather than punish.</i></p>	<p>PRINCIPLE 1 Secure, respectful, reciprocal relationships</p> <p>OUTCOME1:2 Children develop their emerging autonomy, interdependence, resilience and sense of agency</p> <p>OUTCOME 2.2 Children develop a sense of belonging to groups and communities and an understanding of the reciprocal rights and responsibilities necessary for active community participation</p> <p>OUTCOME 2.4 Children become socially responsible and show respect for the environment</p>

KEY MESSAGE FROM NEUROSCIENCE		PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK
		<p><i>Establish rules such as not hitting/hurting others, no breaking things/destroying things.</i></p> <p><i>Opportunities to negotiate and direct and work with other children can develop self regulation, initiative and understanding of consequences.</i></p> <p><i>Help children understand and express emotions safely.</i></p>	
<p>Children learn language by listening to it and using it.</p>	<p>Early experiences shape language and literacy capability. Babies start learning to differentiate sounds soon after birth.</p> <p>The number of words a young child knows is a very good indicator of later good literacy development.</p> <p>Talking with children increases the number of words they recognise and learn and is essential for language development, setting literacy and language pathways.</p> <p>Oral language is acquired through hearing it and using it. Conversations with children in nurturing relationships provide the cognitive and emotional experience for brain development and function for language.</p> <p>The quality of adult-child relationships determines how children receive cues and information.</p>	<p><i>Make sure babies can hear – treat ear infections promptly.</i></p> <p><i>Extensive talking, listening and positively responding, reading, writing and singing with children, story telling, poetry, drawing, neighbourhood walks, visiting the local library and museums, creating opportunities to play with friends. Sound, letter and word play, language games and songs, visits to the library, making shopping lists.</i></p> <p><i>Talking using a wide vocabulary and listening in different situations to expand communication experiences, e.g., talk about what you are doing, expand what children say, have conversations with children, ask for their ideas, visits to friends, include children in group conversations, help children with information to build their vocabulary and knowledge.</i></p> <p><i>Sit with and talk with your child at mealtimes.</i></p> <p><i>If you speak a second language, use it with your children so they can learn the two languages and be confident users of both from an early age.</i></p> <p><i>Reduce television time, increase times of interaction – eg, family meals, playing games together, visit neighbours, extended family.</i></p>	<p>PRACTICE 4 Intentional teaching</p> <p>OUTCOME 5 Children are effective communicators</p> <p>OUTCOME 5.1 Children interact verbally and non-verbally with others for a range of purposes</p>

KEY MESSAGE FROM NEUROSCIENCE		PARENTING STRATEGIES (These suggested strategies require shaping to engage particular targeted parent groups and communities.)	EARLY YEARS LEARNING FRAMEWORK
	<p>Support home language maintenance as well as the acquisition of standard Australian English.</p>	<p><i>Make photo albums of family activities and look and talk about them.</i></p> <p><i>Keep some favourite books within reach so children can choose to handle them.</i></p> <p><i>Talk about books, create an interest in them. Look where they are and draw attention to them.</i></p> <p><i>Talk about pictures, what's happening in them.</i></p> <p><i>Interact with books, telling a story from pictures, reading, making sounds.</i></p>	<p>PRACTICE 6 Cultural competence</p>
<p>Children are born ready to use and learn maths.</p>	<p>Babies intuitively use number to make sense of their world.</p> <p>Young children learn maths more effectively through trying things, finding out things themselves rather than by rote or drill.</p> <p>Early experiences shape perceptual and cognitive ability.</p> <p>The key to intelligence is the recognition of patterns and relationships.</p>	<p><i>Play together including counting games/rhymes using fingers singing songs and rhymes, play with numbers in everyday activities, play games with counting, guessing, listening to and making music (rhythm and pitch) using body and simple utensils, board games, counting games (e.g., Snakes & Ladders).</i></p> <p><i>Include children in experiences that allow them to explore mathematical concepts – cooking and food preparation/sharing, navigating space on play equipment, jigsaw puzzles and block building, domestic tasks, – clothes sorting, table setting, unpacking/shelving shopping, talking about time, counting steps, board games with numbered squares, etc.</i></p> <p><i>Draw children's attention to and play with pattern making and relationships between objects and ideas.</i></p> <p><i>Play guessing/prediction games, talking about what's happening and ask questions to help children think about what's happening, what might happen and how things happen.</i></p>	<p>PRACTICE 3 Learning through play</p> <p>PRACTICE 4 Intentional teaching</p> <p>OUTCOME 5 Children are effective communicators</p> <p>OUTCOME 5.4 Children begin to understand how symbols and pattern systems work</p>

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APPENDIX 1

Definition of terms

For the purposes of this summary:

- **brain development** refers to the cellular and physiological processes (genetically controlled maturation and the chemical and experiential environments) that generate, shape and reshape the nervous system (which includes the brain), architecture (structure) and function from an embryo and throughout life. Brain development is the result of the complex interaction of nature and nurture, that is, between the unique genetic code an individual inherits and his/her experiences before and after birth.
- **early childhood development** refers to the physiological, psychological and intellectual growth **and learning** of a child from conception to school age. It recognises that changes are a result of genetic and environmental factors and are fundamentally a result of the interaction of the two factors.
- **interactionist approach** is an approach that views development as the result of an interaction between the organism and the environment. It reflects an understanding that learning is located within nested social contexts and constrained by the developing architecture of the brain. Children's social contexts include relationships, culture, resources, environment, nurturing style (University of Oxford, 2009:75). An interactionist approach includes interpreting the behaviour of others as a significant way of understanding that the world is socially constructed.
- **learning** is the adaptation of the brain in response to experience. Changes (creation, strengthening or weakening) occur in the networks of connections (synapses) between neurons as a result of stimuli from the environment. It describes the process of acquiring knowledge, skills attitudes or values resulting in a permanent change in behaviour or understanding (OECD, 2007:41). Learning is strongly mediated by emotion-related processing (chemical and cellular).
- **neuron** is a nerve cell. It has chemical and electrical properties. Neurons receive, decipher, coordinate and transmit information.
- **nurturing relationship** is an engaging relationship between a parent or carer in family or community where the child is cared for with concern, reaches out to the adult and the adult is attentive and attuned to the child's cues and develops a bond with warm, sensitive interactions characterised by mutuality, reciprocity and caring, sensory stimulation. The child is engaged in sustained co-regulated chains of communication with the carer (adapted from Greenspan & Shanker in McCain et al., 2007:48).
- **parent/carer** is used to describe the significant primary caring role of a mother, father, family or community member not necessarily a biological parent for their child.
- **socio-economic status (SES)** is a hierarchical structural concept representing wealth, power and prestige (adapted from McCain et al., 2007:32).
- **synapse** is the junction (connection) between two neurons. A synapse allows nerve impulses to travel from nerve cell to nerve cell using chemical neurotransmitters to transmit electrochemical signals supporting skill development and learning capacity.
- **wellbeing** results from the satisfaction of basic needs – the need for tenderness and affection; security and clarity; social recognition; to feel competent; physical needs and for meaning in life, (adapted from Laevers 1994). It includes happiness and satisfaction, effective social functioning and the dispositions for optimism, openness, curiosity and resilience, (EYLF 2009:46).

APPENDIX 2

Guiding questions for parents, carers and professionals

- What do we understand by learning and development and how do views differ? What other theories of learning and development influence our understandings and practices?
- Do our practices and actions truly reflect what we say we believe?
- What life experiences contribute to our assumptions? Are there things from our past experiences that prevent us from seeing things in a new way? How might we challenge any of our assumptions to bring about new insights?
- In what ways are the above messages and implications relevant for each of our families and groups of children?
- What are parents' perspectives? How can different views be reconciled?
- Who benefits from the dominant view of the world? Whose voices are not represented?
- What other ramifications of neuroscience are there for government, staff and families?

