# THE BRAIN, EARLY DEVELOPMENT AND LEARNING

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Associate Professor Michael Nagel has more than 25 years experience in various forms of education on three continents. Dr Nagel's research and teaching interests extend across a number of areas but he is most interested in human development and the psychology of learning. His PhD research encompassed an international project that looked at the learning experiences of Australian and Canadian teenagers. Before his arrival at USC, Dr Nagel spent time in the USA, researching neurological development in children, with a particular interest in early and adolescent development and areas related to a sexually dimorphic brain. In 2006 his book *Boys-stir-us: Working WITH the hidden nature of boys* was released in Australia, followed in 2008 by *It's a girl thing: Schooling and the developing female brain*.

In 2012 his two newest books were released. *In the beginning: The brain, early development and learning* and *Nurturing a healthy mind: Doing what matters most for your child's developing brain* complement his previous volumes of work but focus on neurological development in children from birth to the age of eight years. They have been written for any person whose professional interests encompass child development, learning and parenting respectively. He is currently working on his next volume of work entitled *In the middle: The adolescent brain, behaviour and learning*, which is to be published by ACER and released in early 2014.

Aside from his teaching and research activity at the university, Dr Nagel has also conducted workshops and seminars for teachers and parents at more than 200 schools in Australia and abroad.

Twice nominated as Australian Lecturer of the Year, Dr Nagel has also won a number of awards for linking theory with the everyday realities of raising and working with children, and he is a feature writer for the *Child* series of magazines, which offer parenting advice to more than 1 million Australian readers.

Dr Nagel is keenly interested in all facets of education and child development but his primary motivation is helping to ensure that schools and 'schooling' are positive and enriching experiences for 21st-century students and teachers alike.

## ABSTRACT

Since the 1990s, advances in technology and scientific research have provided new insights into the neurological development of children. As a result of this work, all aspects of education and child care have been reinvigorated with new understandings of how the brain grows and develops, how this might affect behaviour and learning and ultimately how early experiences may shape who we become as we grow into adulthood. Worryingly, neuroscientific research has also been used to perpetuate a number of neuro-myths focusing on enrichment and building 'better brains'. This presentation focuses on debunking a number of those myths by looking at contemporary research into how the brain matures and develops, how nurture affects nature and the implications of this as we engage with children in various educational contexts.

> *[I]n order to develop normally, a child needs the enduring irrational involvement of one or more adults in care of and in joint activity with that child. In short,* somebody has got to be crazy about that kid. *(Bronfenbrenner 2005, p. 262)*

While it is widely recognised that the path to a nation's future prosperity and security begins with the wellbeing of all children, only recently have we been able to identify the important links between this sense of prosperity in conjunction with experience, environment and brain development. Science tells us that early experiences determine whether a child's developing brain architecture provides a strong or weak foundation for the future of all aspects of learning, behaviour and health and, by association, the foundation for contributions to society in general (Center on the Developing Child, 2007). For decades a range of academic and research disciplines have been aware of the extraordinary development of a child's brain during the first few years of life. Recent advances in neuroscience have helped crystallise earlier findings, bringing new clarity and understanding to parents, educators, policy makers and all those concerned with early childhood brain development. This discussion focuses on unpacking some of the most recent findings regarding the developing brain and the implications of this on raising and educating young minds.

## NEUROSCIENCE AND BRAIN DEVELOPMENT: A CAUTIONARY TALE

The human brain has been a topic of interest and curiosity for countless generations. Some of the earliest known writings about the brain date back to 4000 BC and it is safe to say that interest in the gelatinous mass between our ears has never waned. In the early 1990s, advances in technology made it possible for researchers to literally look at the brain in action and today newer technology is allowing scientists to watch the brain at a cellular level. But, whether it be by accident or through artistic licence, advances in technology and brain science have also seen the rise of a number of 'neuro-myths' related to the brain and early development and, as such, it is important to debunk such myths at the outset of this work.

Perhaps the most prominent myth surrounding early development focuses on the whimsical notion that parents or teachers or both can actively enhance a child's academic prowess through various enrichment activities. This myth was born out of the science that tells us that early experiences help to shape the brain and mind of a child. We now know that the way a brain develops hinges on the complex interplay between the genes a person is born with and the experiences a person has from birth onwards; while it is indeed true that experiences are important, the notion of somehow providing 'enriched' activities to accelerate cognitive capacities is, to date, beyond our nurturing capabilities for a number of reasons (Aamodt & Wang, 2011; Berk, 2006; Diamond & Hopson, 1999; Fox, Levitt & Nelson, 2010; Nagel, 2012).

First, and with regards to experience, the brain actually *expects* some types of experiences to occur and *depends on* others on the road to normal development (Nagel, 2012). For example, in order for a child's visual system to develop properly, the brain expects to have opportunities to see things and this obviously becomes much more readily available when a child leaves the womb. Every time an infant sees something, hears something, smells something, tastes something or feels something, its brain is rapidly building a network of neural complexity that will become a superhighway for learning. The type of stimulation expected by the brain is usually readily available in 'normal' healthy, safe, supportive and loving environments.

Second, and in contrast to the experiences a child's brain expects to have happen, the experiences it depends on are adaptive processes that arise from specific contexts and the unique features of a child's individual environment. In other words, the brain depends on particular experiences to learn how to do things such as reading a book or riding a bicycle and this is where the science of brain development is often misinterpreted or misused under the guise of enrichment. The last couple of decades have seen an expansive market of brain 'enriching' toys and tuition programs purporting to do everything from teaching two-year-olds to read to enhancing one hemisphere over the other to making bilingual babies via language DVDs. It is misleading to think that a child's brain can be systematically improved or that learning can be accelerated by providing excessive levels of stimulation. Indeed, it appears that the brain actually has a neurological timetable that extends from birth through childhood and into adulthood and it is mediated by various structures and processes. In order to understand this some insights into brain development and brain structures are warranted.

## BRAIN DEVELOPMENT: MORE MARATHON THAN SPRINT

The formation of the brain and its architecture is a journey encompassing the first three decades of life. Indeed, even into a person's twenties, the brain is changing and maturing and, while adolescence sees a significant restructuring of the brain, it is in the earliest stages of life that our neural foundations are created. Early brain formation occurs not long after conception when the neural tube closes, neurons generate and the brain begins to take shape (Nagel, 2012; Nelson, de Haan & Thomas, 2006). During this early period of brain development, we have our first glimpse of how 'learning' takes place when neurons speak to each other and form connections through electrochemical impulses called synapses. These connections are influenced by both genetics and the environment and, the more repetitive an experience, the greater the opportunity to permanently hardwire these connections or, simply stated, the more the brain learns (Chugani, 1997, 2004). But it is important to remember that, although synaptic connections are formed in the womb, much of the brain's neural architecture is formed when a child enters the world.

At birth, the hundreds of billions of neurons that humans are born with continue to make synaptic connections via sensory stimulation from the environment ultimately 'wiring' the brain for action. It is significant to emphasise that the experiences an individual has affect the types and amount of synaptic connections that are made. Synaptic connections are created at a rapid rate to the age of three years and the brain actually operates on a 'use it or lose it' principle (Diamond & Hopson, 1999; Healy, 2004; Herschkowitz & Herschkowitz, 2004; Shonkoff & Phillips, 2000). In other words, only those connections and pathways that are activated frequently are retained. Other connections that are not consistently used will be pruned or discarded, most notably through the teenage years, so that the active connections can become stronger and more efficient. This process, in turn, maintains some important considerations in terms of early development and learning.

First, it is important to remember that for children's brains to become highly developed for learning, repeated experiences are essential (Aamodt & Wang, 2011; Howard, 2006). Connections become stronger and more efficient through repeated use. Reading to children every day, for example, helps strengthen essential connections. Connections are also made stronger when children have daily opportunities to develop both large- and small-muscle skills, have the chance to practise developing social skills and interact directly with their environment. This is one of the reasons that 'play' is such an important component across all aspects of early development. It is also vital to incorporate rich language into all of these activities, since exposure to rich language creates the foundation for a child's use and understanding of words, and increases the likelihood of reading success at a later age. Research shows that the richness of a young child's verbal interactions has a dramatic effect on vocabulary and school readiness, with differences correlated to socioeconomic status. A watershed study on the topic found that by the age of three, the observed cumulative vocabulary for children in professional families was 1116 words; for working-class families it was about 740, and for welfare families 525 (Hart & Risley, 1995). Studies such as this remind us that nature and nurture are intimately connected (Fox, Levitt & Nelson, 2010).

Second, and as noted above, while stimulation from the environment is important, other factors play an equally important role. Through early childhood and into adolescence, the development of the brain and mind is significantly influenced by myelin, a fatty material that insulates an important part of the neuron known as the axon (Howard, 2006). Current research identifies that the escalation of myelin occurs in various stages with a substantive increase in this important white substance during adolescence (Giedd et al., 1999; Paus et al., 1999, 2001; Durston et al., 2001; Sowell et al., 2003). Myelin is important because it aids in the transmission of information from one neuron to another and the more 'myelinated' axons in the brain, the greater opportunity for neural information to be passed quickly. The end result of all of this is that certain activities may be easier to learn when regions of the brain are sufficiently myelinated or when or brains become 'fatter' (Berninger & Richards, 2002; Eliot, 2000; Shonkoff & Phillips, 2000). At birth we have few myelinated axons. This is one reason visual acuity and motor coordination are so limited during the first days of life: the neural networks responsible for facilitating vision and movement aren't working fast enough and will become much more efficient when myelin increases. Furthermore, as we grow older, different regions of the brain myelinate at different ages. For example, when Broca's area, the region of the brain responsible for language production, myelinates, children are then able to develop speech and grammar. To that end it is important to remember that a healthy brain knows which areas need to be myelinated first, that myelination cannot happen all at once and that it cannot be accelerated via flashcards, extra tuition or the latest 'learning' toy (Diamond & Hopson, 1999; Herschkowitz & Herschkowitz, 2004; Kotulak, 1996; Nagel, 2012). This is also why any enrichment agenda postulated to enhance learning must be scrutinised carefully.

The road to brain maturation takes time and, by association, so too do a range of developmental and learning capacities. Worryingly, there are those who might suggest, or advocate, that if experience and activity are indeed significant factors in neural development then surely the earlier the stimulation (read 'enrichment') the greater the propensity for learning and early success. But, while we know that input from the environment helps to shape the brain and that experience is important, equally important is the fact that each child is an individual with similar but not identical developmental timelines (Healy, 2004; Hirsch-Pasek & Golinkoff, 2004; Nagel, 2012). Moreover, it is also not possible to accelerate emotional maturation since the emotional region of the brain (limbic system) has its own developmental clock and as such how do we ensure that trying to push children to do things too soon does not ultimately result in engulfing children in undue stress beyond their emotional coping abilities? For some children, trying to do too much too soon can lead to stress-related anxieties that actually turn off thinking processes. It is these types of considerations that should inform any foundation related to how we nurture a child's developing mind. Indeed, for all children, the road to nurturing healthy brain development is not too difficult for parents, teachers and other caregivers to follow. Children do not have to be hyper-stimulated or prepped for university by the time they are five years old. There isn't a magic formula for improving one hemisphere over another and while Mozart is a joy to listen to it will not help children become more mathematically inclined or smarter. What will help healthy brain development in children are regular routines and consistency, opportunities to consolidate learning through repetition, hands-on interactions and activities, novel ways to learn through exploration and experimentation, exposure to rich, interactive language and, most importantly, positive, reliable and supportive relationships or, as noted earlier, adults who are crazy about kids (Bronfenbrenner, 2005; Eliot, 2000; Hirsch-Pasek & Golinkoff, 2004; Nagel, 2012).

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