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WIRING THE BRAIN

The following article is based on a recent presentation by Dr Rowley to the 2011 Family Law Conference

"At least one in five New Zealand children experience significant deprivation that compromise their health, their education, and their future"

stated Dr Claire Dale in a report published in September 2011.

We now understand much about how a child's brain develops and how it is affected by experience in either a positive or negative fashion. This development starts before birth and continues through the teenage years when adolescence adds further complexity to the young person's development.

The following article focuses on some of the neurobiology of infant brain development and some of the more recent advances in our understanding of this topic.

The key to understanding the link between early childhood experience and subsequent behaviour is in the age-old nature versus nurture relationship. There is a complex interplay here that is at the core of human emotional development and behaviour.

Our genes are not a static blueprint; they can actually alter with experience in the sense that they can be 'switched on' or 'switched off'. Nature and nurture operate together to fashion our brains. This process occurs throughout our lifetime but it occurs at a much faster and more intense rate in childhood.

From the first few days of conception our brains begin to form from rudimentary cell tissue. As the foetus develops, in the brain, layer upon layer of nerve cells (or neurons) migrate to their ultimate anatomical positions. They send out their axons to meet each other and become connected enabling communication with each other. The organisation of our brain in this way is primarily genetically determined.

In later foetal life, and particularly from the moment of birth, experiences interact with our genes to 'switch on' our connections. Thousands of new connections occur as we develop synapses in response to the environment we find ourselves in. Each sensory experience modifies and 'sculpts' the thousands of surrounding neurons and in this way our brain becomes 'wired'. This process occurs regardless of the post-natal environment but the subsequent pruning and refining of the pathways is environmentally determined.

All drugs, including alcohol that the mother ingests, will be received by the foetus. Many of these, including alcohol, can have direct harmful effects on the brain. In addition, there may be less obvious but equally important effects on brain connection formation that will cause the behavioural issues such as attention deficit and hyperactivity.

Touch is the first sensory modality to come 'on line' and has been labelled the 'mother of all senses'. Smell, taste, balance, hearing and vision follow in that sequence, and it appears that each sense needs to follow the sequential pattern for complete development. The type, the frequency, the intensity and quality, the order, and the number of experiences will all have an impact. The neurons 'talk' to each other via these connections and our brain becomes wired as axons and dendrites or spider-like projections reach out in all directions within the brain. They send their messages electrically with the help of brain chemicals. Larger distances are covered by the formation of long projections called axons, which can form nerves.

Most nerves are eventually coated with myelin or white matter, which enables very rapid transmission of information. Myelin is particularly vulnerable to certain toxic insults in development especially excess cortisol. In most areas of the brain this process of 'connectivity' or synapse formation and subsequent myelination occurs over the first 2 to 3 years. After this time there is a process of pruning where only the pathways that are being used frequently are retained and the brain becomes a more efficient and less complicated structure in terms of its neural pathways.

Those connections that are not frequently being used are lost. The more mature brain is less sensitive to experience and less likely to change. It becomes harder for new patterns to develop. We are 'hard wired' according to the quality and amount of experience we have in those formative early years.

There are critical and sensitive periods in brain development during which rapid changes take place, and after which it becomes difficult if not impossible to re-capture those developments: learning a musical instrument is a good example of this. Attachment to a consistent care-giver is another. The connections that occur with an attachment relationship need to be made within the first 18 months before the window of opportunity is lost.

With failure of this to occur there are likely to be problems in many areas in later life as the child grows up unable to establish firm trusting relationships with other humans. Lack of early attachment has been shown to correlate with poor social competency, lower teacher ratings of educational competence and other outcomes in teenage years.

The experiences essential for activating neurons and promoting synapse formation need to be the right ones. When a child is nurtured, played with, sung to, cuddled and stimulated positively, he or she will be programmed in a positive fashion. This type of experience sets a child up for life.

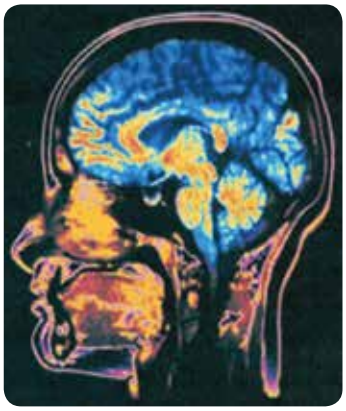
If they are negative, then the hard wiring that takes place retains all the negative connotations including the emotional memory of the experience. This includes a triggering of the physiological and somatic sensations that accompany a negative experience such as a smack or witnessing family violence. Therefore if a child is repeatedly smacked, put down, ignored or abused they may become 'hard wired' for these emotions and after 2 or 3 years it becomes more difficult to change.

Lack of stimulation or neglect i.e. lack of positive input can be equally devastating. The connections will be weak or may never develop.

When negative interactions occur in infancy, the physiological associations that accompany the experience include the release of hormones including adrenaline and cortisol. This has been described as a 'fight or flight' reaction. Unfortunately cortisol, although a crucial hormone in normal amounts, when secreted at inappropriate times and at much higher levels can interfere with the developing brain and there may even be structural changes occurring that are irreversible, along with loss of myelin. The brains of chronically deprived and abused children have been shown to be smaller than normal.

The evidence for the link between early childhood experience and subsequent brain development comes from a number of sources and is still accumulating. Neuro-imaging techniques, animal studies, autopsy findings, and blood analysis of hormones can all support the hypothesis.

Up until now the focus has been on the brain changes occurring in the first few years. Brain development continues at different rates in different areas throughout life. Functional and structural MRI scans are showing us just what the extent of this brain development is, particularly in late childhood and adolescence.



It seems that there is a burst of neuronal activity, with increased connectivity and subsequent pruning of lesser used connections similar to that which occurs in the 1st 3 years, in the pre-frontal cortex, corpus callosum and in other parts of the brain. The pre-frontal cortex is the area of the brain that controls 'executive functioning' or reasoning and judgment.

Prior to 15 or 16 years of age we tend to make decisions based on our emotional ('gut reaction') rather than our rational thinking. This is based in the amygdala where emotional values are processed. Functional MRI scans show that teenagers use this part of the brain when making decisions. From the early teen years there is a transfer of decision making to the prefrontal cortex where decisions are more rational and objective, and consequences are thought through. The prefrontal cortex denotes social behaviour and knowledge and allows us to control impulsive behaviour. At the same time the corpus callosum (the bundle of fibres connecting the two sides of the brain) changes and grows. This allows problem solving and creativity to develop and assist us in planning.

Therefore, throughout adolescence we slowly become more reasoned, and our decision-making reflects the fact that we are using this important part of our brain in everyday life. Impulse control, planning and an understanding of the rules of conduct become incorporated into our thinking. There is a sex differential operating with boys lagging 2 or 3 years behind girls in this developmental process.

The implications of this are huge. Teenagers are not the same as adults in their ability to think rationally or make sound judgments.

The teen brain and the adult brain are therefore both anatomically and physiologically different. The forces that shape this adolescent brain development are unclear. Obviously this is biologically driven as part of puberty, but just how important environmental factors such as nutrition, parenting, education, physical activity, peers, drugs, infections and many other factors are not yet known.

It is likely that at least until our mid 20's these neurobiological changes which are occurring create potential for change and in some cases repair. More research will hopefully show just how we might both enhance cortical development and promote such repair.

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