Neurobiological Markers of Childhood Trauma
Implications for Therapeutic Interventions
The developing brain

The neurologist Paul MacLean identified three prominent phases in the development of the human brain (MacLean 1990). Much of this development occurs in the pre-natal phase. However the key role of the interaction between the brain (nature) and its environment (nurture) – genetic expression - has been well documented through significant research findings.

MacLean identified the “reptilian brain” as the first stage of brain development. The key areas that can be identified in this phase are the brain stem, pons and cerebellum. These structures are linked with key aspects of the survival mechanisms of an organism – like regulating breathing and heart rate. Whilst development of these structures continues and become more refined, a second phase of brain development emerges - the mammalian brain. Structures situated deep in the brain, and sitting on top of the brain stem and below the corpus callosum, develop at a rapid pace. These structures include the thalamus, hypothalamus, amygdala and hippocampus – a cluster that MacLean called the Limbic System. Research indicates that these structures play a vital role in processing sensory information, developing the implicit memory reaction to stress, short term memory and the first line of emotion regulation. Powerful memory systems are developed in the early stages of development (especially the first ten months post birth) through these structures.

Lastly the cortical areas, the neo cortex, or in MacLean’s terminology the “paleomammalian brain” emerges. These areas form the cognitive, emotional and motor powerhouse of neural functioning. Executive reasoning, emotional control and integration of responses are facilitated in these areas.

This information is vital to understand the impact of violation of basic developmental tasks and needs on the developing brain. This information is even more significant to identify effective strategies to manage/ treat victims of childhood trauma (Rossouw 2011a).

Children are born with a fully developed “reptilian” brain. The ability to maintain basic survival function like regulating breathing and heart rate are essential to basic existence. Violation of these abilities may have serious implications to sustain life.

With the survival part of the neural functioning intact, the second “layer” of brain functioning comes into play. At birth, newborns have fully functional limbic structures however the operational ability still needs to develop. Studies of macaque monkeys by Shen and Battersby indicate high risk genetic factors (two short serotonin transporter gene 5HT-alleles) that never express in the group exposed to enriched safe environments. The genetic risk was only expressed in the group exposed to adverse conditions (less safe and poorly enriched environments) (Shen & Battersby 2002).
Violation of basic needs

From birth, limbic structures (especially the amygdal) of newborns constantly scans the environment for cues of risk, discomfort or danger and need to be down-regulated by fulfilment of basic needs – safe environments: demonstrated through secure attachment and control. Fulfilment of these basic needs down-regulates the need for constant scanning of the environment for danger and allows healthy neural development of the neo cortex. Research clearly indicates that neural growth is enhanced through enriched environments. In order to maximise effective neural growth, sprouting and effective neural pruning, key operational needs must be effectively fulfilled.

These needs are:
- The need for secure attachment
- The need for control
- The need for self-esteem enhancement and self-esteem protection and
- The need for pleasure maximization and distress avoidance.

Safe proximity of the primary carer, normally the mother, provides ongoing down-regulation of the stress response and up-regulation of neural sprouting into the neo cortex. This leads to effective myelination and maturation of neural connections in open firing patterns essential for effective neural development. Implicit and explicit memory systems are facilitated that enhance neural proliferation, plasticity and pruning (Grawe 2007, Rudy 2008). A recent study by Luby and colleagues indicated the link between secure attachment and larger hippocampal volumes in children at school age (Luby et.al. 2012). Van der Kolk proposes a new disorder for the Diagnostic and Statistical manual of Mental Disorders (fifth edition) of a Developmental Trauma Disorder – a disorder to be diagnosed in children with complex trauma histories.

Violation of basic needs – excessive emotional discomfort, pain, bullying, and the absence of essential nutrients - has severe consequences on the developing brain.

The stress response

On the neurochemical level increased activation of the HPA system (hypothalamus-pituitary-adrenal system), facilitates significant increases in the production of CRF (corticotrophin release factor), ACTH (adrenocorticotropic hormone) and adrenalin and corticosteroids (among them cortisol) (Wehrenberg and Prinz 2007). Normal stimulation of the HPA system is important as it acts as the first line defence against external triggers of threat to push the body into hyper-alertness (De Bellis 2003).

Rising cortisol levels trigger a feedback loop to the hypothalamus, automatically down-regulating the stress response. However, ongoing exposure to perceived threats over activates the HPA system, leading to increased production of stress hormones. Overproduction of cortisol can lead to a condition called hypercortisolemia – a destructive process that results in the death of glia and neurons, and a related decrease in the volume of neural areas (atrophy). Areas that tend to be affected by this process are

The left prefrontal cortex, orbitofrontal cortex, anterior cingulate, and sections of the limbic system – especially the hippocampus. Excessive cortisol secretion and chronically elevated cortisol levels can lead to a host of related metabolic disturbances and an increased risk for developing a variety of chronic conditions (Carrion et.al. 2002). These conditions include:
- Metabolic effect (cortisol-induced) - chronic health condition
- Increased appetite, accelerated muscle catabolism (breakdown), suppressed fat oxidation, enhanced fat storage - obesity

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Increased cortisol levels are typically found in traumatized children.
Master & Kusumakar 2004). Adult PTSD is closely associated with smaller hippocampal or hippocampal volume loss/atrophy (Sapolski 2000), whereas child trauma does not show this same pattern of atrophy (Carroll et.al. 2001; De Bellis et.al. 2002). This highlights an important neurophysiological difference between adult and child PTSD.

The hippocampus is generally seen as the powerhouse for neural plasticity and neurogenesis (due to the production of the protein brain derived neurotrophic factor (BDNF). It seems that it is this very fact that safeguards the hippocampus from atrophy (for the child at least). However continuing decrease of function increases the hippocampal vulnerability and lowers the resilience to manage ongoing cortisol release. Eventually, as indicated by the adult studies, atrophy does set in. The introduction of chemicals (high fat diets, high refined sugar intake and ETOH – alcohol) decreases BDNF production and neural plasticity and enhances neural rigidity and so these are also contributing factors to increase detrimental neurobiological indicators as result of trauma (Rudy 2008).

The developing brain shows robust resilience to trauma however intensity and duration of exposure to distress are key factors inhibiting effective neural maturation (Sapolski 2000), myelination (Dunlop et.al. 1997), production of BDNF proteins (Rudy 2008), neural pruning (Lander 1988), synaptogenesis (Rudy 2008) and neurogenesis (Sporns 2011).

Myelinated areas of the brain are particularly susceptible to the effects of early exposure to significant levels of stress hormones. Since the early study of Teicher and colleagues (1990), fMRI studies confirmed the inhibition of development of the corpus callosum linked with early childhood trauma. Non-effective development of the corpus callosum has a significant effect on the development of the effective neural connections that regulate mood and cognition (Sporns 2011, De Bellis et.al. 2005). One of the eventual consequences of this process is the inability to cognitively down regulate distress – the result of implicit memory loops.

**Indicators for interventions**

What are the lessons that we learn from neurobiology research in terms of childhood trauma?

- **In terms of prevention:**
  The developing brain is robust and resilient but is also highly susceptible to violations of basic needs. These violations effect the neural development and direction of neural connections and eventually brain structure. Gene expressions happen as a result of ongoing interactions with the environment. Risk factors need to be clearly identified and addressed. Down regulation of limbic alertness (emotional, physical and cognitive) safety is paramount for effective neural sprouting. The concept of controllable congruence - as opposed to uncontrollable incongruence (trauma), should be the guiding principle (Grawe 2007).

- **In terms of intervention:**
  Although there are many theoretical models for childhood intervention, neurobiological evidence show that the overlap between them is much bigger that the differences. The key principles for effective interventions point towards early intervention, limbic down regulation, neurochemical balance and enriched environments to facilitate effective change.

  The brain is a dynamic, plastic entity that continues to grow and change. It has an amazing ability to compensate for areas negatively affected and to heal itself. This “healing” can be functional or dysfunctional. Proper facilitation of enriched environments facilitates effective neural connection, and
The good news is that neurochemical and more importantly neurostructural changes due to trauma are not necessarily permanent.

Activation leading to safe situations of controllable incongruence and deconstruction of emerging unhelpful default neural patterns. The introduction of early intervention decreases the risk of powerful default neural patterns and can facilitate lasting changes in a shorter time with less risk of returning to default patterns (relapse).

Limbic down-regulation is paramount. The establishment of a secure therapeutic relationship down-regulates the limbic alertness and stress response, and enhances neural activation to frontal cortical structures. This is essential to facilitate neural change. Without a safe, supportive therapeutic relationship any changes that are facilitated will be solely cosmetic.

Neurochemical balance is needed to enhance neural change. Chemicals introduced to the system play a significant role in helpful or unhelpful neural activity. High intake of caffeine, alcohol, tobacco, sweeteners, and high fat diets affect production of key neurotransmitters, elevate blood sugar levels, inhibit neural plasticity and neurogenesis. Healthy intake of chemicals enhances therapeutic interventions.

Sleep and exercise play a vital role in mental health and even more so in recovery. Without effective hippocampal discharge (quality sleep) and regular cortisol burning (exercise), the brain is at risk of strengthening unhelpful neural patterns rather than developing open neural activation patterns as well as becoming more rigid due to the negative effect on synaptic connections and neural strength (Lambert & Kinsley 2011).

Healing trauma

The good news is that neurochemical and more importantly neurostructural changes due to trauma are not necessarily permanent. Many neuro-imaging studies indicate effective neural changes due to psychotherapeutic interventions. Nobel laureate in Medicine, Eric Kandel refers to the effectiveness of talking therapies, to facilitate neurostructural change as the remarkable scientific revolution that is transforming the way mental health services are provided (Kandel 1998, 2006, Davidson & Begley 2012). This remarkable scientific revolution is indeed happening, and clear neurobiological evidence demonstrates the power of talking in-
Interventions to facilitate effective changes in the brains of traumatized children (Rossouw 2011b, Siegel 2010, Siegel & Branson 2011, and Murphy & Mathews 2010).

**Literature**


Dr Pieter Rossouw specialises in Neuropsychotherapy in Australia and is an expert in anxiety and mood disorders. He has published five scientific books and over twenty scientific articles. He has been involved in research in extensive clinical trials and presented research papers at thirty international conferences worldwide. He is on the Advisory Board of The Neuropsychotherapist.
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Pieter is the Director of the Master of Counselling Program at the School of Psychology and the School of Social Work and Human Services at The University of Queensland, Australia. His research and teaching focuses on Neuropsychotherapy. Pieter is also the Director of Mediros – a company that provides training in Neurobiology and Neuropsychotherapy.

Pieter has established a distinguished career as Clinical Psychologist, Lecturer, Clinical Consultant and Supervisor. He has been in Private Practice for the past 25 years. Pieter holds Honours Degrees in Philosophy and Psychology, a Master Degree in Clinical Psychology and a PhD. Pieter is a member of the Australian Psychological Society and the APS College of Clinical Psychologists. He provides Mental Health training for GP’s and is accredited at the Royal Australian College of General Practitioners. In this role he developed and facilitated a Clinical Audit for General Practitioners (30 PD point activity) with over 600 GP’s Nationwide involved in the training.

Before relocating to Australia, Pieter was a Professor in Clinical Psychology for 11 years. He was a guest lecturer at Universities in Canada, Holland and South Africa where he also spearheaded a Psycho-Therapeutic Assistance Program to support people being exposed to trauma. In Sydney he worked as Senior Clinical Psychologist at the Northern Beaches Adolescent Service – Department of Health, he was the Clinical Director of the St John of God Psychiatric Hospitals – both Richmond and Burwood Hospitals as well as worked in Private Practice. He provided clinical supervision to many Masters and PhD students as Clinical Associate of the Universities of Sydney, New South Wales, Western Sydney, Macquarie, Wollongong and Newcastle. Currently he is involved in full time research in the fields of neurobiology and neuropsychotherapy as well as clinical training for clinicians, psychologists and general practitioners.

Pieter specialises in neuropsychotherapy and is an expert in anxiety and mood disorders. He has published 5 Scientific Books and 20 scientific articles. He has been involved in research in extensive clinical trials and presented research papers at 30 International Conferences worldwide.

He is a member of the Global Association for Interpersonal Neurobiology Studies, the International Society for Traumatic Stress Studies, the International Association for Family Therapy and the Professional Association for Drug and Alcohol Workers. He also facilitates a Global Neuropsychotherapeutic Interest Group through its e-Journal (Neuropsychotherapy in Australia) and local specialist research and discussion groups. Currently it has over 2500 active members – comprising of clinicians and academics in the field of neuroscience.

Pieter developed three 2-day APS, specialist endorsed workshops – The Brain and Anxiety: Utilizing Neurobiological Information as Psychotherapeutic Tool; The Neuroscience of Depression: New Opportunities for Effective Treatment; and The Developing Brain and the Neuroscience of Memory and Trauma. He also runs neuropsychotherapy applied skills classes.

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Go to www.mediros.com.au for information on Australian Neuropsychotherapy Workshops
The Developing Brain and the Neuroscience of Memory & Trauma
*Implications for effective skills based interventions*

The psychological and neurobiological effects of trauma have significant implications for well being. Theoretical and treatment modalities for trauma have been the focus of study for many researchers. Recent discoveries in neurobiology have changed the landscape of theory and treatment of Psychological Trauma. These discoveries assisted with our understanding of neural processes, memory and neural communication. Clarity about these concepts assists clinicians towards more effective interventions with clients suffering from the aftermath of trauma.

The Brain and Anxiety
*Utilizing neurobiological information as a psychotherapeutic tool*

Anxiety is a prevalent problem among Australians. Over one quarter of adults suffer from anxiety in any given year. The last decade of brain research made possible by fascinating advances in brain imaging and neurobiological data has moved the understanding of anxiety disorders into a new dimension. Although we can successfully treat clients without knowing the full implication of research, we can be more effective with more people in less time if we have a grasp of the neurobiology and why and how our treatment methods change brain function.

The Neuroscience of Depression
*New opportunities for effective treatment*

Depression is a common disorder without geographic, educational, socioeconomic, or racial boundaries. Recent advances in neuroscience provided new dimensions to the understanding and treatment of depression. Discoveries in the association of depression with neural plasticity and neurogenesis as well as insight in the role of talking therapies to change neural functioning as well as neural structure opened fascinating new perspectives and treatment options.

Neuropsychotherapy for Anxiety
*Applied strategies for treatment*

These workshops look at recent advances and research into anxiety and depression and the implications for therapeutic interventions.