THE IMPACT OF CHILDHOOD TRAUMA ON BRAIN DEVELOPMENT:

A LITERATURE REVIEW AND SUPPORTING HANDOUTS

Samantha Kirouac, M.C. (Master of Counselling)[1]
Calgary, Alberta
samkirouac@shaw.ca

Dawn Lorraine McBride, Ph.D.
University of Lethbridge
dawn.mcbride@uleth.ca
Faculty of Education: Counsellor Education
44010 University Drive
Lethbridge, Alberta T1K 3M4

April 16, 2009

[1] **Note:** This manuscript was based on a comprehensive graduate project originally submitted to the School of Graduate Studies, Faculty of Counselling, Athabasca University, Canada on April 16, 2009 in partial fulfillment of the requirements for the degree of Master of Counselling.

ABSTRACT

This project provides a comprehensive overview of the research literature on the brain and how trauma impacts brain development, structures, and functioning. A basic exploration of childhood trauma is outlined in this project, as it is essential in making associations and connections to brain development. Childhood trauma is processed in the brain; it is responsible for our emotional, cognitive, behavioral, social, and physiological functioning. Understanding how the brain develops, including basic brain structures and functions, as well as how trauma impacts these areas provides the means to better understanding the traumatized child. This project is a comprehensive literature review focusing on the brain and the impact of traumatic experiences on brain development and function. It also includes supportive handouts, which can be used by professionals.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Overview

Unfortunately, children in our society experience and are exposed to trauma, which has an enduring effect on the brain, especially when it occurs during childhood. Maltreatment of children can take on numerous forms, all of which influence how the child's brain develops and the function of specific brain structures. The intended audience of this project is professionals with a minimal understanding of the brain who work with children. The goal is to provide an introduction to brain development, the brain's structures and their function, the effect of trauma on the brain and the brain's response to trauma. The project includes quick reference handouts that outline key points taken from the literature review.

Rationale

Inflicting serious emotional trauma on children is a common occurrence in our society (Lubit, Rovine, Defrancisci, & Eth, 2003). Only in the last 30 years have the long-term adverse consequences of childhood trauma been researched (Teicher, Anderson, Navalta, & Kim, 2003). Prior to this a majority of the research explored traumatic experiences in adulthood (Falasca & Caulfield, 1999). This indicates that it was commonly believed that young children were not affected by trauma, either because they are born resilient, do not verbalize and/or do not remember the experience (Osofsky, 2004). However, research has since found that childhood trauma has a significant impact on the emotional, behavioural, cognitive, social and physical function of children (Perry, Pollard, Blakley, Baker & Vigilante, 1995). An understanding of brain development and how trauma can negatively impact it is important for providing a sensitive and effective approach when working with traumatized children (Osofsky).

As a student in the Masters of Counselling (MC) program, I became conscious of how few of my peers were aware of brain development. In the MC program, brain development is not a formal area of study. The brain may be addressed briefly in some academic courses, however it is the responsibility of the student to pursue a more comprehensive exploration. How trauma impacts the brain and the connection between brain development and therapy has not been clearly addressed in the MC program; therefore, this may result in this topic not being perceived as valuable information. Graduate counsellor training programs have not adequately addressed the impact of trauma on childhood development, leaving many therapists ill equipped for trauma work (Lonergan, O'Halloran & Crane, 2004). This project will not only provide a clearer understanding of trauma, but will also have implications for counsellors providing treatment to children or adults who have experienced trauma.

Without a basic understanding of the impact of trauma on the child's brain, the therapist may misinterpret, misdiagnose and/or inaccurately assess the client, which can lead to inappropriate treatment. For instance, instead of listening to the therapist, a traumatized child may be fixated on his or her own safety, which could lead the therapist to believe the child is resisting therapy. This may result in the therapist challenging the child, leading to the child being re-traumatized.

This project provides a concise beginner-level exploration of childhood trauma, brain development, brain structures and functions and the brain's response to traumatic experiences. Also included is a handout package (Appendix A) that can be provided to therapists, school staff, parents and clients as a means of educating them on the effect of trauma on the brain and increasing understanding of the traumatized child.

Structure of Project

Chapter 2 consists of the methodology for the project's literature review and databases and key terms used to locate relevant research are listed. Chapters 3, 4, and 5 consist of the literature review on childhood trauma, brain development and the brain's response to trauma, respectively. These three chapters detail an introduction to brain development and trauma and are considered to be my project. Chapter 6 includes the discussion, limitations of the project and possible areas for future research. The Appendix includes the applied element of this project and the supportive handout package that accompanies the literature review. The handouts provide the reader with a summary of key points made through chapters 3 to 5.

CHAPTER 2: METHOD

This chapter consists of the method used to complete this project. It details the sources used for the literature review, how the sources were located, range of years sources were reviewed, and key terms used.

No interviews were conducted in researching this project; research methods were limited to available library research and adherence to the Canadian Code of Ethics for Psychologist (CCE; Sinclair & Pettifor, 2001). The literature review is based in large part on journal articles and supplemented by additional sources from relevant books. The journal articles were found through a series of literature searches. Electronic databases that were used to find relevant journals included Academic Search Complete, Cambridge Journals Online, Proquest Science Journals, Psychology and Behavioral Sciences Collection, Science Direct, Psychology: A SAGE full-text Collection, and PsycInfo.

Only literature from 1995 to 2008 was reviewed. The following key terms were used to search pertinent literature: brain structure and trauma, stress response system, emotional trauma and children, trauma and brain development, maltreatment and development, childhood trauma, childhood maltreatment, physiology and trauma, neglect and children, neurobiology and trauma, and developmental neurobiology.

The applied aspect of this project is the handout package that details key concepts taken from the literature review. These handouts are presented in a user-friendly, creative manner and supplemented with figures and tables.

My project details brain development and the impact trauma has on its structures and functioning. To understand the impact trauma has on the brain, it is necessary to discuss trauma. The following chapter provides a brief summary of childhood trauma.

CHAPTER 3: A BRIEF OVERVIEW OF CHILDHOOD TRAUMA

Childhood Trauma

The focus of this project is not trauma, but the brain. However, it is necessary to outline some basic assumptions surrounding trauma in order to make appropriate associations and connections in the chapter on brain development and the impact of trauma. This chapter will briefly detail the definition of childhood trauma, its two subtypes, forms of maltreatment and factors influencing a child's response to trauma.

Definition of Childhood Trauma

Childhood trauma (maltreatment or abuse during childhood) can be a repeating event, a sudden single event or a pattern of interaction between the abuser and the child (Glaser, 2000). Two conditions contribute to an event being traumatic: the presence of an actual or feared threat of serious physical and/or emotional injury or death and specific meaning of the event for the child (Dripchak, 2007; Mulvihill, 2005). Traumatic events share certain common elements, however the degree to which these are present varies and different forms of maltreatment can often coexist (Cohen, Berliner & Mannario, 2000). In 2003, authorities in Canada conducted maltreatment investigations involving 235,315 children; 49 per cent of these investigations found evidence of child maltreatment (Jack, Munn, Cheng, & Macmillan, 2006).

Type I and Type II Trauma

It is important for those working with children to understand the nature and type of trauma the patient has experienced, because this will affect the course of treatment pursued. Trauma can be classified into two sub-categories, which are used to diagnose both children and adults. Type I, or event trauma, involves a single event that is sudden, unexpected, and

stressful (Ogawa, 2004). Examples of type I trauma include school shootings, natural disasters, transportation accidents and/or fires. Type II, or process trauma, involves exposure to ongoing and unrelenting stressors that are viewed with fearful anticipation (Dripchak, 2007; Shaw, 2000). Examples of type II trauma include war, repeated acts of physical, sexual and/or emotional abuse, or living with violence in the home or surrounding environment.

Forms of Child Maltreatment

There are four commonly accepted forms of child maltreatment: physical abuse, sexual abuse, emotional harm, and neglect (Wolfe & Yuan, 2001). In Alberta, exposure to family violence has recently been recognized as a fifth form of childhood maltreatment (Jack et al., 2006). The following section provides definitions for all five forms of maltreatment. The Appendix (handout package) includes a definition of the forms of maltreatment.

Physical abuse. Physical abuse is the purposeful use of unreasonable force to any part of the child's body (Wolfe & Yuan, 2001). The abuse can result from a single or repeated incident(s). According to Jack et al. (2006), physical abuse includes shaking, choking, biting, kicking, burning, pushing, grabbing, strangling, suffocating, stabbing, poisoning, shooting and/or any other harmful use of excessive force or restraint.

Sexual abuse. Any sexual experience involving a child and an adult or adolescent is considered abusive (Wolfe & Yuan, 2001). Sexual abuse, as described by Jack et al. (2006) includes attempted and real fondling of a child's genitals, intercourse, incest, sex talk, voyeurism, sodomy and sexual exploitation.

Emotional harm. This category involves actions by an adult that harm a child psychologically, emotionally and/or spiritually (Jack et al., 2006). It also involves an attack on a child's sense of self-worth. Emotional harm can include verbal threats, demeaning or

insulting behaviour(s), forcing a child into social isolation, exploitation and terrorizing or constantly making unrealistic demands of a child (Jack et al.).

Exposure to family violence. This category refers to violence that occurs in the home between parental figures, caregivers and/or other members of the family (Jack et al., 2006). This includes a child seeing, hearing or being exposed to signs of violence such as bruises, other physical injuries or overhearing violent events (Jack et al.).

Neglect. Neglect is the most common form of child maltreatment in Canada (Jack et al., 2006) and can take numerous forms, making it difficult to study. A general definition of neglect involves a failure by a parent or caregiver to provide for the basic physical and/or psychological needs of the child (Jack et al.; Perry, Colwell, & Schick, 2002). Research suggests that extreme neglect is the most pervasive and persistent form of trauma with regard to long-term implications for brain development (Perry et al.; Ziegler, 2002). The concern, according to Ziegler, is not only how the brain reacts during neglect but also what the brain is not doing while it is in survival mode. Ziegler believes that while a child is experiencing neglect, his or her brain does not engage in essential exploration needed for fundamental learning.

The main categories of neglect include physical neglect, emotional neglect, educational neglect and medical neglect. Table 1 provides a list of the four categories and a brief definition of each.

Table 1

Main Categories of Neglect

Categories	Definitions and/or Examples
Physical neglect	Child abandonment, lack of supervision or failure to provide for the child's safety, as well as his or her basic needs.
Emotional neglect	Allowing the child to engage in substance abuse, refusal of or delays in psychological care, inadequate attention to the child's needs for affection, emotional support and/or attention. It can also include exposing a child to domestic violence. Severe emotional neglect of infants can lead to failure to grow and thrive and can also lead to infant death.
Educational neglect	Allowing a child to engage in chronic truancy, failure to enroll a child in mandatory schooling and/or ignoring the child's special needs in school.
Medical neglect	Not providing appropriate necessary medical or mental health treatment when financially able to do so.

Factors Influencing Trauma

There are several factors that influence a child's response to trauma and whether the trauma occurred within or outside the family unit as well as the relationship or closeness

between the child and the person involved affect how the trauma impacts the child (Dripchak, 2007). For example, a parent intentionally traumatizing a child will have a greater impact than overhearing a violent argument between the parents of an acquaintance. Mulvihill (2005) suggests this might be because the child is traumatized not only by the violation of trust, but the child's ongoing relationship with his or her parent also acts as a trigger to re-experience the trauma and engage the fear response.

Research also suggests that the victim's developmental age, cognitive development, temperament and personality characteristics also influence the child's response to trauma (Weitzman, 2005). Other factors impacting a child's response to trauma include the traumatic event itself, prior history of trauma, the child's support system, whether the child was the recipient of or a witness to the event, and the child's intelligence (Falasca & Caulfield, 1999; Lubit, Rovine, Defrancisci & Eth, 2003). Dripchak (2007) also includes the child's sense of mastery in his or her world as a factor influencing the impact of trauma. Shaw (2000) states that a child's response to trauma is also influenced by the child's coping strategies, reactions of family members concerning the trauma and the child's theory of causality.

Summary

Unfortunately, millions of children around the world experience maltreatment, either in the form of a perceived or real single traumatic experience or repeated exposure to a traumatic experience. Exposure to trauma can occur at any time in the child's development and does not discriminate between genders. Maltreatment consists of physical abuse, sexual abuse, emotional harm, neglect and/or exposure to family violence. Research suggests that neglect is one of the more common forms of child maltreatment, however due to the nature of neglect, there may be no outward signs of its occurrence, making it difficult to study.

How the experience of trauma influences a child is dependent on numerous factors, including whether the child witnessed or was the recipient of the traumatic event, the relationship the child had/has with the abuser, the child's support system, prior history of trauma and the child's developmental age. It is important for therapists working with children who have experienced trauma to understand the nature of trauma and how the experience of trauma impacts the child's brain development. Brain development impacts all areas of the child's life including his or her emotional, social, cognitive, behavioural and psychological functioning. Children's brains undergo substantial change; therefore the experience of trauma negatively impacts the development and structure of the child's brain.

The next chapter introduces the reader to the brain. Chapter 4 presents a literature review on brain development, brain structures and their functioning, and also the effect of trauma on the brain.

CHAPTER 4: LITERATURE REVIEW ON THE BRAIN

This literature review provides the novice audience with an introduction to the brain and the impact trauma has on brain development and brain structures. It is written at an introductory level for those who have minimal understanding of the brain and its structures. This chapter summarizes a basic outline of brain development, a list of brain structures and the impact of trauma on the developing brain and brain structures.

Brain Development

This section of the chapter will introduce the reader to the following topics: use-dependant brain, brain plasticity, sensitive periods, and information on neurons and glial cells. It will also provide a foundation for the exploration of brain structures and the impact trauma has on these structures.

All necessary brain structures are present at birth; however, brain development continues to unfold at a significant pace afterwards. At this point, the brain becomes dependent on environmental cues to establish how neurons will differentiate, form and maintain synaptic connections, and create the final neural networks (Perry, 2002). According to Heide and Solomon (2006), the brain is not completely developed until a person's early twenties. During the first year of life the brain will expand to two and a half times its birth size (Stien & Kendall, 2004). By the age of four, a child's brain has grown to 90 per cent the size of an adult brain (Perry, 2006).

The brain develops in a sequential and hierarchical manner with different areas in the brain developing and becoming fully functional at different times during childhood (Perry et al., 1995). Perry et al. assert that, due to differences in maturation of brain functions, there are different sensitive or critical periods in childhood when certain experiences are necessary

for normal brain development. Because the majority of brain development occurs in early childhood, this period of life has the most powerful and enduring effect on how the brain functions and is organized well into the future (Perry, 2006).

The Use-Dependent Brain

The brain develops and changes in a use-dependent fashion (Perry et al., 1995). During the first two years of life there is an overproduction of axons, dendrites, and synapses in different regions of the brain (Stien & Kendall, 2004). Through a process referred to as pruning, the unused connections are eliminated (Cicchetti, 2002) while synapses that are repeatedly activated are maintained. For example, if an infant is in an environment where he or she is spoken to regularly, the neural system responsible for language and speech are constantly activated. However, if the infant is rarely spoken to, the synapses responsible for language will not develop normally, resulting in speech and language delays (Perry, 2006). Neural systems that are repeatedly activated can permanently change by altering the number of synapses, dendrite density, and the structure and function of the neurotransmitter (Perry, 2001). Therefore, the more a neural system is activated the more it will change and become firmly established (Perry et al.). Returning to the aforementioned example, the more the child hears language, the more the neural system involved with this particular behaviour develops.

Up to a certain point, all functions in the brain are dependent on the presence of appropriately patterned and timed cues that stimulate the neural system (Perry, 2006). For example, an infant's gross motor organization will not develop if the infant is not provided with ample opportunity to crawl or stand. In the same way, consistent emotional neglect prior to the age of three negatively impacts the individual's ability to form loving relationships throughout his or her life (Perry et al., 2002). These use-dependent alterations in the brain

can result in changes in cognition, emotional function, motor function, and state-regulation capacity (Perry, 2006). The more a particular neural system is activated the more it will change. For instance, a child cannot learn how to build with blocks without having ever seen or touched a block, nor can one teach a child to speak while he or she is asleep. In the same way, a child will not feel safe in his or her environment unless s/he has experienced safety, such as being raised in a safe nurturing environment.

Perry (2002) discussed the 1833 case of Kaspar Hauser, who was raised in a dungeon from the approximate ages of two until seventeen. This boy experienced sensory, emotional, and cognitive neglect resulting in delayed and rudimentary emotional, behavioural, and cognitive functions as an adult.

Sensitization and the experience of trauma. As the brain develops in a use-dependent fashion, the repeated experience of trauma creates a phenomenon called sensitization (Perry et al., 1995; Ziegler, 2002). The brain interprets meaning as it processes new information, therefore due to past traumatic events, the meaning of new information will be associated with and resemble past experiences (Ziegler). This leads to maladaptive functioning whereby everyday or minor stressors that previously did not elicit any response now result in a response similar to that in the face of a real or perceived threat (Glaser, 2000). As a result, the child who experiences the world as threatening due to early experiences of witnessing domestic violence may react with fear to an event that another child might find fun, like seeing a circus clown invade personal boundaries for entertainment value. By the same token, if her mother's boyfriend has sexually assaulted a female child, she may interpret her male teacher's placing his hand on her shoulder in a friendly manner as threatening.

The more frequent and traumatic the experience, the more the brain is affected. One

therapist who works with children who have experienced trauma likens this type of neural development to the child walking through a field (P. Beveridge, personal communication, December 20, 2008). The more the pathway is used, the more pronounced it becomes until an actual path is developed. At that point, the brain will once again take the well-worn path that sees the event as threatening when interpreting a similar event. Just as important, however, the brain is not only described as use-dependant but also plastic.

Brain Plasticity

The human brain is considered plastic in nature, meaning it is capable of changing in response to patterned, repetitive activation (Perry, 2006) as demonstrated above. The period of brain plasticity allows the child to develop new synaptic connections and grow neurons that are necessary for learning to occur (Osofsky, 2007). New learning would not be possible if the brain was not malleable. An infant's brain is more susceptible to change than a ten-year-old child's and a teen's brain is more susceptible than an adult's (Perry et al., 1995). Weber and Reynolds (2004) believe that during the period of brain plasticity, children are not only learning but are also vulnerable to stress and trauma, which can impact their brain development. Perry et al. (1995) state, "experience may alter the behaviour of an adult, experience literally provides the organizing framework for the infant and child" (p. 276). For example, an infant that is rarely touched or held may not develop the ability to feel empathy; however an adult's ability to be empathetic is not influenced by a lack of touch as an adult, even though he or she may not be happy.

Perry (2002) explains that not all parts of the brain are equally plastic; once a region in the brain fully develops it becomes less responsive to the environment. The lower part of the brain, known as the brainstem, develops prior to birth, and controls regulatory functions;

it is not very malleable. However, the most complex area of the brain, the cortex, is very malleable and remains so throughout life (Perry, 2006). Brain plasticity, especially in the cortex, allows for an individual to emotionally heal from past traumatic events by learning new coping strategies, relaxation techniques, and reframing stressful situations to manage or alter the person's innate/conditioned response to situations perceived as stressful.

Sensitive Periods

As previously mentioned, the brain develops sequentially and is reliant on environmental cues to activate neural systems. Research suggests that there are points in a child's development when specific experiences are critical for proper function(s) to develop (Stien & Kendall, 2004). Failure to go through these specific experiences may interrupt brain development. The critical period of development for vision is during the first year of a child's life (Davies, 2002). For example, if a child is raised in darkness during the first six months of his or her life, the absence of light negatively impacts a critical point in development and the creation of the neural pathway responsible for sight may be delayed or never fully develop (Davies). Studies have shown that physical contact between a mother and child in the period immediately following birth appears to be connected with the activation of hormones that regulate the child's immune system and stimulate physical growth (Blackwell, 2000). Nevertheless, no brain development would occur without neurons and glial cells; the next section will focus on their role in development.

Neurons and Glial Cells

Cells comprise the basic structural units of the brain and the two major types of specialized cells are neurons and glial cells (Perry, 2002). It is important to highlight the types of cells and their functions as this has a direct impact on how past and current

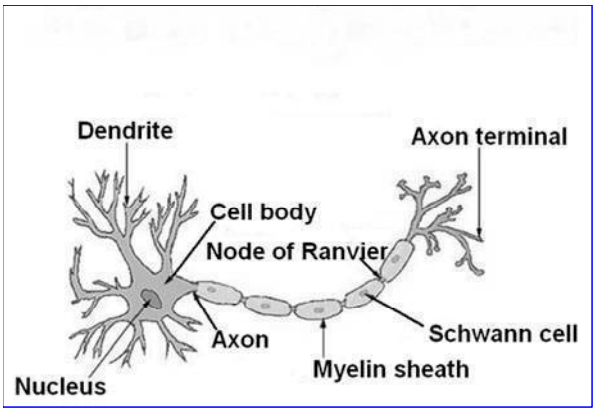
experiences are processed in the brain. Neurons and glial cells form the "building blocks" of brain structure (Perry). Neurons' role is in communication: they specialize in receiving, storing, and transmitting information (Perry). Cell communication allows for the brain to process, store and retrieve the information concerning our environment. Bodies receive instructions from neurons. For example, if a child places his or her hand on a hot stove, the sensory information is transmitted from the child's hand to the brain, which then sends signals to the muscles in the arm causing it to immediately lift the hand.

A typical neuron consists of a cell body with a long extension known as an axon (Broderick & Blewitt, 2006; see Figure 1). The end of the axon contains chemical substances called neurotransmitters (Broderick & Blewitt). There are many different types of neurotransmitters, however all of them are chemical messengers that stimulate the neuron to fire or stop firing (Broderick & Blewitt). Dendrites grow out of the cell body and are responsible for receiving information from other neurons through synaptic connections (Perry, 2002). As previously stated, repeated experiences create stronger synaptic connections and the absence of specific experiences will cause the synaptic connection to deteriorate and die through pruning (Davies, 2002).

Glial cells account for approximately 90 per cent of brain cells; their functions include providing nutrition to neurons, formation of myelin and repair and maintenance of neurons. However their primary function is to support communication between neurons (Perry, 2002). Myelin is the fatty substance that covers the axons to create a sheath that supports the neural system in functioning more quickly and effectively (De Bellis, 2005, Perry). The process of myelination is the procedure in which glial cells wrap themselves around the axon to facilitate conduction (Broderick & Blewitt, 2006). Myelination, according

to Perry, may begin in the first years of life but continues throughout childhood until sometime in adolescence.

Figure 1. Structure of a neuron [2]



The following section expands on brain development by exploring the structures in the brain. The impact of trauma on the function and structures of the brain will also be addressed.

The Triune Brain

Repeated trauma alters the structure and function of the brain, which is the focus of the section. Researchers have used Magnetic Resonance Imaging (MRI) to demonstrate that maltreated children have smaller head size and brain volume compared to children with no history of maltreatment (De Bellis, Keshavan, Clark, Casey, Giedd, Boring et al., 1999; Mulvihill, 2005). This impacts all areas of a child's functions; smaller brain sizes may be responsible for lower intelligence or cognitive ability, less impulse or emotional control, motor development delays, diagnosis of mental and psychological disorders, and poor socio-emotional and/or psychological function (De Bellis, 2005; Glaser, 2000).

The description of the organization of the brain is dependent on the perspective of the

[2] From "Structure of Neurons and Glial Cells," retrieved November 24, 2008, from http://training.seer.cancer.gov/ss_module00_bbt/unit02_sec04_b_cells.html

researcher (Perry, 2002). Therefore, there is more than one way the organization of the brain can be described. A common perspective, and the one that will be used for this paper, is referred to as the Triune Brain Model, which was proposed by MacLean (1990). This perspective divides the brain into three major areas the brainstem, the limbic system, and the cortex (Stien & Kendall, 2004), and proposes that the brain has a hierarchical organization in which the top area of the brain is more complex than the lower area (Ziegler, 2002).

The following section explores the three parts of the brain referred to as the triune brain. The limbic system and the cortex also describe areas in each region that have a significant role in how the brain responds to stress. Please refer to the Appendix A for a description of each part of the triune brain.

The Brainstem

The brainstem is the first region of the brain to develop *in utero* (see Figure 2). It is responsible for regulating basic cardiovascular functions (Stien & Kendall, 2004) and any other functions associated with our survival (Ziegler, 2002). The brainstem includes the cerebellum, the pons, the medulla oblongata, and the midbrain (Perry, 2002).

Figure 2. The shaded area represents where the brainstem is located in the brain.

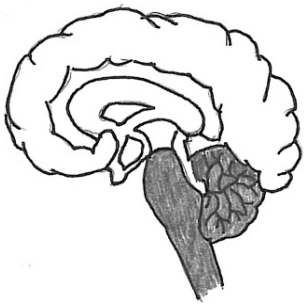


Table 2

The Brainstem

Structures	Functions
Cerebellum	Involves coordination of fine motor movement, balance and equilibrium and muscle tone.
Pons	Assists in relaying motor and sensory messages in the brain. It also is the respiratory center.
Medulla Oblongata	It relays nerve signal between the brain and the spinal cord. It is also connected with vital functions like breathing, blood circulation, vomiting and swallowing.
Midbrain	Contains auditory and visual reflex centers.

The Limbic System

The limbic system, which is the second part of the triune brain, is often referred to as the emotional brain because it is the source of our urges, needs, and emotions (Stien & Kendall, 2004: see Figure 3). Emotions, according to Ziegler (2002), are a complex combination of experience, perception, memory, and body chemistry, all of which the limbic system regulates. It also generates functions necessary for our self-preservation and areas within the limbic system impact learning, memory, behaviour, and emotional states (Weber & Reynolds, 2004). The limbic system consists of the basal ganglia, cingulated cortex, septum, hypothalamus, hippocampus and the amygdala (Siegel & Hartzell, 2003).

An important aspect of the limbic system is control of emotion and bodily functions

in response to emotional stimulants such as memory, impulse control, sense of smell, appetite and sleep (Ziegler, 2002). Therefore, research suggests the limbic system is often directly impacted by trauma and maltreatment (Siegel & Hartzell, 2003).

The following section will describe three sections in the limbic system: the hypothalamus, the hippocampus, and the amygdala. Appendix A provides a definition of these three sections as well as their functions.

Figure 3. The shaded area represents where the limbic system is located in the brain.

The hypothalamus. The hypothalamus is the "neuroendocrine centre of the brain" that provides hormone secretion and neurotransmitters as a means of coordinating many brain-body functions, including the response to stress (Siegel & Hartzell, 2003, p. 176). Stien and Kendall (2004) describe the function of the hypothalamus as maintaining normalcy in the brain by regulating critical functions such as blood pressure, body temperature, and glucose levels. Siegel and Hartzell state that the cerebellum sends inhibitory GABA (gamma amino butyric acid) fibres to the hypothalamus and the remaining limbic structure to reduce emotional irritability. GABA is a neurotransmitter that prevents over-firing of the nerve cells by blocking impulses from one cell to another (Siegel & Hartzell).

The hippocampus. The hippocampus plays a critical role in memory functions, learning, and behaviour inhibition (Anda, Felitti, Bremner, Walker, Whitfield, et al., 2006).

According to Siegel and Hartzell (2003), the hippocampus can be understood as a cognitive mapping agent, because it creates links between various neural inputs. Taylor and Lamoreaux (2008) explain that when the brain receives new sensory experiences, the brain tries to find already established connections as a means to understand the new input, which leads to the increased likelihood of information being remembered. These links are important for interpreting a number of processes that result in the formation of semantic or factual memory, a type of long-term memory of factual information such as names and dates in history, and autobiographical memory, meaning the memory of events and issues related to oneself (Siegel & Hartzell). Repeated exposure to trauma in the hippocampus has been associated with deficits in memory, cognitive impairments, ineffective coping responses, dissociation, problems processing and storing spatial information, and the breakdown of experience into isolated images, bodily sensations, smells and sounds (Diseth, 2005; Watts-English et al., 2006; Weber & Reynolds). These are some of the effects of trauma (or indicators of Post-Traumatic Stress Disorder) that might indicate a need for therapy.

Auditory, sensory, visual, and motor information that is required for long-term memory is delivered to the hippocampus from the cortex. The information is then registered, integrated and encoded into long-term memory (Stien & Kendall, 2004), making regulation of memory and learning a primary function of the hippocampus.

Studies have shown that one result of exposure to trauma is a decrease in activation in the hippocampus (Weiss, 2007). Decrease in size of the hippocampus has been found in adults diagnosed with borderline personality disorder, women with a history of childhood trauma and depression (Anda et al., 2005) and patients with anxiety disorders such as post-traumatic stress disorder (PTSD) and obsessive-compulsive disorder (OCD) (Phillips,

McGorry, Garner, Thompson, Pantelis, Wood, et al., 2006). Studies have found that damage to the hippocampus can affect disregulation and result in impairment of associative learning (Weber, Habel, Amunts, & Schneider, 2008). Damage to the hippocampus results in an increase in cortisol-exposure which research has shown can cause atrophy of hippocampal dendrites, cell death, and reduced hippocampus volume, possibly leading to amnesia and dissociative symptoms (Bremner, 2005; Heide & Solomon, 2006).

Hippocampal impairment affects the interpretation of incoming information and hinders normal categorization and evaluation of experiences (Weber & Reynolds, 2004). For example, a maltreated child may react to new arousing stimuli reminders as a threat and misinterpret new information due to a dysfunctional hippocampus (Diseth, 2005). Following a traumatic event, the brain creates a set of implicit traumatic memories based on that event that include images and emotions (Ziegler, 2002). These memories become reactivated when the child experiences a specific reminder of the event, thinks of the event, and/or dreams of the event (Perry & Pollard, 1998). Because the brain processes information based on previous experiences, certain associations are made and therefore, specific cues become generalized (Perry & Pollard). Although the child no longer experiences the traumatic event, the brain is reactivated based on those associations and the child's maladaptive emotional response results from the brain's original adaptive response to the traumatic event (Perry et al., 1995).

A person who has experienced trauma may not be consciously be aware of what has happened to him or her but nevertheless be victim of a flashback upon hearing a certain sound or smelling a particular smell (a common reaction with trauma survivors). In turn, this initiates the stress response from the amygdala (Anda et al., 2006; Teicher, Andersen,

Polcari, Anderson, Navalta, & Kim, 2003).

The amygdala. The amygdala is where emotions are processed and is known to have involvement in the memory of emotional reactions, including fear (Siegel & Hartzell, 2003). The amygdala has a role in controlling aggressive, sexual behaviours (Teicher et al., 2003) and in mediating the fear response (Anda et al., 2006). It is also associated with emotional learning, such as positive or negative associations to incoming information (Weber et al., 2008). Weber and Reynolds (2004) explain that it is through the amygdala that experiences are given emotional significance, which is then associated with larger schema. Thus, it is one of the most significant areas of the brain, evaluating the meaning of incoming stimuli (Stien & Kendall, 2004). For example, a child who is physically abused by an intoxicated parent may become hyper-aroused at the sound of ice cubes being dropped into a glass because s/he has associated that sound as a precursor to physical abuse.

During a traumatic event the amygdala automatically records all elements of the experience, including the smells, sounds, and sensations (Heide & Solomon, 2006). After the event, any incoming information that is associated with the experience, such as the scent of the abuser's cologne, will act as a trigger for flashbacks (Anda et al., 2006; Heide & Solomon).

The amygdala is very sensitive to stress and high levels of emotional arousal may negatively affect its functions. Since it takes little stimulus to produce an effect, the amygdala easily becomes excitable and very reactive (Stien & Kendall, 2004). Prolonged trauma can over-stimulate the amygdala, resulting in arousal that will have significant impact on behaviour. This leads to hyper-arousal in the form of aggression, anxiety, impulsivity, and sexual activity (Diseth, 2005). These behavioural reactions are found within PTSD as signs

and symptoms of the diagnosis (Teicher et al., 2002). Studies have also discovered that persons surviving abuse have an amygdala that is eight to ten per cent smaller compared to persons with no history of abuse (Heide & Solomon, 2006). People with a smaller amygdala have also reported depression, irritability, and aggression (Heide & Solomon).

The final section of this chapter provides an overview of the third region of the triune brain. The three regions of the triune brain consist of the brainstem, the limbic system, and the cortex.

The Cortex

The brain structures continue to develop throughout childhood until early adulthood (Heide & Solomon, 2006). The cortex, also known as the cerebral cortex or neocortex, is the last area of the brain to develop and controls the brain's most complex functions (Siegel & Hartzell, 2003: see Figure 4). It is the site of the most evolved brain functions, such as abstract thinking, reflection, auditory processing, and complex motor action (Stien & Kendall, 2004). A three-year-old who is angry will react by screaming, kicking, throwing things or hitting someone (brainstem-type responses). By contrast, an equally angry adolescent may have the urge to react in a similar fashion but does not because of his or her developmental age and because the development of his or her cortex is such that s/he can modulate and/or inhibit those urges (Perry, 2002).

Perry (2002) suggests that underdevelopment of the cortex is the result of sensory-motor and cognitive deprivation, basically neglect. All aspects of the child's life, including his or her psychological, academic, social, and physical life can be affected by this underdevelopment (Perry). Further, research has also found brain abnormalities and evidence of tiny seizures, which can impede cognitive function, in maltreated children (Mulvihill,

2005). Appendix A includes definitions of the structures and functions of the cortex including the prefrontal cortex, which will be discussed in the next section.

Figure 4. The shaded area represents where the cortex is located in the brain.

The prefrontal cortex. The prefrontal cortex, which is located in the centre front part of the brain, communicates with almost every other structure in the brain (Weiss, 2007). It filters out unnecessary information so only relevant inputs specific to the experience are processed and responded to accordingly (Weiss). It also plays an important role in planning, judgment, controlling impulsivity, and creating meaning (Diseth, 2005). Research infers that childhood neglect interferes with the effective development of the prefrontal cortex and therefore impedes executive function, leading to inattention, impulsivity and inferior academic achievement, as well as poor judgment, reasoning, and self-monitoring (De Bellis, 2005; Stien & Kendall, 2004).

Children with damage (via abuse or physical injury to this part of the brain) to the prefrontal cortex often misinterpret emotional cues; this impairs their ability to negotiate social interactions (Bremner, 2005), putting the child at risk for further trauma because their response does not meet expectations and can be interpreted as defiance. This area in the brain

is especially at risk to emotional stress as it does not fully develop or mature until early adulthood (Weber & Reynolds, 2004).

Research conducted by Anderson, Damasio, Tranel and Damasio (2000) found that clients with childhood damage to the prefrontal cortex displayed behaviour similar to persons with psychopathology, such as conduct disorder and/or antisocial personality disorder. It could therefore be hypothesized that children who receive these diagnoses may have experienced trauma. The concept of pseudopsychopathy, which was coined by Blumer and Benson (as cited in Weber et al., 2008), refers to patients with lesions in the prefrontal cortex displaying aggressive and socially inappropriate behaviour. The last section of this chapter explores the corpus callosum, which is found in the cortex.

Corpus callosum. Information travels across the right and left hemispheres of the brain via the corpus callosum. The corpus callosum is a bundle of nerves that links the two hemispheres of the brain and serves as their main information pathway (Davies, 2002). The left hemisphere specializes in perception and expression of language; it is logical and analytical, and more dominant for mathematical and logical calculations (Teicher et al., 2003). The right hemisphere specializes in the perception and expression of emotion (predominantly negative), spatial abilities, face recognition, visual imagery, and music ability (Teicher et al., 2002). Interrupted communication between the two hemispheres may lead to difficulties in expressing emotions, coordination, translating symbols into language, and memory (Weber & Reynolds, 2004).

The corpus callosum has been found to be significantly smaller in children who have experienced trauma comparison to those with no history of trauma (Jackowski, et al., 2008; Watts-English, Fortson, Gibler, Hooper, & De Bellis, 2006), thus resulting in diminished

communication between the two hemispheres (Diseth). The implication of a smaller corpus callosum is that the abused child may have greater difficulty regulating his or her emotion(s) and thinking (Heide & Solomon, 2006). For example, instead of thinking out alternate responses to conflict, a traumatized child may impulsively respond by hitting another child.

Summary

The brain develops in a use-dependant manner, meaning that the more an experience occurs (repeated activation of the neural system), the stronger the function associated with the experience becomes. New information that is stored in the brain becomes connected to previous information as a means to make sense of the information. The brains of children who have experienced perceived or actual trauma will associate incoming information as potentially threatening based on the child's past experience.

The triune brain consists of three regions, the brainstem, the limbic system, and the cortex. Systems in the brainstem are responsible for regulating heart rate, blood pressure, and other functions that contribute to our basic survival. The limbic system is responsible for emotional regulation, attachment, and memory; within the system, the areas directly impacted by trauma include the hypothalamus, the hippocampus, and the amygdala. Exposure to trauma in the hippocampus has been associated with numerous impairments, including memory and triggering trauma flashbacks. The amygdala is where emotions are processed; continuous trauma over-stimulates the amygdala, resulting in hyper-arousal. The third part of the triune brain and the last area to develop is the cortex, which is responsible for abstract thinking, and complex cognitive function.

The research into brain development, brain structures and the impact of trauma is an ever-expanding area of study that is important for those working with children to understand.

This literature review has provided an introduction to the brain and the impact trauma has on brain structures, however, more detailed information than can be discussed in this paper can be accessed using the references provided.

CHAPTER 5: THE BRAIN'S RESPONSE TO TRAUMA

This chapter will focus on how the brain responds to trauma. It will present what the stress response is, stress hormones, and responses to perceived or real threats.

The Stress Response

The stress response is a physiological coping mechanism to help human bodies physiologically respond to and repair after a stressful encounter (perceived or actual; Glaser, 2000). It involves numerous biochemical and hormonal adaptations, which are used as a means to restore equilibrium in the brain and promote survival (Osofsky, 2007). The stress response involves four systems: the hypothalamic-pituitary-adrenal axis (HPA), the sympathetic nervous system (SNS), the neurotransmitter system and the immune system (Diseth, 2005; Glaser, 2000). As stated in Chapter 4, the stress response begins in the amygdala; it is then regulated by the HPA. Since the amygdala processes all incoming stimuli through the senses to detect any threats to one's survival, the amygdala's fear response is processed as either, "the fast low road" or "the slow high road" (Christopher, 2004, p.80).

Two Processing Paths

The fast low road response passes through the thalamus directly to the amygdala, so it involves instantaneous, unconscious reactions (Stien & Kendall, 2004). This type of response is effective and needed during emergency events, such as a child hearing gunshots being fired nearby and then hiding (Christopher, 2004).

The slow high road response passes through the thalamus like the fast low road, but this time it goes to the cortex before making its way to the amygdala (Stien & Kendall, 2004). As a result of the response passing through the cortex, the person is given the

opportunity to use logic and decision-making to decide the best course of action in response to the physical threat. For example, a child who arrives home from school with a friend asks the friend to hang out, knowing that his or her father (who has not gone to work because he has been drinking all day) will not become abusive if there is company.

Research suggests that trauma may influence the brain's preferred mode of processing incoming stimuli (Stien & Kendall, 2004). This means that the brain will automatically process incoming information in the fast low road, where it involves an immediate unconscious response, rather than the slow high road, where the incoming information can be processed and decision-making can occur. Every stimulus is interpreted and responded to as a threat.

Activation of Brain Systems

The body reacts to stress by activating other systems in the brain. For example, intense stress (such as a child watching a parent physically abuse another parent) activates the child's locus coeruleus, which is a structure in the brain that houses a cluster of neurons that secrete norepinephrine (NE) (Watts-English et al., 2006). Increased NE results in "increases in heart rate, blood pressure, metabolic rate, and alertness" (Watts-English et al., p. 720) and also affects alertness and focus (Weiss, 2007). Thus, the child in this case would experience a rush of adrenaline and as the stress progresses to a threat to him or herself, the locus coeruleus becomes hyper-vigilant and tunes out any non-critical information, acting as a filter to ensure focus stays on the threat (Perry & Pollard, 1998). For example, the child in this scene would fail to notice the water overflowing in the sink as he or she is too focused on his or her parents, as a result of the locus coeruleus hyper-vigilant response.

At this time the SNS (sympathetic nervous system) promotes the release of

catecholamine. These are hormones that are released during stressful events (Diseth, 2005). Catecholamine encourages arousal and provides energy in the body's vital organs, preparing them for physical activity (Diseth). The adrenal gland, which houses epinephrine and cortisol, is also activated (Watts-English et al., 2006). Epinephrine increases respiration, heart rate, attention and concentration (Weiss, 2007) to increase the probability of survival. In effect the brain secretes these hormones in order to better assess the odds of survival; activity in the SNS and the elevated levels of epinephrine ultimately cause activation of the fight or flight response (De Bellis, 2006; Glaser, 2000).

A lot of systems become activated during a stress response, so for a child experiencing real or perceived trauma, the activation of the locus coeruleus also stimulates the amygdala, which initiates a series of system activations that then result in the release of cortisol. Cortisol acts as an anti-stress hormone by participating in the termination of the stress reaction and stops the brain from releasing more cortisol (Christopher, 2004). Cortisol protects the body's immediate and normal response to stress, as its goal is to avoid the brain overreacting to a perceived or actual threat which would damage the brain's normal functioning (Diseth, 2005). It also helps the brain to calm down after the initiation of the stress response by converting fats to glucose and suppressing the immune response (de Kloet, Joels, & Holsboer, 2005; Stien & Kendall, 2004). Finally, cortisol works to shut down reactions and other stress-related changes before any damage is done to the brain (Weber & Reynolds, 2004).

Once the stressor is no longer detected by the amygdala, cortisol begins terminating the stress reaction in other systems in the brain through a process referred to as a "negative feedback inhibitory" response (De Bellis, 2005, p. 155). As specific brain regions receive

cortisol, they send messages through the HPA (hypothalamic-pituitary-adrenal axis) to reduce the level of cortisol that is being released (Glaser, 2000), thus returning the hormones of the HPA to normal levels (Christopher; De Bellis).

Consider the following example. A four-year-old boy is playing in the yard when he hears his parents yelling in the house (the locus coeruleus becomes activated and NE is released into the boy's system). As the boy starts to walk toward the house, the yelling increases and he hears furniture being destroyed (the locus coeruleus perceives an increased threat and becomes hyper-vigilant, catecholamine and cortisol are released). When the boy enters the house he sees that his parents are watching a loud movie, which was what he heard while he was playing outside (threat is no longer present, cortisol initiates the negative feedback inhibitory response signalling the brain to stop releasing cortisol and return to normal functioning).

The Effect of Stress Hormones on the Body

An overload of stress hormones can have detrimental long-term effects on the brain (Bremner, 2005). The altered levels of stress hormones can change the density, number, and type of receptors on nerve cells in the brain (Stein & Kendall, 2004). Studies support the hypothesis that prolonged trauma produces an enduring sensitization of the HPA system (hypothalamic-pituitary-adrenal axis) resulting in its not functioning properly (Avital, Ram, Maayan, Weizman, & Richter-Levin, 2006; Gillespie & Nemeroff, 2007).

Research has determined that maltreated children have higher levels of catecholamine (hormones that encourage arousal) and cortisol (the anti-stress hormone) compared to non-maltreated children (De Bellis, 2005; Stien & Kendall, 2004; Watts-English et al., 2006). The altered level of catecholamine impacts brain maturation and neurodevelopment by changing

the manner in which the brain mediates stress (Watts-English et al.). Altered levels of catecholamine are also linked to symptoms of PTSD, including hyper-vigilance, exaggerated startle response, irritability, panic attacks, and intrusive thoughts (Stien & Kendall). Research conducted by De Bellis found that elevated levels of stress chemicals in children, which cause changes in the developing stress system, could negatively affect brain development and lead to "psychopathology and compromised neuropsychological and psychosocial function" (p. 158).

Effects of Cortisol

Since brain development is ongoing, sustained high levels of cortisol over time due to increased stress such as a child living in an environment of domestic violence, is especially damaging to children (Davis, 2002). High levels of cortisol begin to break down the body and cause brain alterations that include a diminished growth of brain cells, cell death, premature break down and loss of neurons, damage to the immune system, delayed physical growth, and delays in sexual maturity (Davis; Diseth, 2005; Mulvihill, 2005; Weber & Reynolds, 2004).

High levels of cortisol have also been found to improve recall of emotionally charged information and merge it into long-term memory (Stien & Kendall, 2004; Weiss, 2007). The traumatic memory therefore becomes firmly established as a neural network and, as previously stated, new information is processed through that neural network resulting in increased potential of triggering flashback(s) through images, thoughts, or perceptions (Weiss).

The negative impact of high cortisol levels have been supported by numerous studies, however, the level of cortisol over time appears to be inconsistent in maltreated children and

adults (Watts-English et al., 2006; Weber & Reynolds, 2004). Perhaps the type and duration of the trauma impacts how the individual reacts to ongoing stress and the body is forced to adapt, which may result in lower cortisol levels.

Low levels of cortisol appear to bias individuals toward use of maladaptive coping strategies (Heide & Solomom, 2006). They might jump to conclusions, react impulsively or with inappropriate rage, or have difficulty regulating their emotions (Heide & Solomon). Studies have suggested that the form of maltreatment, age when the trauma occurred, duration of trauma, and gender differences may contribute to the differences in cortisol levels found over time in individuals that have experienced childhood trauma (Watts-English et al.; Weber & Reynolds, 2004).

Responses to Trauma

The following section describes the most common ways that individuals respond to threats. Continued activation of the stress response can result in the fight-flight-freeze response and dissociation.

The Fight-Flight-Freeze Response

A common first reaction when confronted with a continuous threat is to freeze and be unable to move (Perry et al., 1995). For example, a child who is confronted by his or her mother yelling at him or her may freeze. Freezing allows a child to organize, make a plan and figure out how to respond (Perry & Pollard, 1998). If the child feels threatened or terrorized, even if there is no real threat, the freezing may escalate into a hyper-arousal response (Perry & Pollard). The fight or flight reaction is initiated during the early stages of threat and is characterized by hyper-arousal. Heart rate, blood pressure, respiration and muscle tone increase, and a sense of hyper-vigilance develops (Perry et al., 1995), preparing the body for

defence, whether to fight with or run away from the threat (Perry & Pollard, 1998). These reactions are similar in both children and adults. The origin of this response is in the limbic system and is initiated by the amygdala (Anda et al., 2006). In the above example in the previous paragraph, when the child feels threatened by his or her mother yelling at him or her, s/he prepares to stay and fight or run away.

Extreme anxiety, hyper-vigilance and continuous activation of the stress response will weaken a child's academic and socio-emotional learning (Perry, 2006). A child cannot easily be taught complex cognitive information when s/he is in a state of hyper-arousal due to fear (Perry, 1997). In a child in a hyper-aroused state, the limbic system is activated, not the cortex. This means the child will be focusing on nonverbal cues such as eye contact, body language, facial expressions and tone of voice, not the words that are being spoken (Perry, 1997). Two children in the same classroom with the same intelligence will not necessarily take in the same information. The child who is calm can focus on the words the teacher is using because he or she is engaging his or her cortex. However the other child who has initiated his or her stress response is engaging his or her limbic system and can therefore only focus on the teacher's non-verbal cues. According to Perry (2001), a child who has been raised in an abusive environment has learned that non-verbal information is more vital than verbal information. Perry (2001) suggests this may be why children raised in abusive homes develop amazing non-verbal skills in comparison to their verbal skills. This reliance on non-verbal information may also lead to misinterpretation of such information, meaning a child may interpret eye contact from an adult as a threat.

Children raised in an environment of unrelenting perceived or actual threat rarely obtain a sense of calm (Mulvihill, 2005). Mulvihill believes in order to achieve a sense of

calmness as these children grow up they use artificial means, such as using substances like alcohol, cigarettes, and/or drugs, and may try to escape their emotions by overeating, binging or compulsive sexual behaviours. The next section briefly explores how the individual responds to trauma by dissociating before presenting a summary of the chapter.

Dissociation

According to Perry (2003), dissociation is a mental mechanism in which a person focuses on his or her internal world over his or her external world. There appears to be a graduation of dissociation that can progress through distraction, daydreaming, fantasy, avoidance, depersonalization, and in extreme circumstances, fainting and catatonia (Perry, 2001). Traumatized children (as well as adults) report experiencing a variety of dissociative techniques, such as mentally going to a different place or taking on the persona of a superhero or animal (Perry & Pollard, 1998). Others state it is as if they are watching a movie that they are in (Perry et al, 1995). For example, a child being sexually assaulted by his or her parent may dissociate by entering his or her fantasy world, allowing him or her to focus on that internal world and leading to detachment from his or her external/real world. Dissociation frequently creates a distorted sense of time, a diminished sense of pain and perhaps a feeling that what is occurring is not real (Mulvihill, 2005).

As with hyper-arousal, dissociation involves the activation of the brainstem, which results in increased circulating epinephrine (Perry, 2001). A significant difference between hyper-arousal and dissociation is that in dissociation the heart rate and blood pressure decrease dramatically despite the circulating epinephrine (Perry et al., 1995).

Summary

The stress response is a physiological coping mechanism that involves numerous

systems in the brain. The amygdala plays a significant role in the stress response and the activation of the fight-flight-freeze response. It detects threats to one's survival by processing incoming information through either the fast low road or the slow high road. The low road provides an immediate response and is beneficial in emergencies; however, the high road involves higher brain function and incorporates rational thinking and decision-making. Activation of the stress response releases catecholamine and cortisol, which are stress hormones. Cortisol acts as an anti-stress hormone by assisting the brain in calming down after a threat and by shutting down other responses to stress as a way to prevent damage to the brain. Altered levels of the stress hormone negatively change systems and functions in the brain. Responses to stress include the fight-flight-freeze response and dissociation. When confronted by a perceived or real threat a child may initially freeze before preparing him- or herself to fight or flee. The fight or flight response is characterized by a state of hyper-arousal. Dissociation is another mechanism that is used to respond to increased threat. Children or adults that dissociate focus on their internal world either in the form of daydreaming, fantasy, or depersonalizing instead of focusing on what is occurring in their external world.

CHAPTER 6: CONCLUSION

This chapter includes a discussion of this project and its limitations. A section of this chapter also addresses areas for future research.

Discussion

The brain begins to develop prior to birth with the most significant and rapid development occurring during early childhood. The child's brain is most sensitive to external stimuli during this period of development. The experience of trauma in childhood has a significant impact on brain development and how the structures in the brain function. The brain becomes sensitized whereby new information is assigned meaning based on previous experiences.

For a child that has experienced real or perceived trauma, everyday minor stressors that previously did not elicit a response now result in the child's stress response being engage whereby the child either becomes hyper-vigilant or dissociates. Perry (2006) explains this continual activation of the stress response and hyper-vigilance will negatively impact the child's learning academically, socially, emotionally, and will also challenge the therapeutic process. The experience of trauma can alter how the child thinks and behaves. A therapist working with traumatized children without having an understanding of the brain may not accurately assess the child's needs and developmental state leading to treatment that is ineffective, unrealistic, and may increase the child's stress.

The purpose of this project was to provide professionals with tools to better understand the brain and the impact trauma has on brain development and functioning. Unfortunately the Masters of Counselling program, from my perspective, does not adequately address the value in brain research as it relates to therapy. It has been my

experience that it has been challenging to find information on the brain and trauma that is written for the novice audience. A therapist, in my opinion, that has a basic comprehension of the brain and trauma will develop more effective and sensitive treatment options for their clients.

This project is beneficial to anyone seeking to understand trauma and the effect that trauma has on brain development and functioning. This project as a whole or the Appendix can be distributed to professional counselling agencies working with families and children who have experienced trauma, women's shelters, parent support groups, schools, and can be used as a resource for students and professors in seminars and lectures. The following section will address the limitations of this project.

Limitations of the Project

A limitation of this project is researcher bias. The researcher chose the search terms, the journal articles, and other references that were deemed relevant to this project. The project did not explore areas considered unnecessary or non-beneficial for the intended reader such as: advanced brain functioning, repressed and/or false memory, attachment and trauma, gender differences and trauma, and the exploration of culture and trauma.

Trauma research is a large field of study. Due to the constraints of this project only a limited selection of trauma research was discussed. This project is too short to explore all possible areas related to trauma and the brain such as: flashback memories, treatment approaches, the impact of trauma on psychological diagnoses, posttraumatic stress disorder, the impact of trauma on language development, and trauma induced amnesia.

The research for this project is based on current available research up to 2008. As trauma research expands this document may become outdated as new information and

discoveries emerge. This project should be updated in the future and may include some areas discussed in the following section.

Future Research

As previously stated, trauma research encompasses several areas of study. Expanding on the information presented in this project, an area for future research would include memory. This would provide a more detailed exploration of the memory process, traumatic memories and false memories.

Another area to explore is traumatic experiences and culture, more specifically, culturally sensitive assessment and treatment. Different cultures have differing views on childhood development, parenting roles, children's roles, and disciplining. Do assessment tools adequately consider the cultural element of clients?

Future research can also explore factors associated with childhood resiliency. Why do some children appear more resilient compared to other children who may have experienced similar traumatic experiences? What, if any are factors associated with the experience of childhood trauma and adult violent behaviour? Gender differences are also an area for future research. For example, how, if at all, does gender impact how the traumatic experience is processed and then expressed?

The topic of trauma and attachment is also an area for future research. The experience of trauma (real or perceived) impacts all areas of the child's life. A significant part of children's lives is the relationships they have with others. What impact does trauma have on attachment and if attachment is negatively impacted by trauma how can attachment be re-established.

Summary

This chapter highlighted the importance in understanding brain development as a means to effective and sensitive treatment of clients. This project was written for professionals with minimal understanding of the brain and can be distributed to a number of organizations, professionals and/or anyone trying to understand brain development and the effect of traumatic experiences on the brain.

As this project demonstrated, the experience of trauma has a substantial influence on a child's brain development. The brain is responsible for storing and processing all incoming information, including experiences, which become linked to previous experiences as a means to make sense out of new information. This means that the brain of a child who previously experienced real or perceived trauma will filter all of his or her new experiences through past traumatic experiences linking the past with the present. Minor stressors and/or information that previously aroused little to no response from the child now trigger his or her past trauma. This action initiates the stress response. The child now feels threatened and the brain begins to prepare for the threat by becoming hyper-vigilant. When a child is in this state the limbic system (emotions) is engaged, meaning the cortex (rational thinking) is not. The child will be focusing on nonverbal cues such as tone of voice, eye contact, body language and facial expressions, not the words that are being spoken.

Many counselling professionals encounter children that have had traumatic experiences and having an understanding of how the brain works and how trauma impacts the brain is vital when working with them. The information presented in this project provides a valuable tool to better understand the child and treatment options that are more sensitive and effective.

Appendix A (applied element of the project) contains a handout package that provides the reader with a quick reference to key points of this project. The handout package consists of a summary of the project and can be used alone or with the entire project to provide the reader with an understanding of the brain and the effect trauma has on the brain. This project lays the foundation for further research on trauma and the brain. Having a basic understanding of how the brain develops and functions is essential in not only understanding the traumatized child but also in developing strategies and treatments that are most effective for each individual child.

Conclusion

This project has been dear to my heart because of seeing many of my peers and colleagues interacting with abused children with little awareness of how the brain has been impacted by trauma. Working with children who have been abused has opened my eyes to the importance of understanding brain development not only regarding treatment approaches but also in how I establish rapport with clients, and engage them in therapy. As part of my duty to be responsible to society (as noted in the CCE for psychologists), this project is my way of educating people that work with children that they need to understand how to factor elements of the brain into their goal setting and intervention/ treatment approach. Failure to factor in the brain and the impact of trauma on the brain results in maltreatment and haven't children who have experienced abuse suffered enough?

References

Anda, R., Felitti, V., Bremner, D., Walker, J., Whitfield, C., Perry, B., et al. (2005). The enduring effects of abuse and related adverse experiences in childhood. *European Archives of Psychiatry and Clinical Neuroscience, 256*(3), 174-186.

Anderson, S., Damasio, H., Tranel, D., & Damasio, A. (2000). Long-term sequelae of prefrontal cortex damage acquired in early childhood. *Developmental Neuropsychology, 18*(3), 281-296.

Avital, A., Ram, E., Maayan, R., Weizman, A., & Richter-Levin, G. (2006). Effects of early-life stress on behavior and neurosteroid levels in the rat hypothalamus and entorhinal cortex. *Brain Research Bulletin, 68*, 419-424.

Blackwell, P. (2000). The influence of touch on child development: Implications for intervention. *Infants and Young Children, 13*(1), 25-39.

Bremner, D. (2005). Effects of traumatic stress on brain structure. *Journal of Trauma and Dissociation, 6*, 51-68.

Broderick, P., & Blewitt, P. (2006). *The Life Span Human Development for Helping Professionals Second Edition.* Upper Saddle River, NJ: Pearson Merrill Prentice Hall.

Christopher, M. (2004). A broader view of trauma: A biopsychosocial-evolutionary view of the role of the traumatic stress response in the emergence of pathology and/or growth. *Clinical Psychology Review, 24*, 75-98.

Cicchetti, D. (2002). The impact of social experience on neurobiological systems: Illustration from a constructivist view of child maltreatment. *Cognitive Development, 17*, 1407-1428.

Cohen, J., Berliner, L., & Mannarino, A. (2000). Treating traumatized children. *Trauma, Violence, & Abuse, 1*(1), 29-46.

Davies, M. (2002). A few thoughts about the mind, the brain, and a child with early deprivation. *Journal of Analytical Psychology, 47*, 421-435.

De Bellis, M. (2005). The psychobiology of neglect. *Child Maltreatment, 10*(2), 150-172.

De Bellis, M., Keshavan, M., Clark, D., Casey, B.J., Giedd, J., Boring, A., et al. (1999). Developmental traumatology part II: Brain development. *Biological Psychiatry, 45*, 1271-1284.

de Kloet, R., Joels, M., & Holsboer, F. (2005). Stress and the brain: From adaptation to disease. *Nature Reviews Neuroscience, 6*(6), 463-475.

Diseth, T. (2005). Dissociation in children and adolescents as reaction to trauma-an overview of conceptual issues and neurobiological factors. *Nordic Journal of Psychiatry, 59*, 79-91.

Dripchak, V. (2007). Posttraumatic Play: Towards acceptance and resolution. *Clinical Social Work Journal, 35*, 125-134.

Falasca, T, & Caulfield, T. (1999). Childhood trauma. *Journal of Humanistic Counseling, Education & Development, 37*(4), 212-224.

Gillespie, C., & Nemeroff, C. (2007). Corticotropin-releasing factor and the psychobiology of early-life stress. *Current Directions in Psychological Science, 16*(2), 85-89.

Glaser, D. (2000). Child abuse and neglect and the brain-A review. *Journal of Child Psychology and Psychiatry, 41*(1), 97-116.

Heide, K., & Solomon, E. (2006). Biology, childhood trauma, and murder: Rethinking justice. *International Journal of Law and Psychiatry, 29*, 220-233.

Jack, S., Munn, C., Cheng, C., & MacMillan, H. (2006). *Child maltreatment in Canada: National Clearinghouse on Family Violence*. Ottawa, ON: Public Health Agency of Canada.

Jackowski, A., Douglas-Palumber, H., Jackowski, M., Win, L., Schultz, R., Staib, L., et al. (2008). Corpus callosum in maltreated children with posttraumatic stress disorder: A diffusion tensor imaging study. *Psychiatry Research: Neuroimaging, 162*, 256-261.

Lonergan, B., O'Halloran, M., & Crane, S. (2004). The development of the trauma therapist: A qualitative study of the child therapist's perspective and experiences. *Brief Treatment and Crisis Intervention, 4*(4), 353-366.

Lubit, R., Rovine, D., Defrancisci, L., & Eth, S. (2003). Impact of trauma on children. *Journal of Psychiatric Practice, 9*(2), 128-138.

MacLean, P. (1990). *The triune brain in evolution*. New York: Plenum Press.

Mulvihill, D. (2005). The health impact of childhood trauma: An interdisciplinary review, 1997-2003. *Issues in Comprehensive Pediatric Nursing, 28*, 115-136.

Ogawa, Y. (2004). Childhood trauma and play therapy intervention for traumatized children. *Journal of Professional Counseling: Practice, Theory, & Research, 32*(1), 19-29.

Osofsky, J. (Ed.). (2004). *Young children and trauma: Intervention and treatment*. New York, NY: The Guilford Press.

Perry, B., Pollard, R., Blakley, T., Baker, W., & Vigilante, D. (1995). Childhood trauma, the neurobiology of adaptation, and "use-dependent" development of the brain: How "states" become "traits". *Infant Mental Health Journal, 16*(4), 271-291.

Perry, B. (1997). Incubated in terror: Neurodevelopmental factors in the cycle of violence. In J. Osofsky (Ed.). *Children in a violent society* (pp.124-147). New York, NY: Guilford Publications.

Perry, B., & Pollard, R. (1998). Homeostasis, stress, trauma and adaptation: A neurodevelopmental view of childhood trauma. *Child and Adolescent Psychiatric Clinics of North America, 7*, 1-33.

Perry, B. (2001). The neurodevelopmental impact of violence in childhood. In D. Schetky & E. Benedek (Eds.). *Textbook of child and adolescent forensic psychiatry*. (pp. 221-238). Washington, DC: American Psychiatric Press, Inc.

Perry, B. (2002). Childhood experience and the expression of genetic potential: What childhood neglect tells us about nature and nurture. *Brain and Mind, 3*, 79-100.

Perry, B., Colwell, K., & Schick, S. (2002). Neglect in Childhood. In D. Levinson (Ed.). *Encyclopedia of Crime and Punishment Volume 1* (pp. 192-196). Thousand Oaks: Sage Publications.

Perry, B. (2002). *Brain structure and function I: Basics of organization*. The ChildTrauma Academy. Retrieved September 12, 2008, from http://www.childtrauma.org

Perry, B. (2003). *Effects of Traumatic Events on Children*. The ChildTrauma Academy. Retrieved September 12, 2008, from http://www.childtrauma.org

Perry, B. (2006). Applying principles of neurodevelopment to clinical work with maltreated and traumatized children. In N. Boyd Webb (Ed.). *Working with traumatized youth in child welfare* (pp. 27-52). New York, NY: The Guilford Press.

Phillips, L., McGorry, P., Garner, B., Thompson, K., Pantelis, C., Wood, S., et al. (2006). Stress, the hippocampus and the hypothalamic-pituitary-adrenal axis: Implications for the development of psychotic disorders. *Australian and New Zealand Journal of Psychiatry, 40*, 725-741.

Seer's Training Website (n.d.). Structure of neurons and glial cells. Retrieved November 24, 2008, from http://training.seer.cancer.gov/ss_module00_bbt/unit02_sec04_b_cells.html

Shaw, J. (2000). Children, adolescents and trauma. *Psychiatric Quarterly, 71*(3), 227-243.

Siegel, D., & Hartzell, M. (2003). *Parenting from the inside out*. New York, NY: Jeremy P. Tarcher/Penguin.

Stien, P., & Kendall, J. (2004). *Psychological Trauma and the Developing Brain*. Binghamton, NY: The Haworth Maltreatment and Trauma Press.

Taylor, K., & Lamoreaux, A. (2008). Teaching with the brain in mind. *New Directions for Adult and Continuing Education, 119*, 49-59.

Teicher, M., Andersen, S., Polcari, A., Anderson, C., & Navalta, C. (2002). Developmental neurobiology of childhood stress and trauma. *Psychiatric Clinics of North America, 25*(2), 397-426.

Teicher, M., Andersen, S., Polcari, A., Anderson, C., Navalta, C., & Kim, D. (2003). The neurobiological consequences of early stress and childhood maltreatment. *Neuroscience and Biobehavioral Reviews, 27*, 33-44.

Watts-English, T., Fortson, B., Gibler, N., Hooper, S., & De Bellis, M. (2006). The psychobiology of maltreatment in childhood. *Journal of Social Issues, 62*(4), 717-736.

Weber, D., & Reynolds, C. (2004). Clinical perspectives on neurobiological effects of psychological trauma. *Neuropsychology Review, 14*(2), 115-129.

Weber, S., Habel, U., Amunts, K., & Schneider, F. (2008). Structural brain abnormalities in psychopaths-a review. *Behavioral Sciences and the Law, 26*, 7-28.

Weiss, S. (2007). Neurobiological alterations associates with traumatic stress. *Perspectives in Psychiatric Care, 43*(3), 114-122.

Weitzman, J. (2005). Maltreatment and trauma: Toward a comprehensive model of abused children from developmental psychology. *Child and Adolescent Social Work Journal, 22*, 321-341.

Wolfe, D., & Yuan, L. (2001). *A conceptual and epidemiological framework for child maltreatment surveillance*. Ottawa, ON: Minister of Public Works and Government Services Canada.

Ziegler, D. (2002). *Traumatic Experience and the brain: A handbook for understanding and treating those traumatized as children.* Jasper, OR: Acacia Publishing Inc.

APPENDIX A

Handout Package

Supplementary Handout Package:

Impact of Childhood Trauma on Brain Development

Samantha Kirouac

March 2009

The reader has permission to copy information found in Appendix A providing the borrowed information is referenced as:

Kirouac, S. (2009). *Supplementary handout package: Impact of childhood trauma on brain development.* Calgary, AB: Athabasca University.

Preamble

This handout package compliments my Master of Counselling project, "The impact of childhood trauma on brain development". The project was created for professionals working with traumatized children who had a minimal understanding of brain development, brain structures and functions, and also the impact trauma has on the brain. Many counselling professionals encounter children that have had traumatic experiences. It is vital counsellors have an understanding of how the brain works and how trauma impacts the brain when working with traumatized children.

The information presented in these handouts has been taken directly from my project and have been summarized as a quick reference for the audience. This section of my project can be used alone to provide a review of key points presented in my project or together with my project to reinforce understanding of the brain.

This handout is presented in a user-friendly, creative manner that includes tables and hand drawn sketches. This section of my project does not adhere to American Psychological Association (APA) guidelines.

If the reader wants more detailed information on topics offered in the handouts please refer to my project[3].

[3] Kirouac, S. (2009). *Supplementary handouts package: Impact of childhood trauma on brain development.* Calgary, AB: Athabasca University.

Childhood Trauma

Childhood trauma (maltreatment or abuse) can involve a sudden single event that overpowers the child's ability to cope, such as a school shooting, car accident, and/or a natural disaster.[4] Trauma can also involve exposure to ongoing, chronic, and/or unrelenting stressors such as, war, repeated acts of physical abuse, and/or witnessing domestic violence.[5]

For an event to be traumatic there is an actual or perceived threat of serious physical and/ emotional suffering or possible death and the event has a specific meaning for the child.[6]

[4] Dripchak, V. (2007). Posttraumatic Play: Towards acceptance and resolution. *Clinical Social Work Journal, 35*, 125-134.

[5] Ogawa, Y. (2004). Childhood trauma and play therapy intervention for traumatized children. *Journal of Professional Counseling: Practice, Theory, & Research, 32*(1), 19-29.

[6] Dripchak, V. (2007). Posttraumatic Play: Towards acceptance and resolution. *Clinical Social Work Journal, 35*, 125-134.

Forms of Maltreatment

Category	Definition	Examples
Physical Abuse	Deliberate unreasonable force to any part of the child's body. The abuse can be a single or repeated incident(s).	Hitting, shaking, choking, biting, pushing, burning, suffocating, stabbing, poisoning
Sexual Abuse	Any sexual experience between a child and an adolescent or adult.	Attempted and actual fondling of a child's genitals, incest, sex talk, voyeurism, sodomy, sexual exploitation
Emotional Abuse	Adult behavior that damages a child's psychologically, emotionally, and/or spiritually.	Verbal threats, demeaning or insulting behavior(s), forced social isolation, exploitation, terrorizing, constant unrealistic demands on the child
Neglect	Failure of a parent/ caregiver to provide for the basic physical and/or psychological needs of a child.	Failure to supervise resulting in physical or sexual harm, physical, Medical, educational neglect, failure to provide psychological treatment, abandonment
Exposure to Family violence	Witnessing violence that occurs in the home between parental figures, caregivers, and/or other members of the family	Child seeing, hearing, or being exposed to signs of violence (bruises, other physical injuries, property destroyed)

Jack, S., Munn, C., Cheng, C., & MacMillan, H. (2006). *Child maltreatment in Canada: National Clearinghouse on Family Violence*. Ottawa, ON: Public Health Agency of Canada.

Key Points on Brain Development

The information provided on brain development provides the foundation for understanding and exploring brain structures and the impact trauma has on these structures. This information is vital for counselors who work with traumatized children regarding accurate assessments, creation of realistic and achievable goals, and treatment strategies. Understanding how the brain develops can prevent a counselor from unintentionally re-traumatizing his or her client.

All necessary brain structures are present at birth. After birth the brain continues to develop at a rapid pace.

The brain is not completely developed until a person's early twenties.[7]

The brain develops in a sequential and hierarchical manner meaning different areas of the brain develop and become fully functioning at different times during childhood. Areas of the brain that are responsible for basic functioning and our survival, for example the ability to breathe develops prior to birth; whereas our most complex functioning (abstract thinking) fully develop in early adulthood.[8]

The majority of brain development occurs during childhood meaning this time has the most powerful and enduring effect on how the brain develops and functions.

---

[7] Heide, K., & Solomon, E. (2006). Biology, childhood trauma, and murder: Rethinking justice. *International Journal of Law and Psychiatry, 29*, 220-233.

[8] Perry, B., Pollard, R., Blakley, T., Baker, W., & Vigilante, D. (1995). Childhood trauma, the neurobiology of adaptation, and "use-dependent" development of the brain: How "states" become "traits". *Infant Mental Health Journal, 16*(4), 271-291.

The brain develops in a use-dependant fashion. The more something is experienced the stronger and more established that part of the system in the brain becomes. For instance, for a child to develop the ability for speech, he or she has to be spoken to regularly.[9] In the same way, a child will not feel safe in his or her environment unless s/he has experienced safety, such as being raised in a safe nurturing environment.

The brain processes and gives meaning to all experiences. As new information/experiences occur the brain filters it through previous experiences as a way to make sense of this information.[10] For a child who has experienced trauma, new experiences become linked and are associated with and resemble the past traumatic experience. Previous minor stressors that the child did not have a response to, now result in a response that is similar to that of when the child is experiencing a real or perceived threat. For example, a female child that had been sexually assaulted by her uncle, she may interpret her male coach placing his hand on her shoulder in a friendly manner as threatening.

The brain is considered plastic or malleable, as it is capable of changing according to repetitive patterned experiences.[11] However not all parts of the brain are equally malleable. The brainstem (responsible for basic functioning) is not malleable once it is developed but the cortex (responsible for complex functioning) remains malleable throughout life.[12] This plasticity allows for new learning to occur. For example, adults who have been abused as children, are able to learn new coping strategies and relaxation techniques as a way to heal from their past trauma.

---

[9] Perry, B., Pollard, R., Blakley, T., Baker, W., & Vigilante, D. (1995). Childhood trauma, the neurobiology of adaptation, and "use-dependent" development of the brain: How "states" become "traits". *Infant Mental Health Journal, 16*(4), 271-291.

[10] Glaser, D. (2000). Child abuse and neglect and the brain-A review. *Journal of Child Psychology and Psychiatry, 41*(1), 97-116.

[11] Perry, B. (2006). Applying principles of neurodevelopment to clinical work with maltreated and traumatized children. In N. Boyd Webb (Ed.). *Working with traumatized youth in child welfare* (pp. 27-52). New York, NY: The Guilford Press.

[12] Perry, B. (2002). Childhood experience and the expression of genetic potential: What childhood neglect tells us about nature and nurture. *Brain and Mind, 3*, 79-100

The Triune Brain

The Triune Brain Model divides the brain into three major areas, the brainstem, the limbic system, and the cortex and proposes that the brain has a hierarchical organization in which the top area of the brain is more complex than the lower area.[13]

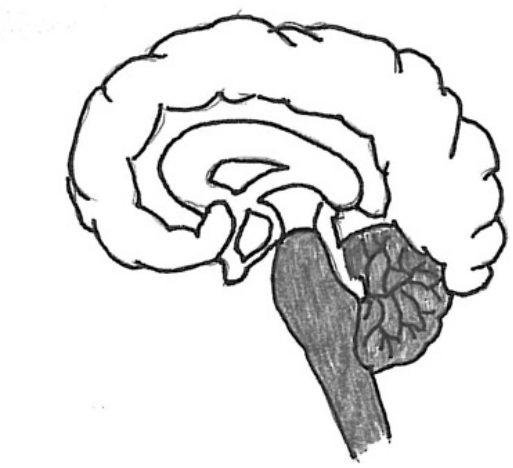
Repeated trauma alters the structure and functions of the brain.

The Brainstem

The brainstem is the first region of the brain to develop prior to birth.

It is responsible for regulating basic cardiovascular functions and any other functions associated with our survival, which include breathing, heartbeat, and blood pressure.[14]

Figure 1. Shaded area represents the location of the brainstem.



[13] Stien, P., & Kendall, J. (2004). *Psychological Trauma and the Developing Brain*. Binghamton, NY: The Haworth Maltreatment and Trauma Press.

[14] Ziegler, D. (2002). *Traumatic Experience and the brain: A handbook for understanding and treating those traumatized as children.* Jasper, OR: Acacia Publishing Inc.

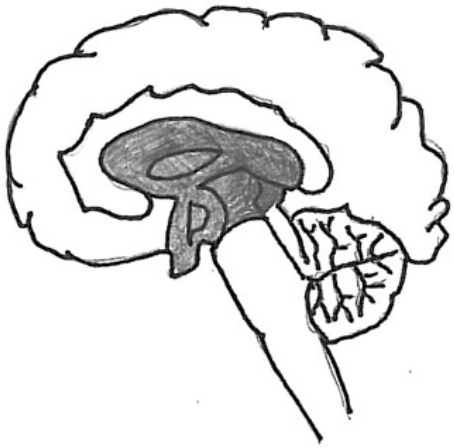
The Limbic System

The limbic system is the second area of the brain to develop and it is often referred to as the emotional brain because it is the source of our urges, needs, and emotions.[15]

The limbic system is the area in the brain that regulates emotions, memory, perception, impulse control, appetite, sleep, and body chemistry.[16] The limbic system impacts learning, behaviour, and our emotional states.[17]

The three main structures in the limbic system are, the hypothalamus, the hippocampus, and the amygdala.

Figure 2. Shaded area represents the location of the limbic system in the brain.



[15] Stien, P., & Kendall, J. (2004). *Psychological Trauma and the Developing Brain*. Binghamton, NY: The Haworth Maltreatment and Trauma Press.

[16] Ziegler, D. (2002). *Traumatic Experience and the brain: A handbook for understanding and treating those traumatized as children.* Jasper, OR: Acacia Publishing Inc.

[17] Weber, D., & Reynolds, C. (2004). Clinical perspectives on neurobiological effects of psychological trauma. *Neuropsychology Review, 14*(2), 115-129.

The Hypothalamus

Function	Impact of Trauma
Maintain normalcy in the brain by regulating critical functions such as blood pressure, body temperature, and glucose levels.[18] It is a key part of the hypothalamic-pituitary-adrenal (HPA) axis that is vital in the stress response.	Prolonged trauma produces an enduring sensitization of the HPA system resulting in its not functioning properly.

The Hippocampus

Function	Impact of Trauma
Plays a critical role in memory function, learning, emotional regulation, and behavior inhibition. [19]	Repeated trauma has been associated with deficits in memory, cognitive impairments, ineffective coping responses, dissociation, problems processing and storing spatial information, and impairments in associative learning.[20] Interpretations of incoming information and normal categorization and evaluation of experiences are also negatively impacted. [21]

[18] Stien, P., & Kendall, J. (2004). *Psychological Trauma and the Developing Brain*. Binghamton, NY: The Haworth Maltreatment and Trauma Press.

[19] Anda, R., Felitti, V., Bremner, D., Walker, J., Whitfield, C., Perry, B., et al. (2005). The enduring effects of abuse and related adverse experiences in childhood. *European Archives of Psychiatry and Clinical Neuroscience, 256*(3), 174-186.

[20] Diseth, T. (2005). Dissociation in children and adolescents as reaction to trauma-an overview of conceptual issues and neurobiological factors. *Nordic Journal of Psychiatry, 59*, 79-91.

[21] Weber, D., & Reynolds, C. (2004). Clinical perspectives on neurobiological effects of psychological trauma. *Neuropsychology Review, 14*(2), 115-129.

The Amygdala

Function	Impact of Trauma
Emotions are processed in this region of the brain. It is involved in the memory of emotional reactions and evaluating the meaning of incoming information.[23] It has a role in the controlling aggressive, sexual behaviors, and in mediating the fear response.[25]	During a traumatic event the amygdala automatically remembers all elements of the experience (smells, sounds, sensations).[22] Prolonged trauma can over stimulate the amygdala leading to hyper-arousal in the form of aggression, anxiety, and impulsivity.[24]

[22] Heide, K., & Solomon, E. (2006). Biology, childhood trauma, and murder: Rethinking justice. *International Journal of Law and Psychiatry, 29*, 220-233.

[23] Siegel, D., & Hartzell, M. (2003). *Parenting from the inside out*. New York, NY: Jeremy P. Tarcher/Penguin.

[24] Stien, P., & Kendall, J. (2004). *Psychological Trauma and the Developing Brain*. Binghamton, NY: The Haworth Maltreatment and Trauma Press.

[25] Teicher, M., Andersen, S., Polcari, A., Anderson, C., Navalta, C., & Kim, D. (2003). The neurobiological consequences of early stress and childhood maltreatment. *Neuroscience and Biobehavioral Reviews, 27*, 33-44.

The Cortex

The cortex is the last region of the brain to develop and controls the brain's most complex functions such as, abstract thinking, reflection, auditory processing, planning, language and speech, and complex motor action.[26]

All aspects of a child's life, including his or her psychological, academic, social, and physical life can be affected by the underdevelopment of the cortex.[27]

The prefrontal cortex and the corpus callosum are two structures in the cortex.

Figure 3. Shaded area represents the location of the cortex in the brain.

[26] Stien, P., & Kendall, J. (2004). *Psychological Trauma and the Developing Brain*. Binghamton, NY: The Haworth Maltreatment and Trauma Press.

[27] Perry, B. (2002). Childhood experience and the expression of genetic potential: What childhood neglect tells us about nature and nurture. *Brain and Mind, 3*, 79-100.

The Prefrontal Cortex

Function	Impact of Trauma
It communicates with almost every other structure in the brain and filters out unnecessary incoming information so only information related to the particular experience is processed.[29] It plays an important role in planning, judgment, controlling impulsivity, and creates meaning.[30]	Inattention, impulsivity, and inferior academic achievement, poor judgment, poor reasoning, and limited self-monitoring.[28] Damage to the prefrontal cortex weakens the child's ability to understand all social interactions, which can then lead to misinterpretations of the child's behaviour.[31]

[28] De Bellis, M. (2005). The psychobiology of neglect. *Child Maltreatment, 10*(2), 150-172.

[29] Weiss, S. (2007). Neurobiological alterations associates with traumatic stress. .*Perspectives in Psychiatric Care, 43*(3), 114-122.

[30] Diseth, T. (2005). Dissociation in children and adolescents as reaction to trauma-an overview of conceptual issues and neurobiological factors. *Nordic Journal of Psychiatry, 59*, 79-91.

[31] Bremner, D. (2005). Effects of traumatic stress on brain structure. *Journal of Trauma and Dissociation, 6*, 51-68.

Corpus Callosum

Function	Impact of Trauma
It is a bundle of nerves that link the two hemispheres of the brain allowing information to travel across. The left hemisphere specializes in perception, and expression of language. It is logical and analytical.[33] The right hemisphere specializes in the perception and expression of emotion, spatial abilities, face recognition, visual imagery, and musical ability.[34]	Interrupted communication between the two hemispheres may lead to difficulties in expressing emotions, coordination, translating symbols into language, and memory.[32] A child who has experienced trauma may act out impulsively and strike another child that s/he is angry with due to his or her difficulty in regulating his or her emotions and thoughts.

[32] Weber, D., & Reynolds, C. (2004). Clinical perspectives on neurobiological effects of psychological trauma. *Neuropsychology Review, 14*(2), 115-129.

[33] Teicher, M., Andersen, S., Polcari, A., Anderson, C., Navalta, C., & Kim, D. (2003). The neurobiological consequences of early stress and childhood maltreatment. *Neuroscience and Biobehavioral Reviews, 27*, 33-44.

[34] Teicher, M., Andersen, S., Polcari, A., Anderson, C., & Navalta, C. (2002). Developmental neurobiology of childhood stress and trauma. *Psychiatric Clinics of North America, 25*(2), 397-426.

The Stress Response

The stress response is a physiological coping mechanism to help human bodies physiologically respond to and repair after a traumatic event (perceived or actual).[35] Initiation of the stress response begins a process where numerous chemical and hormonal changes occur in the brain.[36] These changes occur as a way for the brain to return to a balanced state. For more detailed information on the stress response including how it is activated, chemicals and hormones involved, brain structures involved, as well as the process to restore balance to the brain, can be found in my project.[37]

If the stress response continues to be activated, meaning the real or perceived threat is still present, the brain responds by preparing to fight-flight-freeze and/or dissociate.

[35] Glaser, D. (2000). Child abuse and neglect and the brain-A review. *Journal of Child Psychology and Psychiatry, 41*(1), 97-116.

[36] Osofsky, J. (Ed.). (2004). *Young children and trauma: Intervention and treatment*. New York, NY: The Guilford Press.

[37] Kirouac, S. (2009). *Supplementary handout package*: *Impact of childhood trauma on brain development.* Calgary, AB: Athabasca University.

Fight-Flight-Freeze

A common first reaction when confronted with an ongoing threat is to freeze. By freezing the child can organize, make a plan, and figure out how to respond to the threat.[38] For example, a child who unexpectedly gets yelled at from a teacher may initially freeze as a way to figure out whether this is a threatening situation and action is required. It the child feels threatened then the freezing may escalate to a fight or flight response.

The fight or flight reaction begins during the early stages of a threat and is characterized by the child being hyper-aroused. The child's heart rate, blood pressure, respiration, and muscle tone increase, and a sense of hyper-vigilance develops that prepares the child for action by either fighting or running away.[39]

Extreme anxiety, hyper-vigilance, and the continuous activation of the stress response weaken the child's academic and socio-emotional learning.[40] This happens because a child in a state of hyper-vigilance (due to his or her fear) is activating the limbic system (emotions) and not the cortex (abstract thinking).[41] For example, a child that has been recently yelled at by the teacher feels threatened and is in a state of hyper-vigilance. S/he is no longer focusing on the words the teacher is saying only his or her nonverbal behaviour such as, his or her eye contact, body language, facial expression, and tone of voice.

A child raised in an abusive home has learned that non-verbal information is more important than the verbal information.[42]

---

[38] Perry, B., & Pollard, R. (1998). Homeostasis, stress, trauma and adaptation: A neurodevelopmental view of childhood trauma. *Child and Adolescent Psychiatric Clinics of North America, 7*, 1-33.

[39] Perry, B., Pollard, R., Blakley, T., Baker, W., & Vigilante, D. (1995). Childhood trauma, the neurobiology of adaptation, and "use-dependent" development of the brain: How "states" become "traits". *Infant Mental Health Journal, 16*(4), 271-291.

[40] Perry, B. (2006). Applying principles of neurodevelopment to clinical work with maltreated and traumatized children. In N. Boyd Webb (Ed.). *Working with traumatized youth in child welfare* (pp. 27-52). New York, NY: The Guilford Press.

[41] Perry, B. (1997). Incubated in terror: Neurodevelopmental factors in the cycle of violence. In J. Osofsky (Ed.). *Children in a violent society* (pp.124-147). New York, NY: Guilford Publications.

[42] Perry, B. (2001). The neurodevelopmental impact of violence in childhood. In D. Schetky & E. Benedek (Eds.). *Textbook of child and adolescent forensic psychiatry*. (pp. 221- 238). Washington, DC: American Psychiatric Press, Inc.

Dissociation

Another common reaction to threat (real or perceived) is dissociation.

Dissociation is when the person focuses on his or her internal world instead of his or her external world.[43] Meaning the person goes inside his or her head as a way to not be aware of what is happening in the real world, separating themselves from the real world.

Dissociation is not necessarily the same experience for everyone. There appears to be a process that can occur with people ranging from, distraction, daydreaming, fantasy, avoidance, depersonalizing, and in some circumstance fainting and catatonia.[44]

Dissociative techniques that are used by children and adults that have experienced trauma, can include, mentally going to a different place, taking on a persona of a superhero or animal, and/or feeling as if they are watching a movie they are part of.[45] For example, a child that is being sexually assaulted by his or her sibling may dissociate by mentally going to his or her fantasy world during the time of the assault. This allows the child to detach him or herself from the traumatic experience.

Dissociation frequently can create a distorted sense of time, diminished sense of pain and sometimes a feeling that what is happening to them is not real.[46]

---

[43] Perry, B. (2003). *Effects of Traumatic Events on Children*. The ChildTrauma Academy. Retrieved September 12, 2008, from http://www.childtrauma.org

[44] Perry, B. (2001). The neurodevelopmental impact of violence in childhood. In D. Schetky & E. Benedek (Eds.). *Textbook of child and adolescent forensic psychiatry*. (pp. 221- 238). Washington, DC: American Psychiatric Press, Inc.

[45] Perry, B., & Pollard, R. (1998). Homeostasis, stress, trauma and adaptation: A neurodevelopmental view of childhood trauma. *Child and Adolescent Psychiatric Clinics of North America, 7*, 1-33.

[46] Mulvihill, D. (2005). The health impact of childhood trauma: An interdisciplinary review, 1997-2003. *Issues in Comprehensive Pediatric Nursing, 28*, 115-136.

Additional Resources

If you want to learn more about the brain, childhood trauma, and interventions for traumatized children please refer to these available resources.

Books

Gill, E. (2006). *Helping abused and traumatized children: Integrating directive and nondirective approaches.* New York, NY: The Guilford Press.

Greenwald, R. (2005). *Child trauma handbook: A guide for helping trauma-exposed children and adolescents.* New York, NY: Routledge Taylor & Francis Group.

Herman, J. (1997). *Trauma and recovery*. New York, NY: Basic Books.

Malchiodi, C. (Ed.), (2008). *Creative interventions with traumatized children.* New York, NY: The Guilford Press.

Osofsky, J. (Ed.), (2004). *Young children and trauma: Interventions and treatment*. New York, NY: The Guilford Press.

Perry, B., & Szalavitz, M. (2006). *The boy who was raised as a dog and other stories from a child psychiatrist's notebook.* New York, NY: Basic Books.

Ziegler, D. (2002). *Traumatic experience and the brain: A handbook for understanding and treating those traumatized as children.* Jasper, OR: Acacia Publishing Inc.

Websites

John Briere Ph.D.: http://www.johnbriere.com
Child Trauma Academy: http://www.childtrauma.org
Trauma Center: http://www.traumacenter.org
The National Child Traumatic Stress Network: http://www.nctsnet.org
David Baldwin's Trauma Information Pages: http://www.trauma-pages.com

Reference

Anda, R., Felitti, V., Bremner, D., Walker, J., Whitfield, C., Perry, B., et al. (2005). The enduring effects of abuse and related adverse experiences in childhood. *European Archives of Psychiatry and Clinical Neuroscience, 256*(3), 174-186.

Bremner, D. (2005). Effects of traumatic stress on brain structure. *Journal of Trauma and Dissociation, 6*, 51-68.

De Bellis, M. (2005). The psychobiology of neglect. *Child Maltreatment, 10*(2), 150-172.

Davies, M. (2002). A few thoughts about the mind, the brain, and a child with early deprivation. *Journal of Analytical Psychology, 47*, 421-435.

Diseth, T. (2005). Dissociation in children and adolescents as reaction to trauma-an overview of conceptual issues and neurobiological factors. *Nordic Journal of Psychiatry, 59*, 79-91.

Dripchak, V. (2007). Posttraumatic Play: Towards acceptance and resolution. *Clinical Social Work Journal, 35*, 125-134.

Glaser, D. (2000). Child abuse and neglect and the brain-A review. *Journal of Child Psychology and Psychiatry, 41*(1), 97-116.

Heide, K., & Solomon, E. (2006). Biology, childhood trauma, and murder: Rethinking justice. *International Journal of Law and Psychiatry, 29*, 220-233.

Jack, S., Munn, C., Cheng, C., & MacMillan, H. (2006). *Child maltreatment in Canada: National Clearinghouse on Family Violence*. Ottawa, ON: Public Health Agency of Canada.

Kirouac, S. (2009). *Supplementary handout package: Impact of childhood trauma on brain development.* Calgary, AB: Athabasca University.

Mulvihill, D. (2005). The health impact of childhood trauma: An interdisciplinary review, 1997-2003. *Issues in Comprehensive Pediatric Nursing, 28*, 115-136

Ogawa, Y. (2004). Childhood trauma and play therapy intervention for traumatized children. *Journal of Professional Counseling: Practice, Theory, & Research, 32*(1), 19-29.

Osofsky, J. (Ed.). (2004). *Young children and trauma: Intervention and treatment*. New York, NY: The Guilford Press.

Perry, B., Pollard, R., Blakley, T., Baker, W., & Vigilante, D. (1995). Childhood trauma, the neurobiology of adaptation, and "use-dependent" development of the brain: How "states" become "traits". *Infant Mental Health Journal, 16*(4), 271-291.

Perry, B. (1997). Incubated in terror: Neurodevelopmental factors in the cycle of violence. In J. Osofsky (Ed.). *Children in a violent society* (pp.124-147). New York, NY: Guilford Publications.

Perry, B., & Pollard, R. (1998). Homeostasis, stress, trauma and adaptation: A neurodevelopmental view of childhood trauma. *Child and Adolescent Psychiatric Clinics of North America, 7*, 1-33.

Perry, B. (2001). The neurodevelopmental impact of violence in childhood. In D. Schetky & E. Benedek (Eds.). *Textbook of child and adolescent forensic psychiatry*. (pp. 221-238). Washington, DC: American Psychiatric Press, Inc.

Perry, B. (2002). Childhood experience and the expression of genetic potential: What childhood neglect tells us about nature and nurture. *Brain and Mind, 3*, 79-100.

Perry, B. (2003). *Effects of Traumatic Events on Children*. The ChildTrauma Academy. Retrieved September 12, 2008, from http://www.childtrauma.org

Perry, B. (2006). Applying principles of neurodevelopment to clinical work with maltreated and traumatized children. In N. Boyd Webb (Ed.). *Working with traumatized youth in child welfare* (pp. 27-52). New York, NY: The Guilford Press.

Siegel, D., & Hartzell, M. (2003). *Parenting from the inside out*. New York, NY: Jeremy P. Tarcher/Penguin.

Stien, P., & Kendall, J. (2004). *Psychological Trauma and the Developing Brain*. Binghamton, NY: The Haworth Maltreatment and Trauma Press.

Teicher, M., Andersen, S., Polcari, A., Anderson, C., & Navalta, C. (2002). Developmental neurobiology of childhood stress and trauma. *Psychiatric Clinics of North America, 25*(2), 397-426.

Teicher, M., Andersen, S., Polcari, A., Anderson, C., Navalta, C., & Kim, D. (2003). The neurobiological consequences of early stress and childhood maltreatment. *Neuroscience and Biobehavioral Reviews, 27*, 33-44.

Weber, D., & Reynolds, C. (2004). Clinical perspectives on neurobiological effects of psychological trauma. *Neuropsychology Review, 14*(2), 115-129.

Weiss, S. (2007). Neurobiological alterations associates with traumatic stress. *Perspectives in Psychiatric Care, 43*(3), 114-122.

Ziegler, D. (2002). *Traumatic Experience and the brain: A handbook for understanding and treating those traumatized as children.* Jasper, OR: Acacia Publishing Inc.