



# The neurobiology of child maltreatment

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Melbourne  
Children's  
Excellence in  
clinical care,  
research and  
education



# Outline

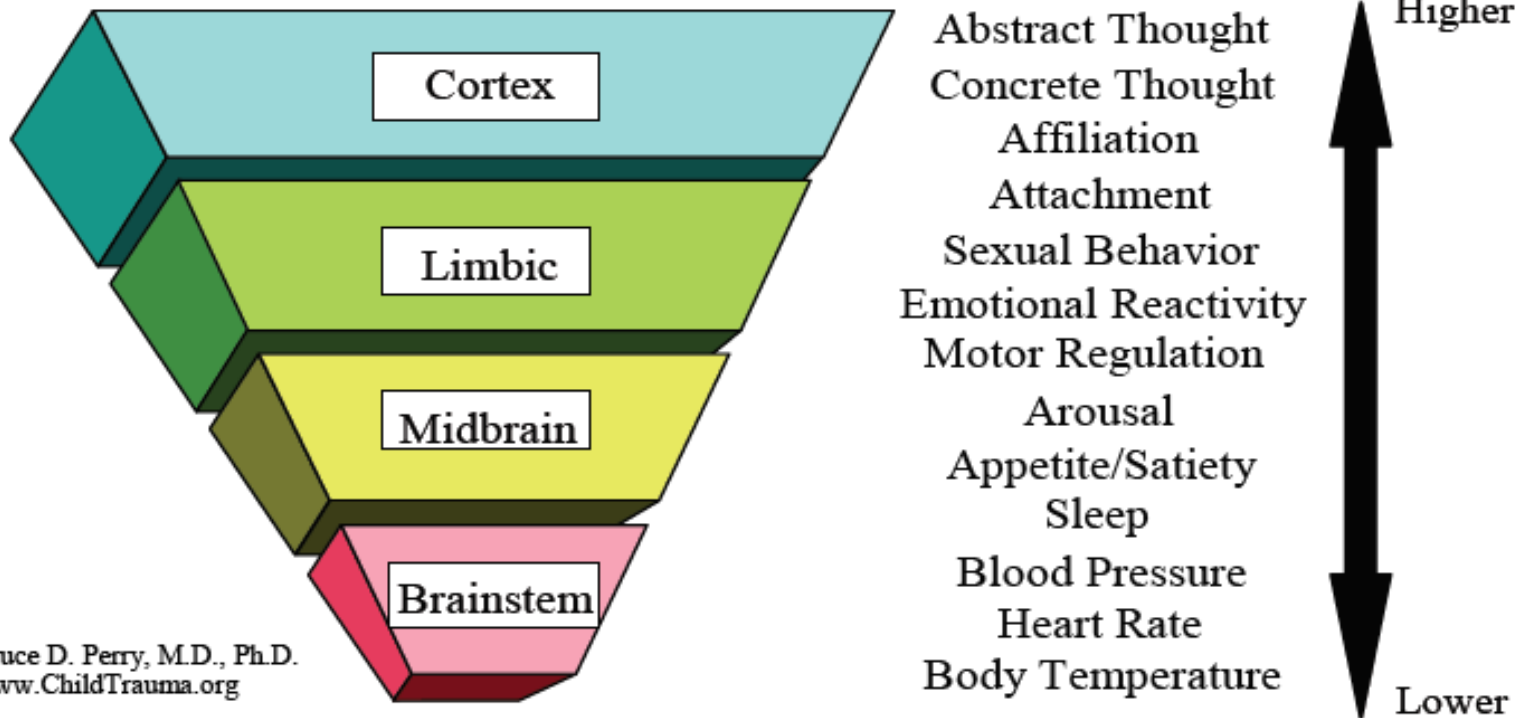
- Brain Development
- Effects of maltreatment on brain
  - Structure
  - Neurochemical pathways
- Effects of maltreatment on child
  - Emotional/behavioural
  - Learning
  - Physical health

# Child Maltreatment

- chronic neglect
- physical abuse
- sexual abuse
- emotional abuse
- medical abuse
- exposure to IPV

# Early Brain Development

**Exhibit 1 – Functions of Brain Regions**



Bruce D. Perry, M.D., Ph.D.  
www.ChildTrauma.org

# The Growing Child's Brain

- Brain development is the process of creating, strengthening and discarding synapses
- At birth
  - very few synapses have been formed
  - mainly for bodily functions
- Synapses develop in early years in response to a child's experiences

- At its peak in a healthy toddler - 2 million synapses per second
- At 2 years of age - 100 trillion synapses
- Pruning - synapse elimination
  
- Adolescence - about half synapses have been discarded

- Myelination also occurs in the same order
- Occurs in response to a child's experiences
- By 3 years of age: brain reached 90% of adult size

# Adolescent Brain Development

- Brain continues to grow and develop (into mid 20s)
- Before puberty
  - growth in frontal lobe
  - executive functioning
- Pruning and myelination occurs last in frontal lobe
- Growth of the limbic system



# Plasticity

*Brain's ability to change in response to repeated stimulation*

- Dependent on the stage of development and particular region affected
- Lower part of brain less flexible
- “Use it or lose it”
- Overall plasticity decreases as child gets older, but some degree remains- allows us to keep learning

# Sensitive Periods

*Windows of time in the developmental process when certain parts of the brain may be more susceptible to particular experiences*

- E.g. Animals that are artificially blinded during sensitive period may never develop capability to see even if blinding mechanism removed
- ?Similar in neglectful situations
- Plasticity can allow recovery from missing experiences, but can be more difficult later in life

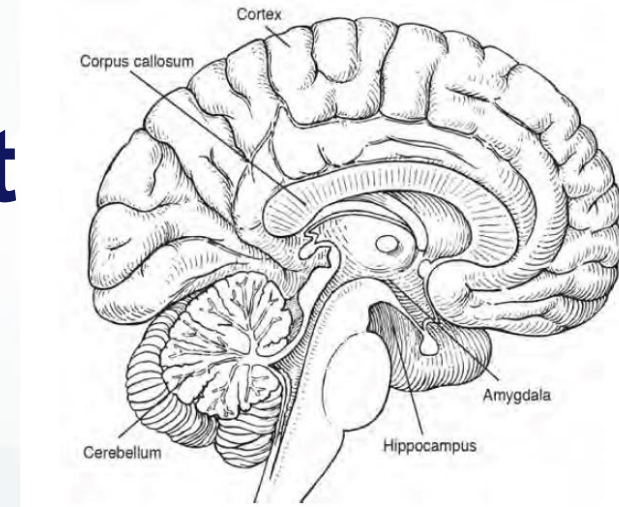
# Stress

- **Positive stress**
  - moderate, brief
  - normal part of life and healthy development
  - e.g. childcare
- **Tolerable stress**
  - events that have the potential to alter the developing brain negatively
  - occur infrequently
  - allow brain recovery time
  - e.g. death of family member
- **Toxic stress**
  - strong, frequent, prolonged activation of the body's stress response system
  - e.g. chronic neglect

- Healthy stress response
  - Activation of hormone/neurochemical system - cortisol, adrenaline
  - **Hormones return to normal after stressful experience has passed**
- Toxic stress
  - **Prolonged activation of the body's stress response system**

# Effects of Maltreatment

- **Corpus callosum**
  - arousal, emotion, higher cognitive ability
  - decreased volume
- **Cerebellum**
  - motor co-ordination, executive functioning
  - decreased volume

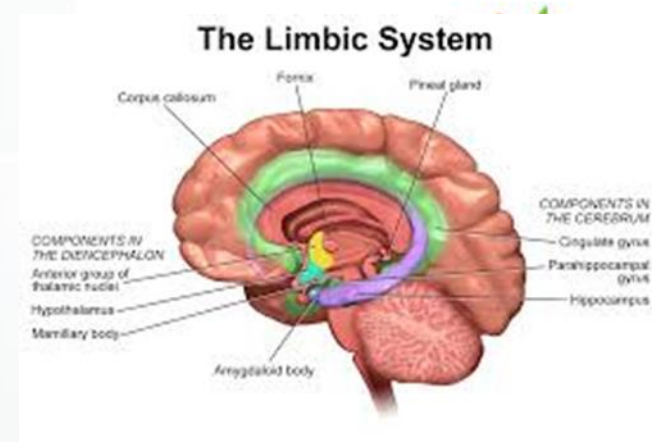


- **Hippocampus**

- learning and memory
- reduced volume
- reduced ability to normalise cortisol levels after stressful event

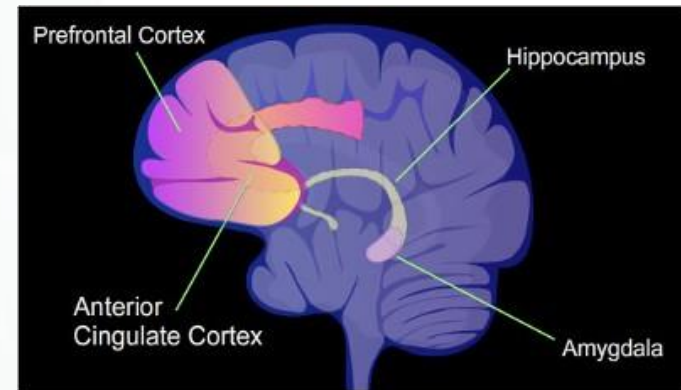
- **Amygdala**

- emotional processing, behavioural regulation, fear conditioning and memory for emotional events
- assesses whether stimulus is threatening and triggers emotional response
- volume not affected but overactivity
- Amygdala is activating



- **Prefrontal cortex**

- centre of executive function
- attention, working memory
- inhibitory control of impulsive behaviour
- personality expression, emotion, motivation regulation, moderating learned social behaviour
- decreased volume vs no change
- impaired functioning
- inhibitory control over activation of amygdala and stress response
- matures later in life



- Hippocampus and prefrontal cortex are inhibitory over activation of stress response
- Amygdala is activating of stress response

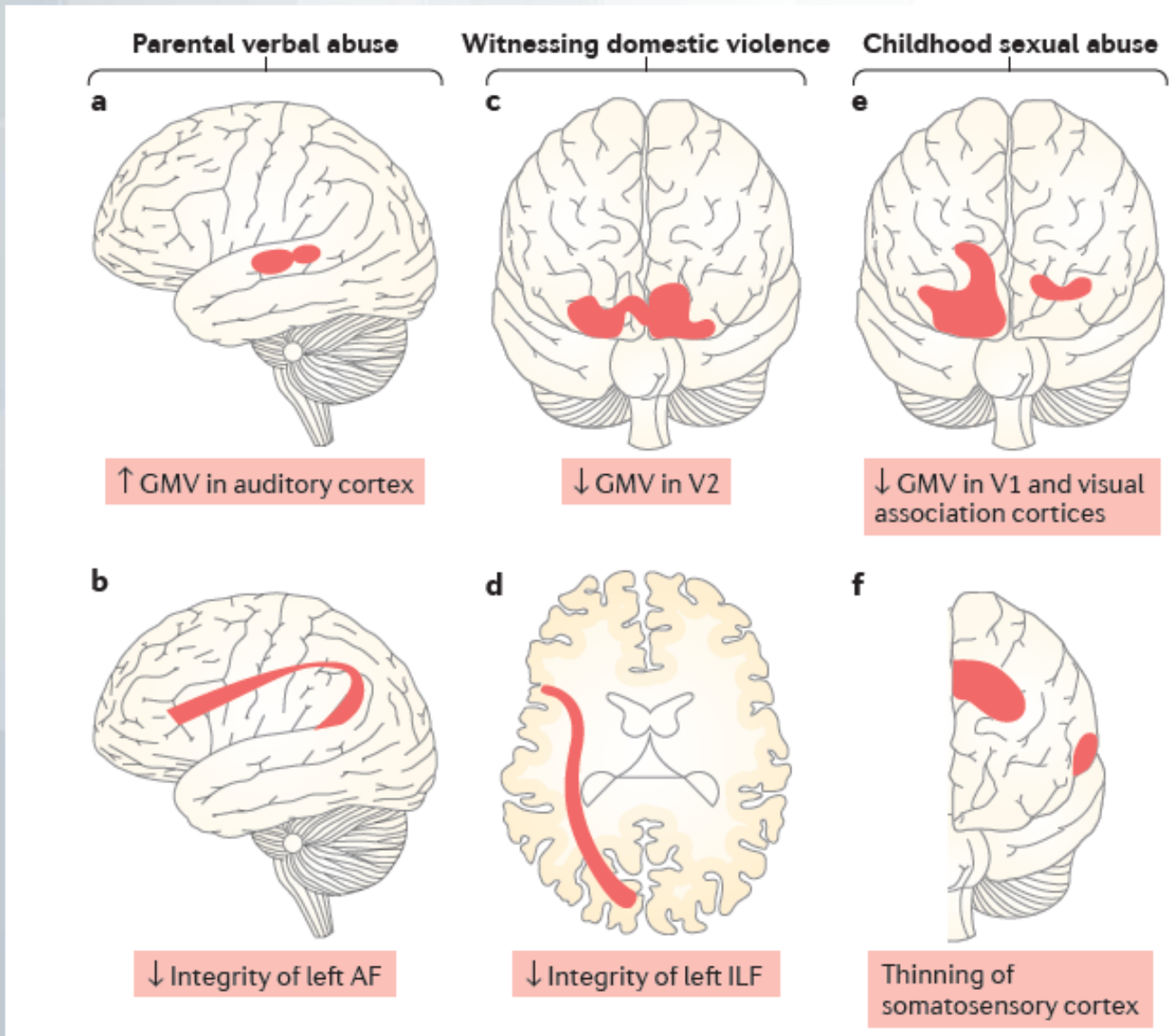


- **Hypothalamic-pituitary-adrenal (HPA)axis**
  - activates hypothalamus to secrete CRH
  - pituitary secretes ACTH
  - adrenal cortex secretes cortisol
- **Locus Coeruleus Noradrenergic (LC-NA)system**
  - increases noradrenaline
  - elevates arousal, vigilance and anxiety
- NA and HPA systems are mutually excitatory- act together in positive feedback loop
- **Autonomic nervous system- sympathetic nervous system**
  - adrenal medulla secretes adrenaline and noradrenaline

# Cortisol

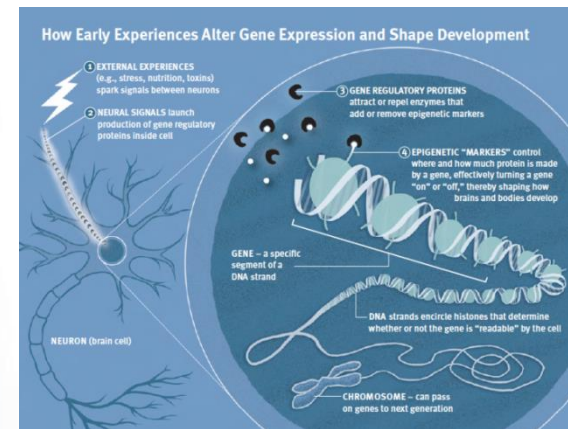
- Normal sharp increase in cortisol in morning and steady decrease during day
- In maltreated children
  - Higher levels vs lower morning cortisol levels and flatter release during day

- Lower cortisol levels
  - decreased energy
  - affects learning, socialisation
  - externalising disorders
  - increased vulnerability to autoimmune disorders
- Higher cortisol levels
  - harm cognitive processes
  - subdue immune and inflammatory reactions
  - heighten risk for affective disorders



Teicher et al. Nature Reviews. 2016

# Epigenetics



- Alterations to genes that do not include structural change to DNA and control whether gene is expressed
- Child maltreatment can cause epigenetic modifications in victims
- In maltreated PTSD individuals, more epigenetic changes in genes associated with CNS and immune system than non-maltreated PTSD individuals

# Effects of Maltreatment on Behavioural, Social and Emotional Functioning

- **Persistent Fear Response**
  - chronic activation of stress pathways
  - lose ability to differentiate danger and safety
  - PTSD, anxiety disorders
- **Hyperarousal**
  - hyperalert for danger
  - fear response automatically triggers response without conscious thought
  - highly sensitive to non verbal cues e.g. eye contact or touch and misinterpret
  - learning difficulties
  - complicated social interactions
  - challenging to navigate social situations, perceive threat

- **Increased Internalizing Symptoms**
  - structural and chemical changes in areas involved in emotion and stress regulation
    - anxiety, depression
  - alter ability to use neurotransmitters such as serotonin
    - produce feelings of wellbeing and emotional stability

# Effects of Maltreatment on Learning

- **Failure to provide adequate learning opportunities/stimulation**
  - Delayed developmental milestones
- **Diminished Executive Functioning**
  - Working memory, inhibitory control, cognitive or mental flexibility
- **Neurocognitive development**
  - Learning difficulties, inattention, verbal deficiency, poor school performance



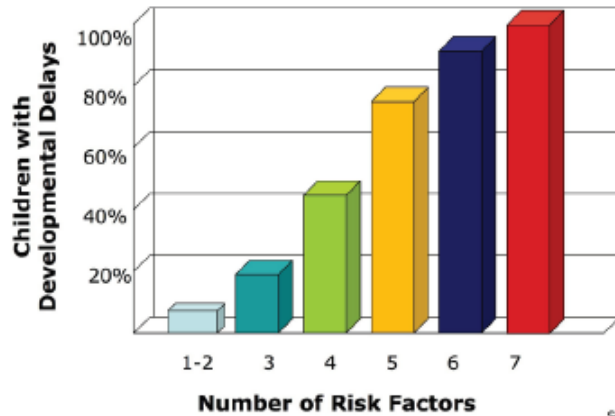
# Effects of Maltreatment on Physical Health

- The ACE (Adverse Childhood Experience) Study
  - Abuse
    - Psychological abuse
    - Physical abuse
    - Sexual abuse
  - Household dysfunction
    - Substance abuse
    - Mental illness
    - Mother treated violently
    - Criminal behaviour

- Strong graded relationship between the breadth of exposure to abuse or household dysfunction during childhood and multiple risk factors for several leading causes of death in adults

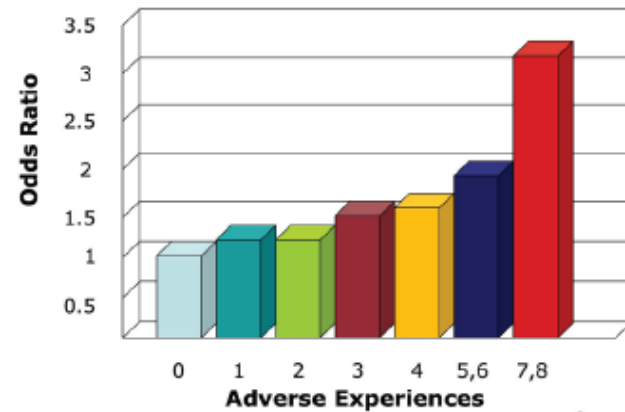


## Significant Adversity Impairs Development in the First Three Years



Source: Barth et al. (2008)

## Risk Factors for Adult Heart Disease are Embedded in Adverse Childhood Experiences



Source: Dong et al, 2004

# Summary

- Chronic maltreatment
  - Disrupts the way children's brains develop and process information
  - Alters the biological stress-response system
  - Associated with significant risk
    - emotional and interpersonal difficulties, mental health
    - learning and behavioural difficulties
    - metabolic disease, physical health

- Research also indicates that supportive, responsive relationships with caring adults as early in life as possible can prevent or reverse the damaging effects of toxic stress response

- <https://www.youtube.com/watch?v=7FC4qRD1vn8&feature=youtu.be>

# References

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