THE NEUROBIOLOGY AND GENETICS OF CHILDHOOD MALTREATMENT

What happens when development is not normative?

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Tom grew up with his Mother, Step-Father and younger brother. Both his parents used drugs and drank heavily. Tom often witnessed violence and arguments at home and was often shouted at and hit by his Step-Father. He didn’t always go to school because he was worried his clothes were dirty and he would be bullied.

At the age of 8 Tom and his brother were removed from home, and after 3 placements were settled in a permanent foster family. Tom had serious behavioural problems at school. He also missed his mum even though he knew she couldn’t look after him.

In adolescence Tom was arrested for hitting another boy. As an adult he found relationships difficult and was often depressed. By contrast, Tom’s half brother did well at school, and secured a regular job, and later settled in a stable relationship.
How many UK children have this kind of ‘non-normative’ experience? *

- Serious Physical Abuse: 7%
- Neglect (serious absence of care): 6%
- Frequent / Severe Emotional Abuse: 6%
- Childhood Domestic Violence: reported in 26% of young adults

Majority of maltreated children experience more than one kind of abuse.

Maltreatment significantly increases the risk of:

> Depression
> Anxiety
> Personality Disorders
> Conduct problems

...during childhood and adulthood.
GENES

NEUROCOGNITIVE FACTORS

ENVIRONMENT

CHILD BEHAVIOUR
1. **Gene X Environment Interaction**
   Could the genes Tom and his brother carry mean that they responded to their care-giving experiences differently?

2. **Brain Function**
   How might Tom’s exposure to physical abuse alter how he processes emotion?

3. **Brain Structure**
   How might the experience of maltreatment affect the structural development of Tom’s brain?

4. **Resilience and Recovery**
   Are the effects of Tom’s early experience fixed and permanent?
1. Gene X Environment Interaction

Could the genes Tom and his brother carry mean that they responded to their experiences differently?
Genetic Influences

- Genetic influences have been shown for a range of psychiatric problems associated with maltreatment - e.g. PTSD, Depression and antisocial behaviour. Koenen et al., 2009; Sullivan et al., 2000; Rhee & Waldman, 2002

- There are no ‘genes’ for these disorders - rather many genetic variants adding a small increment of risk or vulnerability. Plomin et al., 1994

- Genetic variants are likely to act biasing the functioning of several brain and hormonal circuits important for effecting a stress response. Viding et al., 2006
• Altered serotonin functioning is associated with depression

• The serotonin transporter helps removes serotonin from the synapse, terminating its action

• There are two different forms of the gene: Short allele: S - Long allele: L.

• We each have two alleles – most of us have at least one copy of the L allele.
Amygdala Response: s Group > l Group

First Cohort
(N = 14)

Second Cohort
(N = 14)
No differences in symptoms of depression

NORMAL PARENTING
Significantly more likely to show symptoms of depression

‘Risk’ genotype
Children who have experienced maltreatment are more likely to show depression if they carry two copies of the S allele (SS).
Risk of depression

**GENES**

- **S/S 5HTT**

**MALTREATMENT**

- Regular contact with a trusted adult

Risk of depression
Better Social Functioning?

? S/S may represent an adaptive genotype in good care-giving environments

This remains an hypothesized effect
Do the genes Tom and his brother carry mean that they responded to their care-giving experiences differently?

- The additive effects of a range of genetic variants contribute to a child’s relative vulnerability or resilience to psychopathology following maltreatment. Evidence now exists in relation to Depression, Antisocial Behaviour and Post Traumatic Stress Disorder.

- In other words common genetic variants – that we all carry – make some of us more or less sensitive to emotional cues in the environment. The serotonin transporter gene is just one example. Tom may have carried variants (or ‘polymorphisms’) that placed him at greater risk of poor outcome following his exposure to poor caregiving.

- However, POSITIVE environmental experiences (as well as negative ones) can alter the child’s outcome. For example, a trusted caregiver with whom a child has regular contact can reduce the risk of depression, even in children carrying a ‘risk’ allele. It is possible that Tom’s brother benefited from such a reliable attachment figure and reduced his risk of depression.
2. Brain Function

How might Tom’s exposure to physical abuse alter how he processes emotion?
Brain Function

Pollack & Kistler (2002)
Brain Function

• Physically maltreated and control children viewing facial expressions of anger, fear, and happiness were assessed using ERP which measures surface brain electrical activity.

• Differences were found only for anger - which predicts threat.

• This further suggests that physical maltreatment increases a child’s sensitivity to social cues associated with threat in the environment.

Pollak et al. (2001)
Brain Function

• 10-14yr old children from a community sample referred to social services in the UK.

• Asked to complete a gender decision task in an fMRI scanner – is the face male of female?

• While the study is ongoing, pilot data indicate a hyperactivation of the amygdala in this group.

• This is likely to represent the neurobiological locus of the observed hypervigilance to anger.

McCrory et al. (unpublished)
Why might such hypervigilance be problematic?
Children were instructed to attend to emotional faces while ignoring angry voices. The larger N2 response seen here is associated with inhibitory control and conflict resolution – indicating a greater attentional load.
Brain Function

- Physical abuse – and possibly domestic violence – may lead to a child monitoring the environment for angry voices.

- This may be true even in a context when they are not at risk – for example at school.

- Tom may have to work much harder to stay on task at school. In other words, while being hypervigilant may help him at home – at school it has a cost.
2. Brain Function: Summary

*How might Tom’s exposure to physical abuse have altered how he processes emotion?*

- Physical abuse is associated with increases in brain electrical activity when actively searching for angry faces – this may relate to hyperactivity of the amygdala – a key brain region involved in processing threat.

- Tom may have developed a greater level of hypervigilance – scanning the environment for emotional cues. Specifically, he is likely to have shown a rapid processing and sensitivity to angry faces and greater difficulty to disengage from these cues.

- This was probably an adaptive response in his chaotic home environment and kept him out of danger….but may have made it much more difficult for him to concentrate and engage at school.

- The degree of hypervigilance has been correlated with greater levels of abuse and higher levels of anxiety.

(Shackman, Shackman, & Pollak, 2007).
3. Brain Structure

How might the experience of maltreatment affect the structural development of Tom’s brain?
Key brain structures

- Frontal lobe
- Thalamus
- Hippocampus
- Amygdala
- Hypothalamus
- Olfactory bulb
3. Brain Structure

Corpus Callosum

- Very reliable finding of decreased CC volume in maltreated samples
- The functional significance is not clear, but it indicates less effective integration across right and left hemispheres.

(e.g. De Bellis et al., 2002 & 2003).
3. Brain Structure

**Amygdala**

- In animals (rats) stress exposure is associated with an *increased* amygdala volume.

- However, a recent meta-analysis *did not find significant differences* in amygdala volume between maltreated and non-maltreated children.

(Woon & Hedges, 2008; but more recent papers have reported some differences - see Meta et al., 2009)
Hippocampus

- In animals (rats) stress exposure is associated with a *decrease* in hippocampal volume.

- In children, there is no indication that maltreatment leads to measurable damage to the hippocampus.

- However, adult studies consistently find *reduced hippocampal volume* in adults with a history of maltreatment and PTSD. This may reflect a delayed effect.
3. Brain Structure

FRONTAL LOBES

- Currently findings are very mixed.
- Possible vulnerability associated with abuse during adolescence (Anderson et al., 2008).
Timings matters!

**Ages of maximal effect:**
- Frontal cortex: 14-16 years
- Corpus callosum: 9-10 years
- Hippocampus: 3-5 years

> Different brain regions are likely to have their own unique sensitive periods (or windows of vulnerability) to the effects of early stress.
4. Resilience and Recovery

Are the effects of Tom’s early experience fixed and permanent?
Adolescence is a period of marked neurodevelopment.
The frontal lobes undergo marked neuro-biological change during adolescence. This region is associated with higher order social cognitive skills, including:

- Perspective taking
- Empathy
- Emotional regulation

For Tom this is a period of significant plasticity when new learning can occur. In other words, at age 8 Tom’s brain is still immature and will continue to develop until his early 20’s.
Grey matter volume peaks at age 11 in girls and at age 13 in boys. Then, the volume of grey matter begins to decline.

Lenroot & Giedd (2006)
Can intervention make a difference?
Early Maltreatment

Dysregulation of the body’s stress response system

Increased risk for psychiatric vulnerability

Helping foster carers to improve children’s ability to regulate stress

An attachment based intervention

1. Sensitivity Training – following the child’s lead, attending to their signals.

2. Support carers in appreciating the value of hugging & cuddling their child.

3. Helping carers to allow children to express negative emotions, & to better understand and recognise emotions.

Dozier et al., 2008
Evidence that improving sensitive and responsive care can alter the child’s response to stress.
Are there neural markers of resilience?
Cognitive Regulation Node

- Response Inhibition
- Emotion Regulation

Affective Node

↑ response to reward (novelty seeking)

↑ Response to negative affect

Nelson et al., 2005
Steinberg, 2005
The first fMRI investigation of factors associated with resilience in children who have experienced maltreatment.

Factors such as...

- Number of placement changes
- Professional support / intervention
- School affiliation
- Stable attachments
- Individual coping skills

...may all influence the development of key frontal regions important in emotion regulation and effective social functioning.

It is likely that Tom’s brother had one or more of these kind of protective factors that have helped promote more effective social and emotional skills, despite poor early care.
Conclusions
Genes

Neurocognitive Factors

Child Behaviour

Environment

Maltreatment
Conclusions

The interactions between these levels play out across the life span...
...and different factors are likely to be of more or less importance at different stages in development.
Infancy

? Early developing brain regions (e.g. hippocampus & amygdala)

? Key environmental factor – parenting and caregiving quality
Adolescence

? Later developing brain regions (e.g. frontal lobes)

? Key environmental factor – peer influence
Overall Summary

- Maltreatment is associated with different outcomes for different children due to individual genetic factors.

- The brain is affected by maltreatment both functionally – responding in different ways to experience – and structurally, i.e. in how different regions develop.

- There remains a lack of research on resilience and recovery, but we do know there is a significant period of neuro-development in adolescence. Furthermore, we will soon be able to identify neural markers of resilience associated with certain environmental influences.
Acknowledgments

• Dr Essi Viding
• Dr Stephane de Brito
…& our team at the Developmental Risk and Resilience Unit, UCL
Further Reading…

THE JOURNAL OF
CHILD PSYCHOLOGY AND PSYCHIATRY

Research Review: The neurobiology and genetics of maltreatment and adversity

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