Do children's brains recover better?

Attention outcomes after early brain lesions

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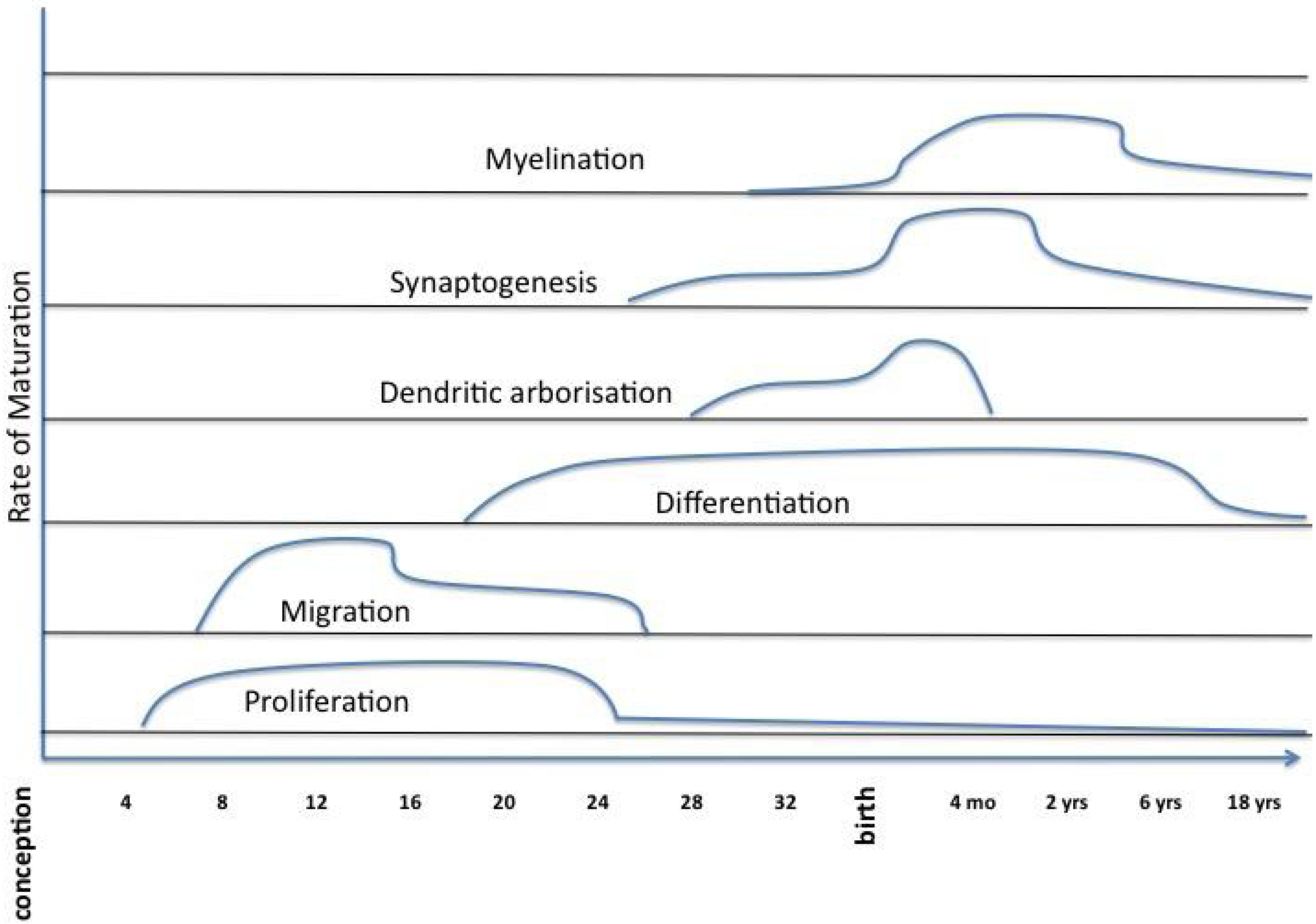
Brain development involves intricate processes



Sarah J Knight (2010) PhD thesis

Spencer-Smith & Anderson (2009) Developmental Neurorehabilitation

Plasticity in the developing brain

- Flexibility to adjust to developmental, environmental, traumatic experiences
- Neural plasticity - brain microstructure and macrostructure

  healthy development – adjust to experience through strength of neural connections or alterations of neural networks

  brain injury – neural repair through formation of new connections or generation of new neurons

- Functional plasticity – behaviour

  healthy development – skill development and acquisition

  brain injury – recovery of some skills through compensatory mechanisms, development or acquisition of new skills

Is plasticity an advantage for early brain insult?

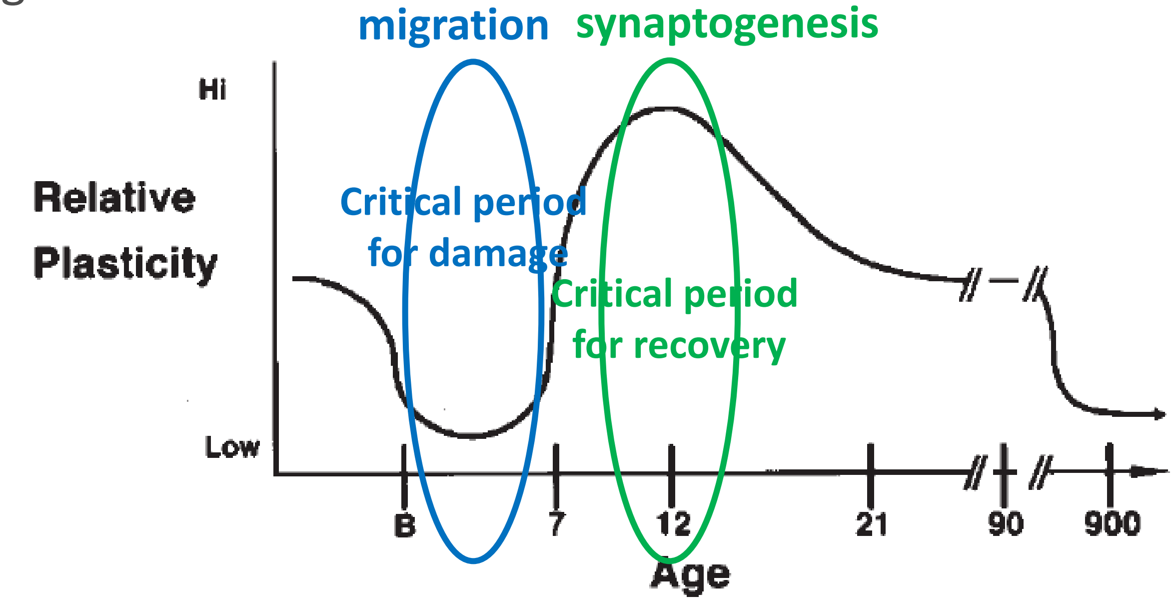
Anderson, Spencer-Smith & Wood (2011) Brain

Critical periods in development

- Limited window of increased plasticity
- *Healthy development* – experience instructs neural networks to process or represent information in an adaptive way
- *Damage* – overlaps with normal development and associated with vulnerability
- *Recovery* – brain has the potential to recover from disruption

Critical periods in neurological development

- Systematic studies of focal brain injuries in rats
- Brain injury at any time associated with severe impairments in 'species typical behaviours'
- Neurological processes occurring at the time of insult are tightly linked to cognitive outcomes



Do these findings translate to humans?

Kolb, Gibb & Gorny (2000) Developmental Neuropsychology

Child studies show timing is important

General intelligence after stroke Pavlovic et al. (2006) n = 33

POOR	reduced	OPTIMAL	reduced
neonatal	2 mo – 4 yr	5 – 9 yr	10 – 16 yr

Executive skills after focal frontal lesion Jacobs et al. (2007) n = 39

POOR	reduced planning	reduced concept formation	OPTIMAL	reduced self-regulation
prenatal	0 – 3 yr	4 – 6 yr	7 – 9 yr	10 yr +

Limitations of previous child research

- Report on a restricted range of child development

  e.g. examine single brain conditions that do not cover the spectrum of development such as traumatic brain injury

- Small samples

- Age bands collapse across neurological processes

- Variability in injury-related factors

  e.g. injury location, size, type, time since injury, presence of seizures, medication

There are gaps in our knowledge about timing of brain lesion

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Does Timing of Brain Lesion Have an Impact on Children's Attention?

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This study examined developmental timing of brain lesion effects on children's attention skills. The sample of 138 children, 10–16 years at assessment, were grouped based on developmental timing of brain lesion: (1) Congenital; (2) Perinatal; (3) Infancy; (4) Preschool; (5) Middle Childhood; (6) Late Childhood. Children with lesions in infancy or earlier demonstrated global attention problems, while children with lesions in middle childhood performed closer to normal expectations. This pattern of results was particularly evident for encoding and shifting attention. Findings highlight vulnerability of the immature brain to lesions and identify critical periods in development for attention skills.

Attention

- Underpinned by a distributed network involving anterior and posterior cerebral regions, subcortical structures

  → particularly vulnerable to brain injury

- Attention problems are common in children with brain lesions

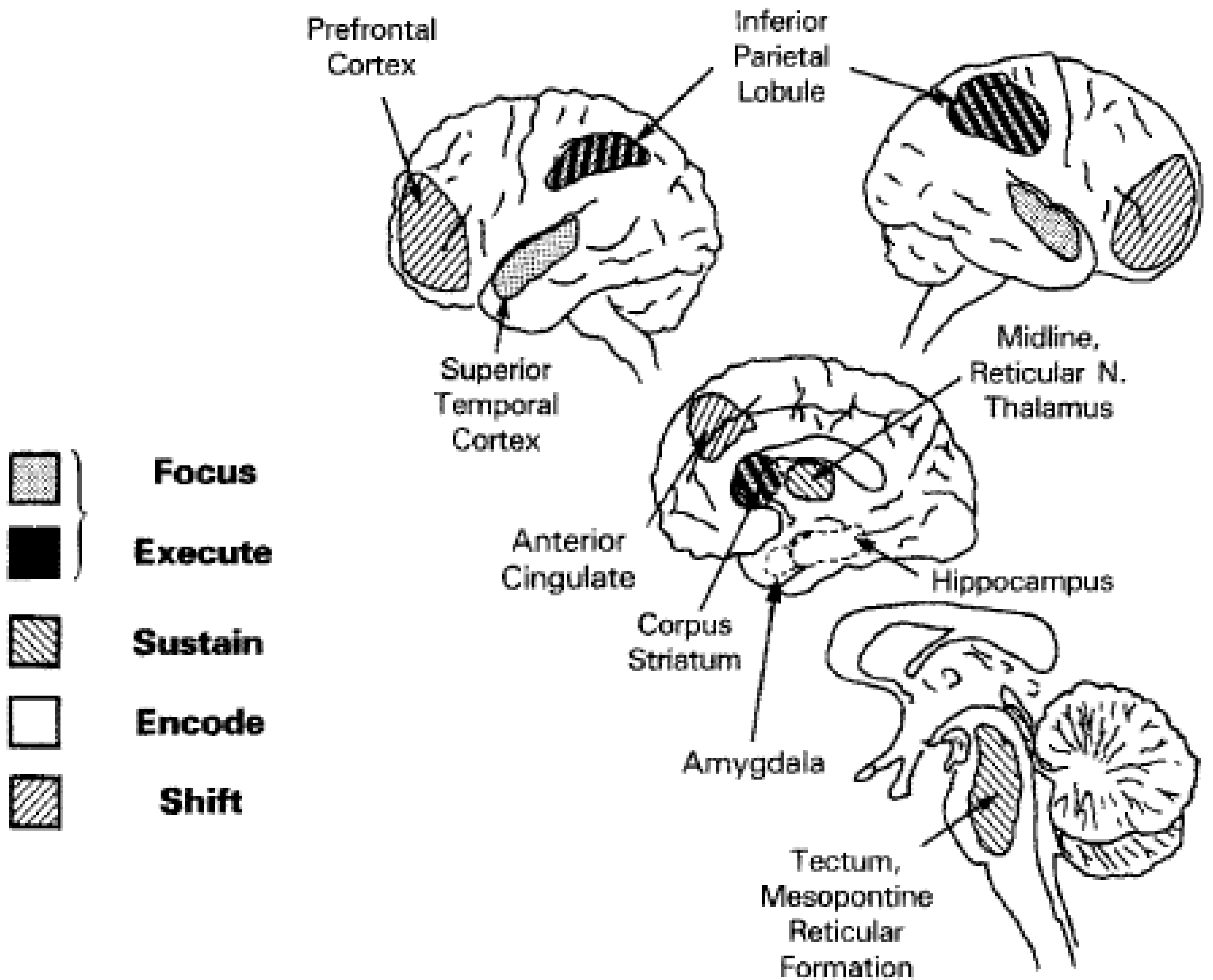
  Basic processes e.g. select, sustain

  Attentional control e.g. shift, working memory, response inhibition

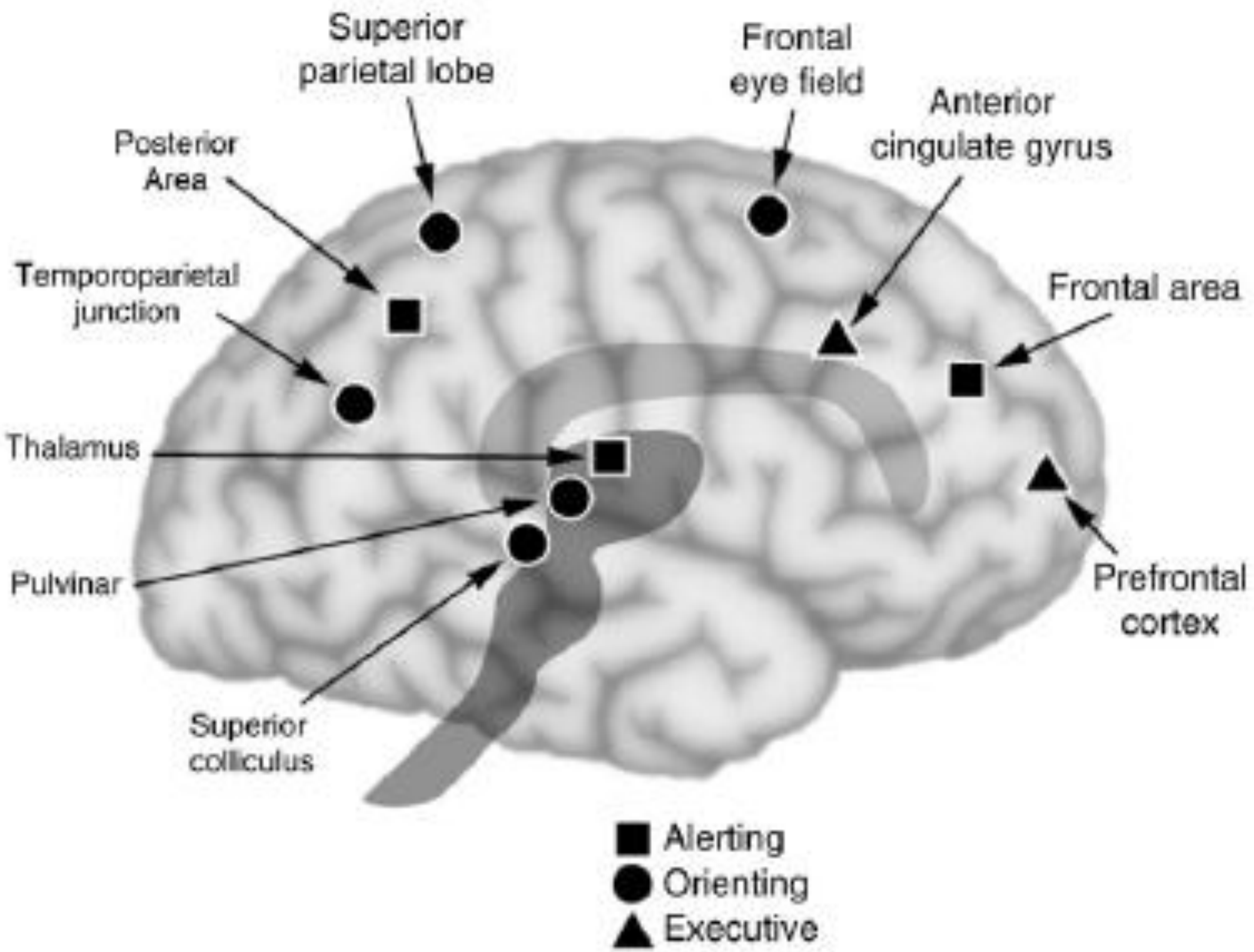
- Important for the development of other cognitive skills and for achieving goals of childhood e.g. learning new skills and knowledge

  → attention problems are likely to have long-term consequences

Mirsky model of attention



Posner network model of attention



Sample

- 138 children (55% males)
- 10 – 16 yr
- Focal lesion on MRI sustained > 1 yr prior
- Different mechanisms of brain lesion
  e.g. developmental, infective, ischaemic, neuroplastic, traumatic
- Children grouped by developmental timing of brain lesion

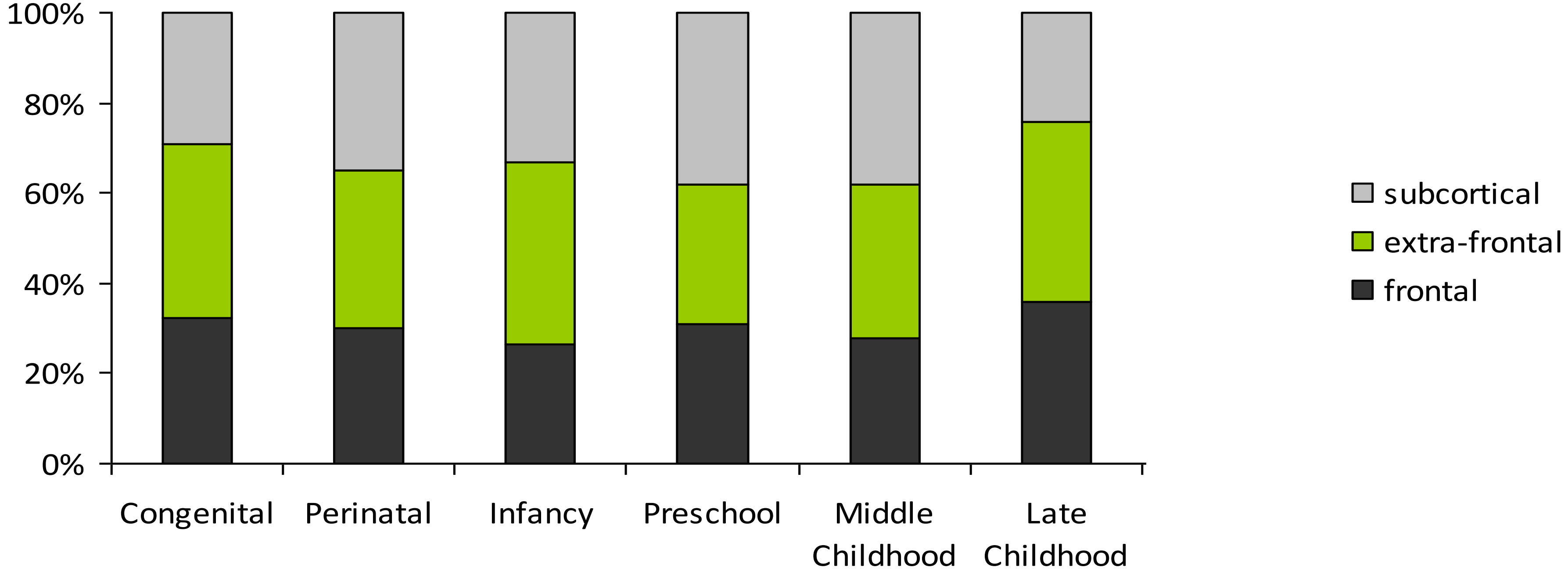
Congenital	Perinatal	Infancy	Preschool	Middle Childhood	Late Childhood
1st – 2nd trim	3rd trim – 1 mo	2 mo – 3 yr	4 – 6 yr	7 – 9 yr	10 yr +

Sample characteristics

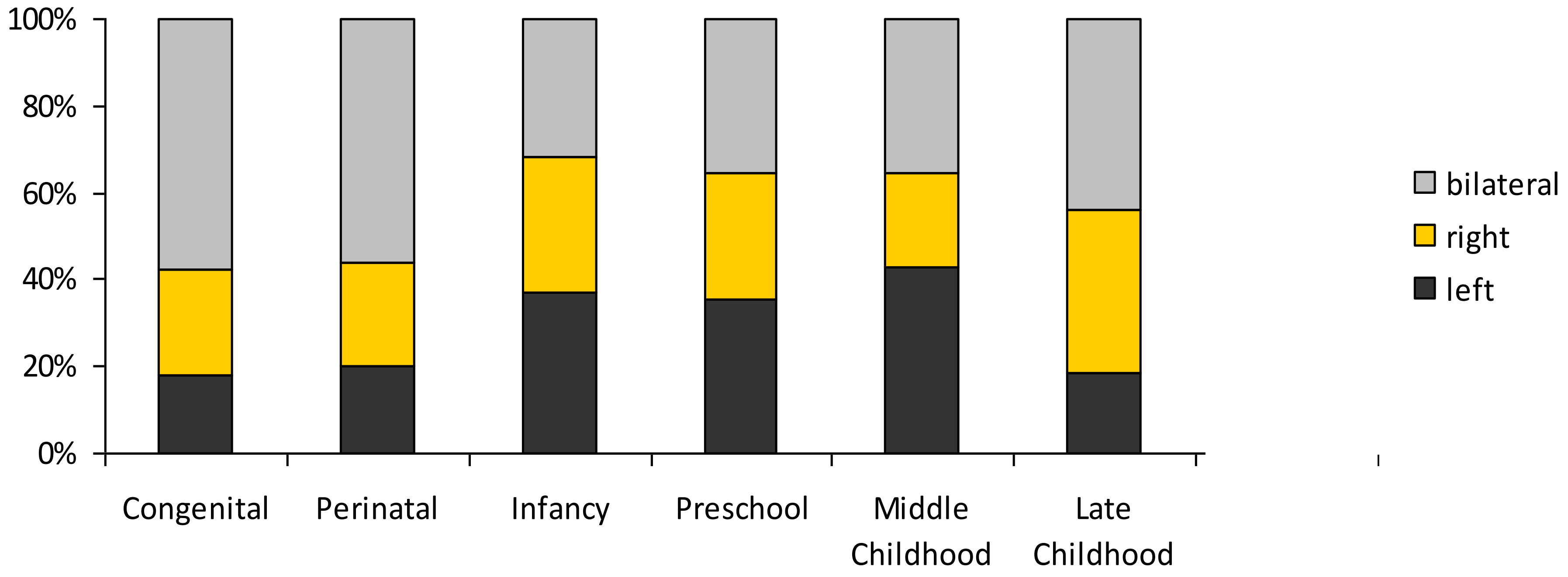
	Congenital	Perinatal	Infancy	Preschool	Middle Childhood	Late Childhood
n	33	25	19	17	28	16
Males	55%	60%	53%	59%	54%	50%
Age at test* *M*	13.0	13.4	12.2	12.5	12.9	14.3
Social risk *M*	2.9	2.5	2.5	2.3	3.0	3.2
Right-handed	82%	75%	75%	82%	82%	87%
General IQ* *M*	82.7	84.5	76.4	94.1	96.5	95.0
Seizures**	66%	44%	63%	12%	41%	33%

*$p < .05$ **$p < .001$

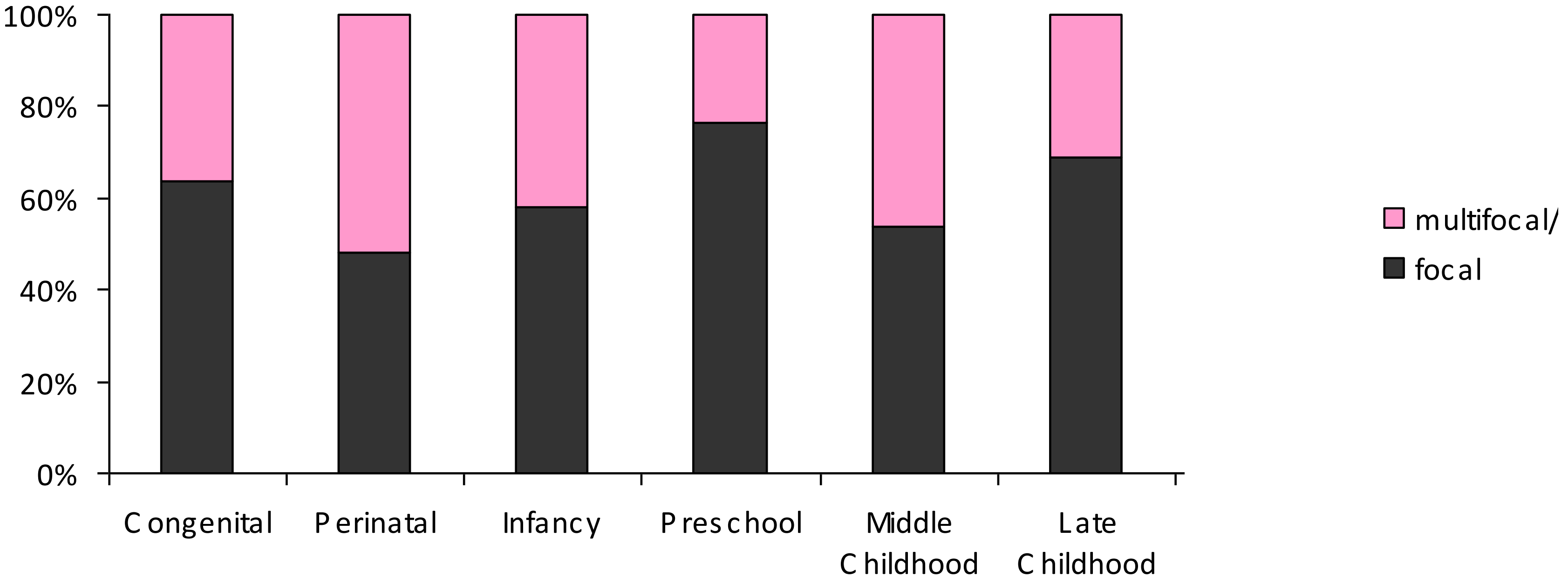
Brain regions



Lesion laterality



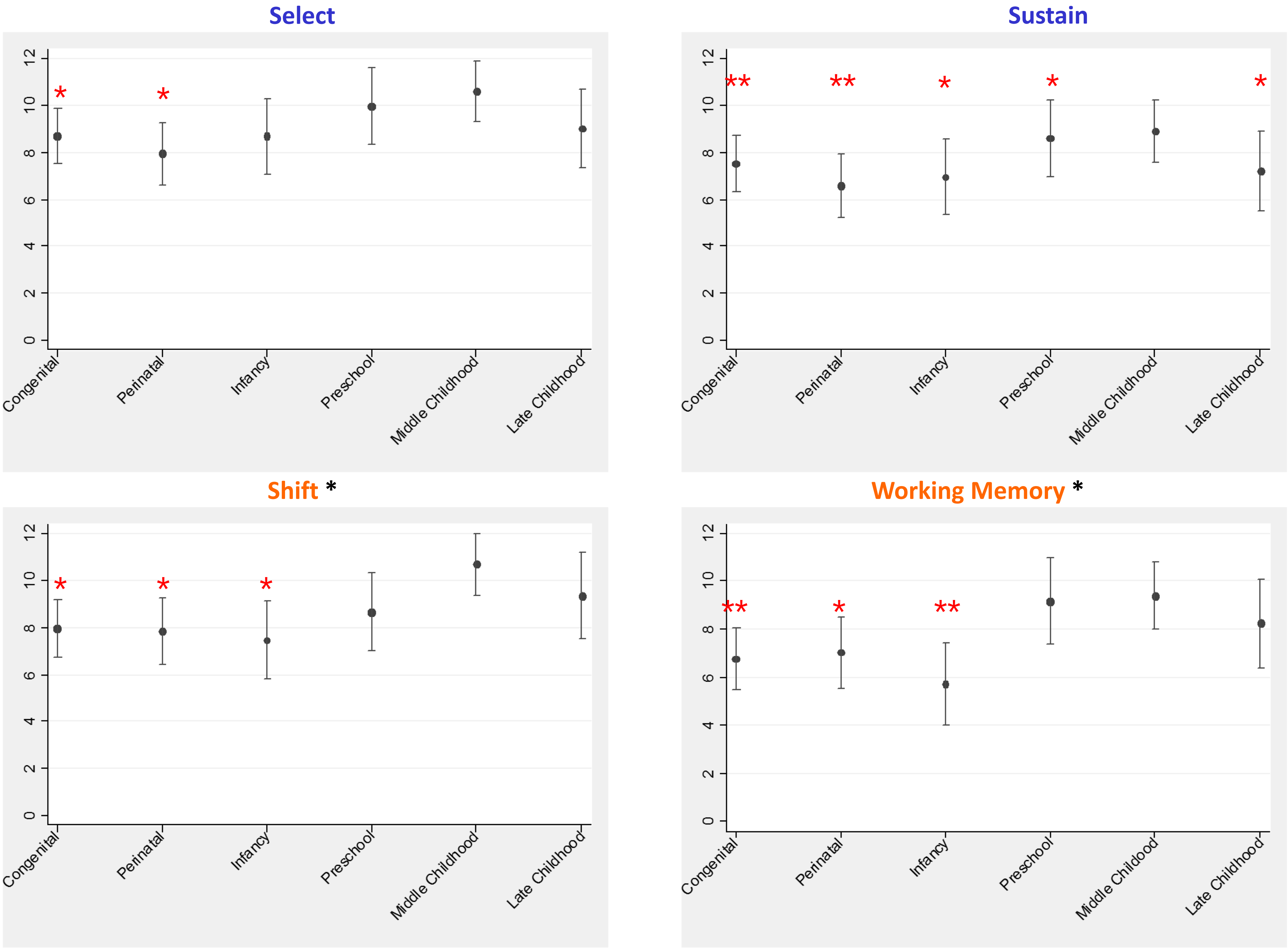
Lesion extent



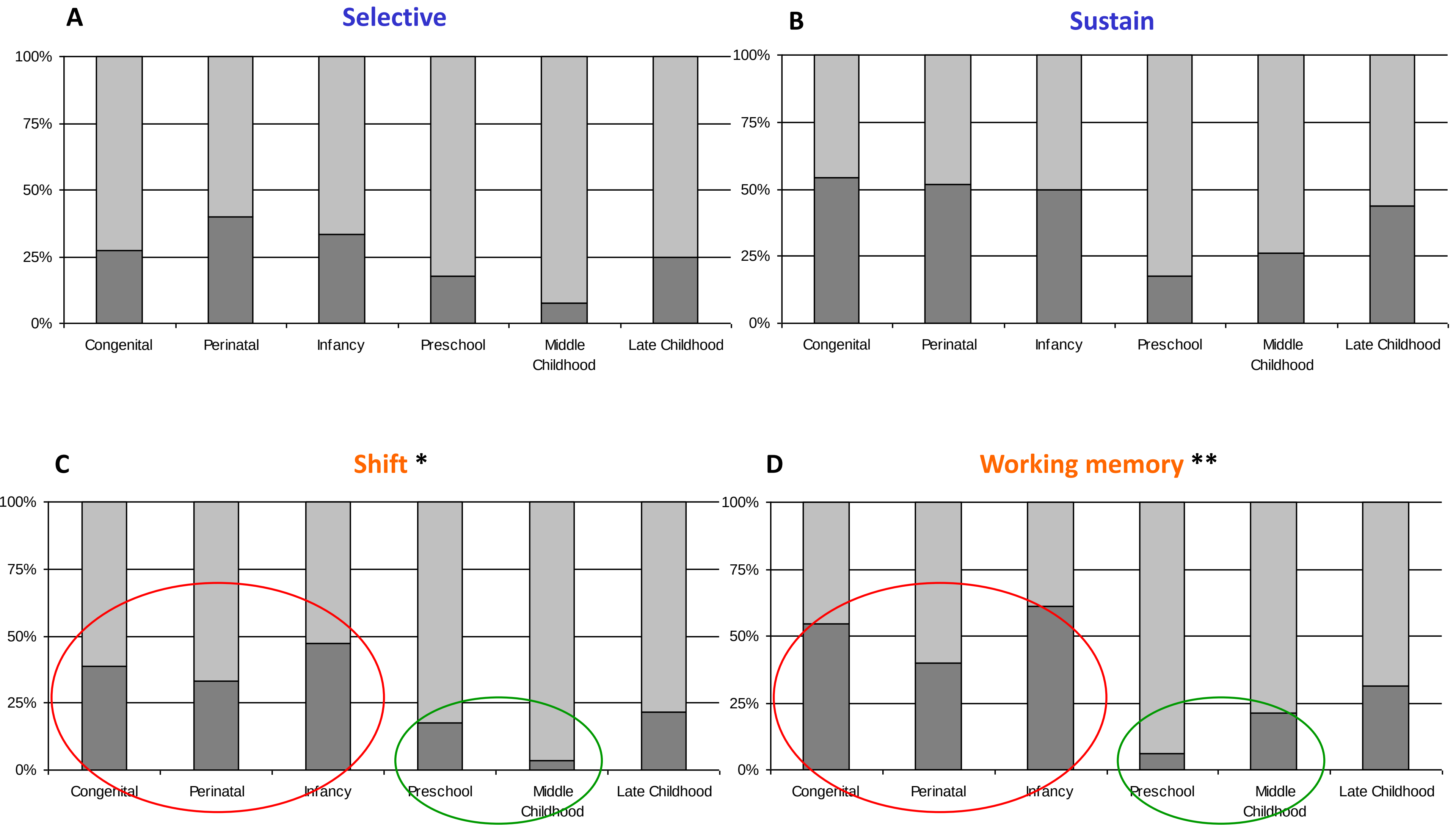
Attention measures

Process		Test	Variable *M* 10, *SD* 3
Select	attend to target information embedded in distracter information	Sky Search TEA-Ch	correct targets
Sustain	maintain attention for prolonged periods of time	Score! TEA-Ch	correct trials
Shift	shift attention from one aspect of a task to another	Trail Making Test D-KEFS	errors
Working memory	mentally manipulate information in mind for a short time	Letter Number Seq WISC-IV	correct trials

Attention outcomes



■ Impairment rates for attention



Conclusions

- Developmental stage at injury has implications for attention

POOR	POOR	POOR	reduced	OPTIMAL	reduced
Congenital	Perinatal	Infancy	Preschool	Middle Childhood	Late Childhood
1st – 2nd trim	3rd trim – 1 mo	2 mo – 3 yr	4 – 6 yr	7 – 9 yr	10 yr +

- Outcomes for select, sustain and shift, working memory vary by developmental timing of brain insult

→ What factors predict outcome for age at lesion groups?

Predictors of attention outcomes in children with focal brain lesions

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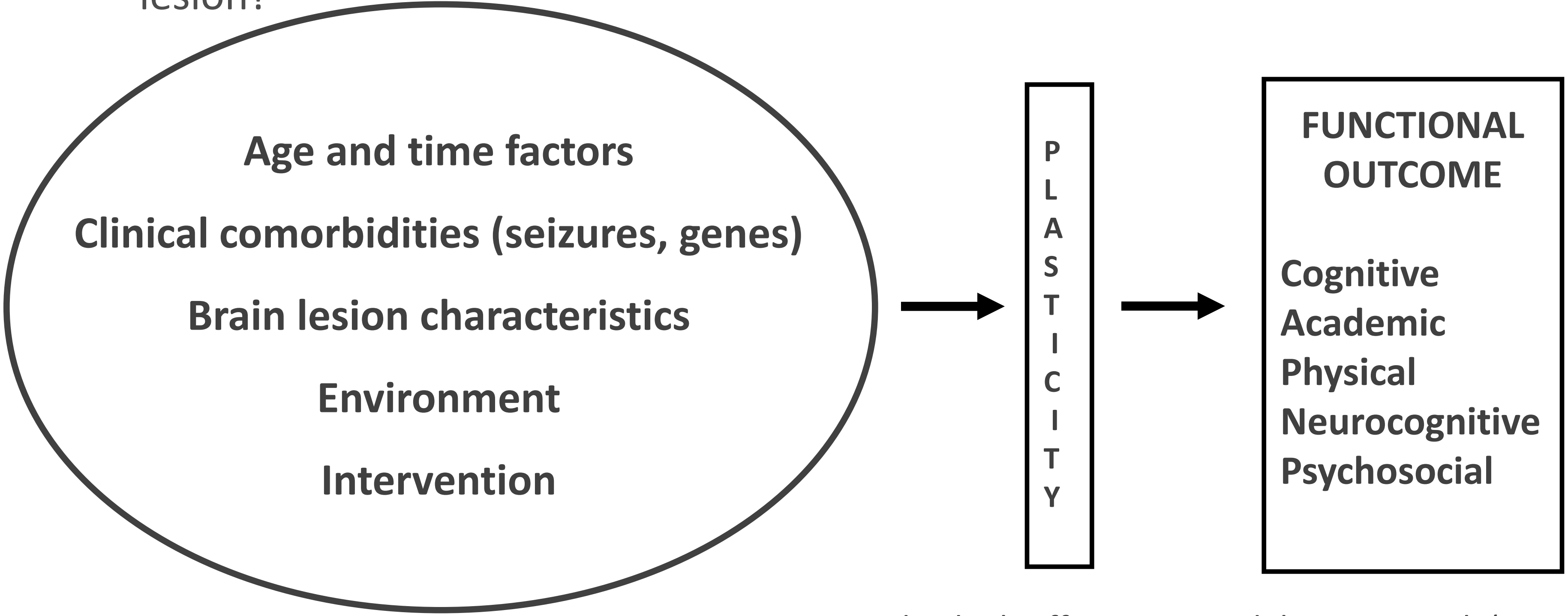
Peter Anderson, Rani Jacobs, Lee Coleman, Vicki Anderson

Spencer-Smith et al. (submitted)

slides not included here
because the manuscript is in submission

Summary

- The developing brain is particularly vulnerable to brain lesion
- Larger lesion volume and seizures are associated with poorest attention outcomes
- What is the formula for understanding variability in outcomes after a brain lesion?



Individual Differences Model Dennis et al. (2006)

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