Neuropsychological development in early childhood and the early detection of children at risk for developmental disorders

Heather Mohay
Queensland University of Technology
• What happens in the early years has an impact on development and behaviour in adult years.

• Development is very rapid in the first few years of life.

• What governs these developmental changes?
  - genetic control – maturation?
  - environmental influences?

• What changes occur in the brain during early childhood?
Evidence from the neurosciences

- Original evidence from studies of brain lesions in animals and humans and autopsy studies.
- Neurophysiological techniques for temporary inactivation of brain areas.
- EEG allowed examination of electrical impulses from the brain. (Important for sleep studies and the diagnosis of epilepsy)
- CT scan shows anatomy of the brain- identifies lesions, tumors etc
- PET (positron emission tomography) shows areas of activity in the brain
- MRI – non-ionizing radiation shows areas of activity in the brain
- fMRI functional magnetic resonance imaging – identifies neural pathways
  - Volumetric analysis
  - Diffusion tension imaging – detects white matter damage
  - Surface based morphometry– detects folding abnormalities in the cortex.

Recent progress in the application of MRI has allowed it to be used with infants and young children leading to increased knowledge about brain development and the emergence of new techniques to detect atypical development at an early age.
Brain growth

- The brain grows from 25% - 80% adult weight in first few years due to increased cell size, increased number of connections, myelination.
- Deep structures of the brain are more mature at birth.
- Brain growth is uneven.
- Infant cortex 1/3 surface area of an adult the dorsal areas of the cortex are more mature than frontal areas.
- the temporal, parietal and frontal cortex grow 2xs as much as other areas.
  
  Example: Development occurs in the Wernicke area in the first year of life and in the Broca area in the second year (important for language development)
  
  Development in frontal lobe associated with the development of executive function.
Brain structure

• Glial cells
• Neurons
  – Cell body
  – Axon with terminal fibres
  – Dendrites
• Synapses
  – Neuro-transmitters

From Peterson 2004
Changes in brain structure

- Most neurons are formed before birth but few connections between neurons exist
- Migration of neurons and differentiation of neuronal functions
- Myelination
- Proliferation of dendrite and axon connections
  - Establishment of neural pathways and networks as the result of stimulation from the environment
- Synaptic pruning
- Lateralisation
- Growth particularly of the cerebral cortex
Research on neuropsychological development in infancy

• Early functioning of prefrontal cortex and emergence of executive function in infancy (Diamond and Goldman-Rakic) using the A not B technique

• Laying down of neural pathways in infancy (Perry; Power and Hertzman)
Current thinking on brain development

• Most of the brains cells are formed before birth but most of the connections between cells are made during infancy and early childhood

• The brain activity of 3 year olds is twice that of adults

• Brain development is non-linear. There are prime times for acquiring specific skills

• Brain development hinges on a complex interplay between genes and experiences

• Early experiences influence the architecture of the brain and hence the nature and extent of adult abilities

• Early interactions directly affect the way the brain is “wired”
  – Eg Talking to babies, providing loving care and new experiences are all important. Expensive toys and special programs are not needed to develop brain power
Early Identification of children at risk of developmental disorders

1. MRI studies

• Much research has been on preterm term infants as they are at high risk for developmental disabilities.

• MRI studies in infancy linked to later follow-up data

• On MRI preterm infants show reduced brain volume associated with white matter atrophy and less grey matter in the cortex. Related to abnormal short term developmental outcomes (Inder and Huppi)

• Cortical folding abnormalities associated with ASD

• Reduction in hypocampal volume associated with memory and learning deficits

• Reduction in corpus callosum volume associated with decreased verbal fluency
Early Identification of children at risk of developmental disorders

2: Neuropsychological assessments

• Rate of processing visual information (Rose)
  – Rate of processing visual stimuli is slower in preterm infants. (ie length of time to inhibition is longer)
  – Inhibition/disinhibition - novelty test (Fagan test)

• Inhibiting attention to distracters -“Pop out effect”

• Tests of executive function.

• Tests of focused attention
What is “pop-out” effect?

- “Pop-out” is a fundamental feature of visual information processing.
- “Pop-out” occurs when one element within a visual display differs from the rest of the display along a fundamental dimension (e.g., colour).
20 familiarisation trials
Test trial: novel v target

Infant should look at the novel stimulus (Red) >50% of time
Test trial: novel v distracter

Infant should look at novel stimulus and distracter equal amounts
• 85% of full term infants at 4 months process information as expected

• 50% of preterm infants process the information as expected

• Are detecting children who will later have learning disabilities or attention deficit disorders?
Executive Function tests for infants

- Inhibition
- Working memory
- Planning

\[ \text{A not B task} \]

- Performance on these tasks does not correlate highly with performance on standard developmental tests eg Bayley
A not B task
Problem solving task
• Preterm infants perform more poorly on these tests than term infants

• Preterm infants also perform more poorly on tests of focused attention tasks
Executive function assessment of preschool children

- Delayed Alternation
- Colour reversal
- Verbal fluency
- Tower of Hanoi
- Goodman lock box
Conclusions

• Critical new knowledge about brain development can be gained from the neurosciences. These can help to identify children at risk of developmental disabilities at an early age.

• Trauma, genetics and everyday experiences affect the architecture of the brain

• Neuropsychological assessments are being refined with the aim of early identification of children at risk of developmental disabilities.