The brain and neuroplasticity in dyslexia and ADHD

A/Prof Karen E Waldie
CBR Learning Difficulties Workshop
Friday 9:10am 17 April 2015
Developmental disorders: A group of conditions identified in childhood that involve serious impairment in different areas

Dyslexia: phonological awareness
Dyscalculia: number sense
ADHD: executive functioning
ASD: social awareness

My research: Cognitive and neurological biomarkers; comorbidity

• Outline:
  1. My background; General introduction to neuroplasticity
  2. Frontal lobe development and ADHD
  3. Compensation, dyslexia and remediation
The Relationship Between Learning Disabilities and Persisting Delinquency

Karen Waldie and Otfried Spreen

Recidivism of delinquency in juveniles with learning disabilities (LD), the focus of the present study, has been virtually unexplored in previous research. Data from a longitudinal study initiated in 1978 are examined. Sixty-five subjects with LD (47 males and 18 females) who had been diagnosed and assessed between the ages of 8 and 12 years were located and, during a personal structured interview at the median age of 18 years, reported police contact. This population was subdivided into two groups on the basis of whether police contact had continued or discontinued, as reported in a second personal interview at the age of 25 years. Discriminant analysis on parent and subject variables correctly classified 75% of the subjects and revealed that certain personality characteristics, such as impulsivity and poor judgment, discriminate between persisting and nonpersisting delinquency in youth with learning disabilities.

Modern brain imaging methods

In the last 20 years, the field of cognitive neuroscience has developed non-invasive methods for studying healthy human brains in action, in adults and now children.

Electroencephalography (EEG)

Functional magnetic resonance imaging (fMRI)
My background: brain scanning

fMRI allows us to map increases in oxygenated blood flow that accompany local brain activity during mental tasks.
1. Neuroplasticity

General introduction

My 1st developmental psychology lectures:
1. Born with 100 billion brain cells
2. Following ~ the first 3 years of life the brain was relatively static

- neurogenesis occurs in humans up to 72 years of age
- stress inhibits neurogenesis
- environmental enrichment enhances neurogenesis

- The capacity of the brain to rewire through experience
1. Neuroplasticity

General introduction

• **Responsiveness to experiences**
  – Can be negative; vulnerable to damage
  • Early sensory deprivation
  • Antenatal maternal smoking, stress, drug use
1. Neuroplasticity
General introduction

• *Responsiveness* to experiences
  – Can be negative; vulnerable to damage
    • Early sensory deprivation
    • Antenatal maternal smoking, stress, drug use
  – Can be positive
    • Aids in recovery from brain damage/injury (e.g., hemispherectomy)
1. Neuroplasticity
General introduction

• **Responsiveness** to experiences
  – Can be negative; vulnerable to damage
    • Early sensory deprivation
    • Antenatal maternal smoking, stress, drug use
  – Can be positive
    • Aids in recovery from brain damage/injury (e.g., hemispherectomy)
    • Can benefit from **stimulation** (e.g., playing a musical instrument; learning a new language; cognitive training / intervention)

Allows for *adaptability*
2. Neuroplasticity
ADHD and the frontal lobe:

Frontal lobe under-activity
- Reduced size / density (MRI)
- Decreased blood flow (activation) during executive tasks (PET, fMRI)
2. Neuroplasticity
ADHD and the frontal lobe:

Executive tasks/functions:
• Planning
• Inhibition
• Response selection
• Top-down allocation of attention
• Regulation of emotion
• Working memory
2. Neuroplasticity

ADHD and the frontal lobe:

Frontal lobe under-activity

- Frontal cortex has the most connections
- Fronto-striatal pathway inadequate in ADHD

= Inattention and failure to inhibit motor responses
2. Neuroplasticity

ADHD and the frontal lobe:

- These areas under-active because of neurotransmitter depletion (faulty metabolism of dopamine and/or norepinephrine at the synapse)
  = poor transmission of neural impulses in fronto-striatal pathway

Challenge: non-pharmaceutical intervention to normalize the frontal lobe (see: [http://movincog.org/public.html](http://movincog.org/public.html))
Risk Factors

Genetic Defects

Concordance rates: if one identical twin has it, the other will too: Ranges from 70-90%

- ADHD genes are common in the general population. When genes from both parents combine - additive effect to cause condition

If genetic susceptibility:

- Low birth weight, Adverse environment,
- Smoking/alcohol during pregnancy
- Stress during pregnancy
3. Neuroplasticity
Dyslexia and compensation

DYS (Abnormal or impaired); LEXIS (words or language)

“An unexplained difference between adequate spoken language & severe reading/spelling difficulties despite normal intelligence and opportunities for schooling”

World Health Organization

Affects 5% of the population (versus 30%)

• Hereditary disorder, males, left-handedness

“defective development occurring in the early stages of embryonic growth” Hinshelwood (1917) versus NZ…Ministry of Ed 2007

Brain anomalies cause dyslexia – areas of the brain involved in phonological processing (letter to sound).
Main cognitive problem

Representing / recalling basic speech sounds

Verbal short-term memory, rapid naming, nonwords, rhyming…

Early phonological skills predict reading ability

- Bradley & Bryant, 1983 Nature
Myths of Dyslexia

1. **Letter reversals:** “unique characteristic of dyslexia with etiological implications”
   - imperfect memory for linguistic associations - not from perceptual confusion

2. **Erratic eye movements cause dyslexia:** “good readers make smooth, regular eye movements over the text”
   - "If deficiencies in motor and visual-motor development or defects in eye movements caused perceptual impairment and reading problems, one would be at a loss to explain how so many children with cerebral palsy and various visual-tracking defects become literate"
A. Typical readers

B. Dyslexic readers

• Right hemisphere reading is a compensatory system
  – But isn’t specialised for reading, particularly phonological processing

<table>
<thead>
<tr>
<th></th>
<th>Left Hemisphere</th>
<th>Right Hemisphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinking</td>
<td>Symbolic, analysis</td>
<td>Holistic, imagination</td>
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<tr>
<td>Focus on</td>
<td>Foreground, specific</td>
<td>Background, general</td>
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<tr>
<td>Aware of</td>
<td>Details</td>
<td>Overall picture</td>
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<td>Better at</td>
<td>Structured tasks</td>
<td>Open-ended tasks</td>
</tr>
<tr>
<td>Language</td>
<td>Decoding, literal surface meaning</td>
<td>Context meaning, humor, metaphor</td>
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– Remediation in Fast ForWord / phonics the best way to re-train the brain?
3. Neuroplasticity
Dyslexia and compensation

Functional activations shown on the left hemisphere for phonological processing in typically developing readers (left), age matched dyslexic readers (middle), and the difference before and after remediation in the same dyslexic readers (right). Red circles identify the frontal region, and blue circles identify the temporo-parietal region of the brain. Both regions are hypoactivated in dyslexia and become more activated after remediation.

Auckland Comorbidity Study: Untangling the ‘dys’ from dyslexia and dyscalculia

AIMS: (i) to determine the extent to which the neural networks implicated in dyslexia and dyscalculia overlap; (ii) to determine the relationship between activation and reading performance

Task design after Shaywitz et al. (1998).
3. Conclusions I

• reading performance is mediated by a **different network** in dyslexics than in typical readers.

• Can their brains be normalised?
• Does normalisation result in better reading performance?
• Does it last?

**Campus Link / Centre for Brain Research intervention:**
– A new cognitive programme for 5-7 year olds that takes advantage of what we know about neuroplasticity

• Why should we care?
## Age 32: Degree qualifications, income

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<thead>
<tr>
<th></th>
<th>No school qualification</th>
<th>Bachelors Degree</th>
<th>Masters, PhD, Law, Med</th>
<th>Median income before tax</th>
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<tbody>
<tr>
<td>Typical reader</td>
<td>14.1%</td>
<td>20%</td>
<td>6.3%</td>
<td>$38,216</td>
</tr>
<tr>
<td>Dyslexic reader</td>
<td>48%*</td>
<td>2.7%*</td>
<td>0*</td>
<td>$27,500*</td>
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</table>
## Age 32: Mental health disorders

<table>
<thead>
<tr>
<th></th>
<th>Any Depressive Disorder</th>
<th>Any Substance Dependence</th>
<th>Any Anxiety Disorder</th>
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<tbody>
<tr>
<td>Typical reader</td>
<td>9.3%</td>
<td>9.9%</td>
<td>9.7%</td>
</tr>
<tr>
<td>Dyslexic reader</td>
<td>8.3%</td>
<td>12%</td>
<td>22.9%*</td>
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</table>

**Bottom Line:** Early identification & intervention is imperative
3. Conclusions II

Next steps:

Developing critical consumers
- Community outreach from Centre for Brain Research
- More neuroscience / psychology in teacher training
- Debunking neuromyths
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