How do children’s brains change following training?

Dr Duncan Astle
MRC Cognition and Brain Sciences Unit
The brain, cognition and learning....

Debunking a few myths....

“What do you know about the brain?” If you ask someone this question, you are most likely to get one of the following answers: “The right hemisphere of the brain is for emotion and creativity. In contrast, logic lies in the left hemisphere.” Someone else might answer: “We only use of 10% of our brains!” These statements are common misconceptions about brain mechanisms, which are taken for granted in today’s society. Many such myths have evolved around the functioning of the brain. In order to classify them, the OECD coined the term "Neuromyths". OECD Website
The brain, cognition and learning....

Top 5:

• 5) We only use x% of our brains
• 4) Short bursts of co-ordinated activity can improve the communication between the two halves of the brain
• 3) Pressing on different parts of the body can enhance specific patterns of brain activity
• 2) Individual’s brains are predisposed to learn in different ways, and will learn best when information is delivered in the preferred style
• 1) Differences in hemispheric dominance can help explain differences in learning style
The brain, cognition and learning....

Our approach:

Education, learning, Everyday functioning

Cognition e.g. working memory

Brain / neuroscience
Attention, working memory and the brain in childhood

Our research aims to:

1) Understand the underlying brain differences that give rise to differences in cognitive ability (e.g. working memory differences)

2) When we deliver an intervention, what does it do to a child’s brain (if anything)? Does it target the root cause, or does it boost a compensatory mechanism?

3) Why might any brain changes mirror any improvements in ability? i.e. what is the mechanism?
Thinking about communication...

One aspect of brain activity that we focus on is **communication**.

Because performance on complex tasks like working memory is heavily dependent on this type of communication.
Thinking about communication...

The more sophisticated the system...
the more complex the communication network becomes
Communication in the human brain

The human brain is an extremely sophisticated system...

These types of scan tell us about the structural pathways that the brain can use, but they don’t tell us about how electrical signals move along them...
Electrical communication in the human brain
Electrical communication in the human brain

Measuring electricity in the brain non-invasively:
Electrical communication in the human brain

Measuring electricity non-invasively with MEG:
Our study:

31 Children (8 to 11 yrs)

9 minutes, eyes closed

Calculate electrical activity at thousands of locations throughout the brain

Search for coordinated patterns of electrical activity
Electrical communication in the human brain

Barnes et al. 2015, Developmental Science
Are these linked to cognitive ability?

Individual differences across children

Dorsal | Lateral | Ventral

\[ \text{Individual differences across children} \]

Barnes et al. 2015, Developmental Science
Can the communication be changed?

Stills from two training tasks
Can the communication be changed?

Does the training work?
Can the communication be changed?

Astle et al. 2015, Journal of Neuroscience
Can the communication be changed?

Natural Differences in Ability

Trained Differences in Ability

R

L

Ventral
Interim Summary:

• Using MEG to explore connections in the brain
• Some electrical connections vary across children, and this is linked to cognitive skills like working memory
• Intensive cognitive training acts to boost these connections – the more they are boosted the greater the gain in working memory ability
So what is this communication doing and how???

These areas in frontal and parietal cortex might be coordinating the activity of these visual areas.....
Why is coordination important?
How might this coordination happen???

... all about the timing???

https://www.youtube.com/watch?v=Aaxw4zbULMs
Attention, working memory and the brain

- Developing new ways to study electrical communication in the developing brain, so that we can understand the mechanisms that underpin differences in attention and working memory in childhood
- Combining this approach with interventions, to understand their impact on brain plasticity and connectivity

**MRC CBU:**
Jessica Barnes
Kate Baker
Gemma Crickmore
Amy Johnson
Erin Hawkins
Joe Bathelt
Sinead O’Brien

**Oxford:**
Mark Woolrich
Kia Nobre
Gaia Scerif
Henry Luckhoo
Giles Colclough

... thanks for your attention
Impacts of social disadvantage on children’s cognition, learning, and brains

Amy Johnson
MRC Cognition and Brain Sciences Unit
16/04/16
ENVIRONMENT

SOCIO-ECONOMIC STATUS
SES PREDICTS COGNITIVE DEVELOPMENT

Performance gap between children from disadvantaged and advantaged backgrounds in just about every measure of cognitive development

- **Language**
  - E.g. Noble 2005, Jednorog 2012

- **Executive Functions**
  - E.g. Farah 2006, Sarsour 2011

- **Attention**
  - E.g. Stevens 2009, Lipina 2013

- **Working Memory**
  - E.g. Evans 2009, Kishiyama 2009

- **Emotion Regulation**
  - E.g. Kim 2013, Gianaros, 2008

- **Long Term Memory**
  - E.g. Noble 2006, Farah 2006

- **IQ**
INEQUALITY IN THE EARLY COGNITIVE DEVELOPMENT OF BRITISH CHILDREN IN THE 1970 COHORT

Feinstein et al. 2003
INEQUALITY IN THE EARLY COGNITIVE DEVELOPMENT OF BRITISH CHILDREN IN THE 1970 COHORT

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INEQUALITY IN THE EARLY COGNITIVE DEVELOPMENT OF BRITISH CHILDREN IN THE 1970 COHORT

Feinstein et al. 2003
Children growing up in poverty in Cambridgeshire achieve less well at school than almost anywhere else in the country." 

1. Office for national statistics, 2012-2013
PILOT DATA

- 310 KS2 children aged 7-11
- Cattell: Fluid IQ
- Woodcock Johnson: reading and maths
## PILOT DATA

<table>
<thead>
<tr>
<th>Test</th>
<th>Mean FSM</th>
<th>Mean N-FSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattell Series</td>
<td>6.93</td>
<td>8.41</td>
</tr>
<tr>
<td>Cattell Classifications</td>
<td>5.90</td>
<td>6.86</td>
</tr>
<tr>
<td>WJ Reading</td>
<td>29.01</td>
<td>35.76</td>
</tr>
<tr>
<td>WJ Maths</td>
<td>33.72</td>
<td>48.23</td>
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<tr>
<td>Test</td>
<td>Mean FSM</td>
<td>Mean N-FSM</td>
</tr>
<tr>
<td>--------------------</td>
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<td>48.23</td>
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</tbody>
</table>
CUMULATIVE EFFECT

Office for national statistics, 2012-2013
Neuroplasticity: environmental factors can have a positive effect.

E.g. Small gains in income result in large gains in academic outcomes\(^1\)

---

1. Dearing, 2001
INTERVENTIONS

Figure 2: Average Impact at the End of Treatment

1. Duncan, 2014
RESILIENCE
OUR APPROACH

1) The factors that make up a person’s SES are highly complex

...yet treat SES as a single number

2) We can’t treat children of the same SES level as one group

...yet treat as one group
OUR STUDY

What puts these children at risk?

What gives these children resilience?

SES

Cognitive

Neural

Educational attainment

MRC Cognition and Brain Sciences Unit
FIRST VISIT: CHILD

Outside scanner:
• IQ: WASI
• Working memory: AWMA
• Phonological processing: PhAB
• Academic: Woodcock-Johnson

Inside scanner:
• Resting state
• working memory and attention task
• phonological processing oddball
FOCUS ON THREE KEY AREAS:

- Language
- Working Memory
- Attention

- 120 children
- 7-11 years old
- 2 visits to unit
Extensive questionnaires to assess SES and other environmental variables that we believe are important.

Areas:
- Several standardised measures of SES
- Family dynamics
- Home environment
- Health
- Other key areas
SECOND VISIT: MRI

T1 weighted image

DTI
So far:
60 behavioural testing and questionnaires
61 MEG scans
53 MRI scans
• Pilot data: strongest effect on maths (ES 0.73)

• Which cognitive measures predict maths?
• Pilot data: strongest effect on maths (ES 0.73)

• Which cognitive measures predict maths?

MATHS ABILITY

INCOME

MATHS ABILITY

N = 13
Maths = 82
N = 14
Maths = 112
N = 14
Maths = 83
N = 13
Maths = 108
HIGH SES

<table>
<thead>
<tr>
<th>Phonological</th>
<th>Verbal WM</th>
<th>VS- WM</th>
<th>Verbal STM</th>
<th>VS STM</th>
<th>Fluid IQ</th>
<th>Vocab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**High SES, High Maths**

**High SES, Low Maths**

**High SES, High Maths**

**High SES, Low Maths**

**High SES, High Maths**

**High SES, Low Maths**

**High SES, High Maths**

**High SES, Low Maths**

**High SES, High Maths**

**High SES, Low Maths**
• Visuo-Spatial WM predicts maths in children

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Predictor</th>
<th>Control Variable</th>
</tr>
</thead>
</table>

**Table 5**

<table>
<thead>
<tr>
<th>Model</th>
<th>Coefficient</th>
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<tbody>
<tr>
<td></td>
<td>Adjusted $R^2$</td>
</tr>
<tr>
<td>Year</td>
<td>0.089</td>
</tr>
<tr>
<td>T1 Numeracy</td>
<td>0.468</td>
</tr>
<tr>
<td>T1 Numeracy</td>
<td>0.529</td>
</tr>
<tr>
<td>T1 Spatial</td>
<td>0.529</td>
</tr>
<tr>
<td>T1 Verbal</td>
<td>0.031</td>
</tr>
</tbody>
</table>

Astle, Woolgar and Scerif (Submitted)
LOW SES

Phonological  Verbal WM  VS- WM  Verbal STM  VS STM  Fluid IQ  Vocab

Z Score

Low SES, High Maths
Low SES, Low Maths
IMPLICATIONS

• Suggests that the deficit in maths in the low SES children is not driven by cognitive factors
• Interventions: These children appear to have the implicit cognitive functions necessary to do well in maths
• What is driving this deficit?
SUMMARY

• SES strong predictor of cognitive and academic ability

• Early childhood interventions can be effective in reducing this gap

• What are the environmental, cognitive and neural factors that mediate these effects?
THANK YOU

Duncan Astle
Gemma Crickmore
Erin Hawkins
Joe Bathelt
Sally Butterfield
CALM:

Dimensions not diagnoses for children struggling with attention, learning memory

Joni Holmes & Susan Gathercole
MRC Cognition and Brain Sciences Unit, Cambridge

CALM Workshop, 16th April 2016
Cognitive developmental disorders: Problems of diagnosis

- High prevalence of ADHD, dyslexia, language impairment and dyscalculia (1-7% population)
- Co-morbidity rates 20-80%
- Symptoms highly variable across individuals with common diagnoses
- Symptoms overlap highly across diagnoses
- Barrier for identifying causes and developing effective treatment for the individual
More similarities than differences between children with ADHD and low working memory

**Teacher ratings of behaviour**

- **Oppositional**
- **Inattention**
- **Hyperactivity**
- **ADHD Index**

- **ADHD**
- **Low WM**
- **Control**

- **age-typical**
- **elevated**
More similarities than differences between children with ADHD and low working memory:

**Working memory**

**Executive function**

![Graphs showing working memory and executive function for ADHD, low WM, and control groups.](image-url)
Different diagnoses but substantial overlap in cognitive dimensions of impairment

Shared impairments in:

- executive functions including abilities to shift attention, inhibitory control, and to plan
- all aspects of working memory
- reading and maths
- Attentional control (inattentive behaviour)

ADHD children have additional problems with:

- rule-breaking
- hyperactive/impulsive behaviour

# CALM: Cognitive dimensions of specific learning difficulties

<table>
<thead>
<tr>
<th><strong>Learning</strong></th>
<th>Language</th>
<th>Reading</th>
<th>Spelling</th>
<th>Maths</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PPVT, Story Recall</strong></td>
<td>WIAT Single Word Reading</td>
<td>WIAT</td>
<td>WIAT Numerical Operations</td>
<td></td>
</tr>
</tbody>
</table>

## Cognition

- **Phonological processing**: Alliteration, Naming Speed (PhaB)
- **Processing speed**: Naming speed (Phab), Simple RT (Teach 2)
- **Working memory**: Digit Recall, Backward Digit Recall, Dot Matrix & Mr X (AWMA)
- **Attention**: Sustained attention, set-switching, visual search (Teach 2)
- **Executive functions**: Tower Test, Number Letter Switching (DK-EFS), Set-switching
- **Nonverbal reasoning**: WASI Matrix Reasoning

## Behaviour

- **Behaviour**: SDQ
- **Executive function**: BRIEF
- **Attention**: Conners
- **Communication**: CCC
- **Mental Health**: JH to complete

## MRI

- **DTI, resting state, structural**

## Saliva
How the clinic works

• Referrals from professionals working in children services
• Children aged 5-18yrs with problems in attention, learning, and/or memory
• Families visit CALM for 3 hour assessment
• Reports to referrers to inform ongoing support

**New recruitment phase (Feb 2016 onwards)**

• Children aged 6-12yrs
  • language difficulties that are receiving support from Speech and Language therapy services,
  • have or are awaiting a likely diagnosis of ADHD or OCD
Overview of sample
October 2014 to March 2016

• Recruitment via:
  • clinical psychology (7%)
  • SLT (7%)
  • education (69%)
  • paediatricians (14%)

• 311 children: 5 to 15 yrs (mean 9 yrs 4 mos), 66% boys
## Referral information

<table>
<thead>
<tr>
<th>Primary reason for referral</th>
<th>n</th>
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<tbody>
<tr>
<td>attention</td>
<td>56</td>
</tr>
<tr>
<td>memory</td>
<td>40</td>
</tr>
<tr>
<td>language</td>
<td>24</td>
</tr>
<tr>
<td>literacy</td>
<td>47</td>
</tr>
<tr>
<td>maths</td>
<td>9</td>
</tr>
<tr>
<td>literacy &amp; maths</td>
<td>112</td>
</tr>
<tr>
<td>total</td>
<td>288</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>223</td>
</tr>
<tr>
<td>ADD</td>
<td>4</td>
</tr>
<tr>
<td>ADHD</td>
<td>22</td>
</tr>
<tr>
<td>Anxiety</td>
<td>0</td>
</tr>
<tr>
<td>DAMP</td>
<td>3</td>
</tr>
<tr>
<td>Depression</td>
<td>2</td>
</tr>
<tr>
<td>Dyscalculia</td>
<td>0</td>
</tr>
<tr>
<td>Dyslexia</td>
<td>21</td>
</tr>
<tr>
<td>Dysgraphia</td>
<td>1</td>
</tr>
<tr>
<td>Dyspraxia</td>
<td>9</td>
</tr>
<tr>
<td>FASD</td>
<td>3</td>
</tr>
<tr>
<td>GDD</td>
<td>1</td>
</tr>
<tr>
<td>Social Anxiety</td>
<td>1</td>
</tr>
<tr>
<td>Autism / Aspergers</td>
<td>12</td>
</tr>
<tr>
<td>OCD</td>
<td>1</td>
</tr>
<tr>
<td>Tourettes</td>
<td>1</td>
</tr>
</tbody>
</table>
The first recruits
Learning and cognitive skills:
mean z-scores
<table>
<thead>
<tr>
<th>Test</th>
<th>Subscale</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conners (T)</td>
<td>Inattention</td>
<td>61.7</td>
<td>30.8</td>
</tr>
<tr>
<td></td>
<td>Hyperactivity</td>
<td>54.7</td>
<td>26.1</td>
</tr>
<tr>
<td></td>
<td>Learning problems</td>
<td>65.1</td>
<td>26.8</td>
</tr>
<tr>
<td></td>
<td>Executive function</td>
<td>67.6</td>
<td>18.5</td>
</tr>
<tr>
<td></td>
<td>Aggression</td>
<td>48.9</td>
<td>22.7</td>
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<tr>
<td></td>
<td>Peer relations</td>
<td>47.5</td>
<td>31.2</td>
</tr>
<tr>
<td>BRIEF (T)</td>
<td>Inhibit</td>
<td>61.6</td>
<td>14.9</td>
</tr>
<tr>
<td></td>
<td>Shift</td>
<td>64.6</td>
<td>15.2</td>
</tr>
<tr>
<td></td>
<td>Emotional control</td>
<td>61.3</td>
<td>14.1</td>
</tr>
<tr>
<td></td>
<td>Initiate</td>
<td>64.8</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td>Working memory</td>
<td>72.6</td>
<td>10.2</td>
</tr>
<tr>
<td></td>
<td>Planning</td>
<td>70.3</td>
<td>10.2</td>
</tr>
<tr>
<td></td>
<td>Organisation</td>
<td>58.6</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>Monitor</td>
<td>62.9</td>
<td>11.3</td>
</tr>
</tbody>
</table>
Subgroups
By areas of deficit: learning scores <86
Mean z-scores for main deficit subgroups

- Voc, read & maths <86
- Voc & maths <86
- Read & maths <86
- Read <86
- Maths <86
- All >85
All learning z-scores >85
Reading- and maths-only deficit groups
Vocab & maths and all learning deficit groups
Dimensions
Pathways to learning

\[ \chi^2(38) = 45.890, \ p = .178 \]

GFI = .940; RMR = 8.501
Pathways to learning and behaviour

\[ \chi^2(59) = 66.634, \ p = .231 \]
\[ \text{CFI} = .983; \ \text{RMSEA} = .031 \]
Are WM problems diagnostic of learning difficulties?

Gathercole, Astle, Manly, Woolgar, Kievit & Holmes (under review)
Do working memory problems predict learning difficulties?

<table>
<thead>
<tr>
<th>Learning difficulty</th>
<th>Working Memory Deficits</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Vocabulary</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>0.33</td>
</tr>
<tr>
<td>Age-typical</td>
<td>0.14</td>
</tr>
<tr>
<td>Reading</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>0.26</td>
</tr>
<tr>
<td>Age-typical</td>
<td>0.12</td>
</tr>
<tr>
<td>Maths</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>0.30</td>
</tr>
<tr>
<td>Age-typical</td>
<td>0.13</td>
</tr>
</tbody>
</table>

- Minority with learning problems had very low WM scores
- But learning problems are rare in children with age-typical WM scores
- Perhaps:
  - these difficulties have multiple causes, and poor WM is one (relative weak) contributory factor
  - robust WM abilities are a protective factor for learning that compensates for other core deficits
Overview
Findings so far

- Reading difficulties usually accompanied by maths problems
- Specific maths difficulties relatively common
- Vocabulary problems rarely found in isolation
- 25% of children have no detected learning difficulties

- Two cognitive dimensions linked to learning and behaviour:
  i) Phonological -> language and reading
  ii) Executive -> maths and inattention

- WM not strongly diagnostic of learning difficulties, but reliably predict typical learning. Multiple contributors or protective factor?

- Going forward
  • Recruit children with language difficulties, ADHD or OCD.
The CALM team
The CALM team

- Duncan Astle
- Susan Gathercole
- Joni Holmes
- Tom Manly
- Frankie Woolgar
The CALM team

Sally Butterfield
Andrew Gadie
Agnieszka Jaroslawska
Gemma Crickmore
Joe Bathelt
Laura Forde

Erica Bottacin
Amy Johnson
Erin Hawkins
Sarah Bishop
Sara Gharooni
Sinead O’Brien
Recognising and intervening in PTSD in children

Richard Meiser-Stedman
University of East Anglia & MRC Cognition & Brain Sciences Unit
The scale of the problem

• Public scandals vs private horror

• “Severe domestic violence” witnessed by 4% children

• British Crime Survey 2009
  • 83000 10-15 year olds required medical attention
  • violence with injury 2.3-7.8%

• 2M children attend ED each year

• 1 in 3 UK adolescents experience “severe victimisation”
  – PTSD in 3%
Post-traumatic stress in youth

• Reexperiencing symptoms
  • Intrusive memories, nightmares, flashbacks

• Avoidance
  • Thoughts, discussion, places & activities

• Hyperarousal
  • Sleep, attention, vigilance, jumpy, irritable

• DRAMATIC IMPACT on academic functioning, peer & family relationships

• GREATER RISK other mental health problems
Our work

• Cambridge (MRC CBU)
  • Tim Dalgleish

• London (KCL)
  • Patrick Smith, William Yule

• Norfolk (UEA)
  • Richard Meiser-Stedman

• Ayla Humphreys, Adrian Boyle, Ed Glucksman

• Schools, Mental Health Trusts, GPs etc
What happens after trauma?

Meiser-Stedman et al., 2005, 2008, Am J Psychiat
What happens soon after trauma?
Who will develop PTSD?

• Two questions:
  • Who experiences the *onset* of symptoms
  • Who experiences *persistent* symptoms

• No support for:
  • Triage, fracture, heart rate, LoC

• Some support for:
  • Being assaulted, head injury

• Protective factors:
  • Admission!
Cognitive mechanisms

• The three M’s

• Memory
  • Fragmented, incoherent, sensory-based, lack verbal component

• Meaning
  • Negative views of self, world and others

• Management
  • Thought suppression
  • Rumination
Cognitive mechanisms

• Can they explain the trajectory of young people’s post-traumatic stress?

• Cambridge, Bury St Edmunds, Bedford, Peterborough; 2w & 9w post-trauma

• Resilient  no PTSD (n= 138)
• Recovery  PTSD then no PTSD (n=28)
• Persistent  PTSD (n=29)
Cognitive mechanisms

Social support

Self-blame

- Resilient
- Recovery
- Persistent
Cognitive mechanisms

- Threat
- Data-driven processing
- Thought suppression

Bars represent different categories: Resilient, Recovery, Persistent.
Cognitive mechanisms

![Graphs showing Memory quality, Appraisals, and Rumination with categories Resilient, Recovery, and Persistent.]
How might we help soon after a trauma?

- **Cognitive Therapy** vs Waiting list
- 8-17 year olds, PTSD
- 2-6m post-trauma
- Improved anxiety, depression & functioning
Changes in cognitive mechanisms over time
Multiple traumas?

- Case series
- *Will youth stick with the treatment?*
- *How many sessions?*

- CPFT, n=9
- Domestic violence (4), rape (2), torture (1), attempted murder (1), sexual abuse (1)
- Mean age 13.7 years (8-16)
- Mostly female (7); only 1 BEM
Multiple traumas?

- No drop outs; mean 11.2 sessions (9-13)
Multiple traumas?
What next?

• PYCES
  • young child study

• DECRYPT
  • RCT for multiple trauma youth
Conclusions

• PTSD is a problem - but **not** for all youth
• Needs follow up & monitoring
• Normalise!

• Focused PTSD treatment addressing the 3 M’s seems to work
  • Know what to focus on in therapy

• Training needs?
Thank you!

Email: r.meiser-stedman@uea.ac.uk
Changes in cognitive mechanisms over time

![Graph showing changes in cognitive mechanisms over time. The x-axis represents different cognitive mechanisms: Appraisals, Memory quality, Rumination, Safety seeking, Self-blame, and Social support. The y-axis represents the values. The graph includes data for CT-pre, CT-post, WL-pre, and WL-post.](image-url)
Cognitive mechanisms

<table>
<thead>
<tr>
<th>Cognitive Mechanism</th>
<th>Recovery Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-blame</td>
<td>Resilient = Recovery = Persistent</td>
</tr>
<tr>
<td>Social support</td>
<td></td>
</tr>
<tr>
<td>Threat during trauma</td>
<td>Resilient &lt; Recovery = Persistent</td>
</tr>
<tr>
<td>Data-driven processing</td>
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<tr>
<td>Thought suppression</td>
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<tr>
<td>Memory Quality Appraisals</td>
<td>Resilient &lt; Recovery &lt; Persistent</td>
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<tr>
<td>Rumination</td>
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Neuropsychological Assessment

In a Child and Adolescent Mental Health Outpatient Service

Ayla Humphrey
Consultant Clinical Psychologist
Brookside Clinic and
Section of Developmental Psychiatry, University of Cambridge
There are serious psychiatric consequences in overlooking SLI [Specific Language Impairment] in behaviourally disturbed populations. . . Mental health professionals should consider including language evaluation in their assessment.

(Goodyer, 2000)
Overview

• **Definitions**: Specific Learning Disorder (SLD)

• **Epidemiology**: SLD in outpatient psychiatric population and patterns in psychiatric presentation

• SLD is a *mental health issue* (treatment efficacy and resource efficiency)
Specific Developmental/Learning Disorders

- Achievement on individually administered, standardized tests is substantially below (2-1.5 standard deviations) that expected for age, schooling, and level of intelligence.

- The disturbance significantly interferes with academic achievement or activities of daily living.
ICD-10 Classification of Mental and Behavioural Disorders

• Specific Developmental Disorders of Speech and Language
  • Specific Speech Articulation Disorder
  • Expressive Language Disorder
  • Receptive Language Disorder
  • Other and Unspecified

• Specific Developmental Disorders of Scholastic Ability
  • Specific Reading Disorder
  • Specific Spelling Disorder
  • Specific Disorder of Arithmetical Skills
  • Other and Unspecified

• Specific Developmental Disorder of Motor Function
• Mixed Specific Developmental Disorders
Specific Learning Disabilities

Specifiers

Specific learning disorder with impairment in **reading** includes possible deficits in:
- Inaccurate or slow and effortful reading
- Difficulty understanding what is read

**Note:** *Dyslexia* is an alternative term used to refer to a pattern of learning difficulties characterized by problems with accurate or fluent word recognition, poor decoding and poor spelling abilities.

Specific learning disorder with impairment in **written expression** includes possible deficits in:
- Spelling difficulties
- Difficulties with Written expression
- Grammar and punctuation accuracy
- Clarity or organization of written expression

Specific learning disorder with impairment in **mathematics** includes possible deficits in:
- Difficulties mastering number sense, number facts, or calculation
- Difficulties with mathematics reasoning
A. Persistent difficulty learning academic skills for at least 6 months despite intervention targeting the area(s) of difficulty.

B. The affected academic skills are substantially below expectations given the individual's age and result in impaired functioning in school, at work and in activities of daily living. (Suggested threshold of 1.5 s.d. below mean for age in academic achievement)

C. LD is readily apparent in the early years, however it is not to be diagnosed until the onset of school years; in some individuals the disorder is not apparent until the onset of a demand for higher-level skills.

D. The academic and learning difficulties occur in the absence of:

- Intellectual Disabilities
- Visual or hearing impairments
- Major psychiatric or neurological disorders (e.g. depression, anxiety, etc.)
- Severe psycho-social adversity
- Lack of Proficiency in language of school
- Lack of access to adequate instruction
IQ and Psychiatric Disorder

• Lower IQ in psychiatric outpatient samples compared to general population (Rutter et al., 1970)
Epidemiology of SLD

**Child Psychiatric Outpatient**

- Language
  - SLD 45%

- Reading
  - SLD 45%

- Maths
  - (ADHD sample) 33%

- Motor
  - 50% w/ reading disorder
  - 10-50% w/ ADHD

**General Population**

- Language
  - SLD 5%

- Reading
  - SLD 5%

- Maths
  - 1.3%
  - Maths+Read 2.3%

- Motor
  - 6%

*References:

- Hinshaw, 1992; Rutter, et al., 1970; Willcutt & Pennington, 2000
- Baker & Cantwell, 1985; Lewis et al., 1994; Semrud-Clikeman et al., 1992
- Denckla et al., 1985; Doyle et al., 1995; Piek et al., 1999; Wolff et al., 1990
- Beitchman et al., 1986; Cantwell & Baker, 1991; Cohen et al, 1993; Cohen et al., 1998
- Willcutt & Pennington, 2000
- Hinshaw, 1992; Rutter, et al., 1970; Willcutt & Pennington, 2000
- Baker & Cantwell, 1985; Lewis et al., 1994; Semrud-Clikeman et al., 1992
- Denckla et al., 1985; Doyle et al., 1995; Piek et al., 1999; Wolff et al., 1990*

<table>
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<tr>
<th>Difficulty</th>
<th>Scoring within abnormal range</th>
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<tr>
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<td>Hyperactivity</td>
</tr>
<tr>
<td>Mental Health Problems (MHP) (n=353)</td>
<td>% (n)</td>
</tr>
<tr>
<td>Hyperactivity</td>
<td>77.1 (272)</td>
</tr>
<tr>
<td>Conduct symptoms</td>
<td>52.1 (184)</td>
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<tr>
<td>Emotional symptoms</td>
<td>20.1 (71)</td>
</tr>
<tr>
<td>No other MHP †</td>
<td>19.3 (68)</td>
</tr>
<tr>
<td>Learning Problems (n=236)</td>
<td></td>
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<tr>
<td>Spelling concerns</td>
<td>40.2 (92)*</td>
</tr>
<tr>
<td>Reading concerns</td>
<td>36.6 (88)*</td>
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<tr>
<td>Printing/writing concerns</td>
<td>39.3 (92)*</td>
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<tr>
<td>Math concerns</td>
<td>29.7 (70)</td>
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<td>Total Learning Problems (n=228)</td>
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<tr>
<td>0 of the above</td>
<td>17.1 (39)</td>
</tr>
<tr>
<td>1 of the above</td>
<td>16.7 (38)</td>
</tr>
<tr>
<td>2 of the above</td>
<td>11.0 (25)</td>
</tr>
<tr>
<td>3 of the above</td>
<td>11.4 (26)</td>
</tr>
<tr>
<td>4 of the above</td>
<td>18.0 (41)</td>
</tr>
<tr>
<td>Other Problems (n=236)</td>
<td></td>
</tr>
<tr>
<td>Fine motor</td>
<td>26.5 (62)*</td>
</tr>
<tr>
<td>Speech and language difficulties</td>
<td>21.7 (51)*</td>
</tr>
<tr>
<td>Gross motor</td>
<td>15.1 (35)*</td>
</tr>
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</table>
Epidemiology of Mental Health and Behavioural Problems within SLD groups

Baker and Cantwell, 1987

Behavior Problems (Language Delay) 50%

Rutter & Yule, 1970

Anti-social Behaviour (Specific Reading Disorder) 24%

General Population 5-7%
Epidemiology of Mental Health and Behavioural Problems within SLD groups

- Love & Thompson, 1988
  - ADHD (Language Delay Group)
    - 75%
- Willcutt & Pennington, 2000
  - Depression (Female, Reading Disorder Group)
    - 21%
  - Depression (Male, Reading Disorder Group)
    - 11%
- General population
  - 3-5%
  - 0.34-2.53%

### Table 1 Neuropsychopathological comorbidity in SLD\(^1\) and LD NOS\(^2\) subgroups

<table>
<thead>
<tr>
<th></th>
<th>SLD</th>
<th>LD Nos</th>
<th>p</th>
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<tr>
<td><strong>Number</strong></td>
<td>240</td>
<td>208</td>
<td>-</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>184</td>
<td>135</td>
<td>-</td>
</tr>
<tr>
<td>Female</td>
<td>56</td>
<td>73</td>
<td>-</td>
</tr>
<tr>
<td><strong>Age (mean ± sd)</strong></td>
<td>10.3 ± 2.45</td>
<td>10.2 ± 2.67</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total Comorbidity %</strong></td>
<td>58.3%</td>
<td>66.8%</td>
<td>0.64</td>
</tr>
<tr>
<td>ADHD</td>
<td>33%</td>
<td>25.4%</td>
<td>0.00*</td>
</tr>
<tr>
<td>Anxiety disorder</td>
<td>28.8%</td>
<td>16.4%</td>
<td>0.00*</td>
</tr>
<tr>
<td>Mood disorder</td>
<td>9.4%</td>
<td>2.1%</td>
<td>0.00*</td>
</tr>
<tr>
<td>Language disorder</td>
<td>11%</td>
<td>28.6%</td>
<td>0.00*</td>
</tr>
<tr>
<td>Motor coordination disorder</td>
<td>17.8%</td>
<td>27.5%</td>
<td>0.00*</td>
</tr>
</tbody>
</table>

\(^1\) Specific Learning Disorders; \(^2\) Learning Disorders Not Otherwise Specified; *p < 0.005.
Psychiatric Symptoms Associated with SLD

• Boys at risk of overt externalising behavioural difficulties (Bruck, 1989; Rutter et al., 1970; Smart et al., 1996).

• Girls at risk of internalising symptoms (Beitchman et al., 1996).

• SLI and comorbid ADHD increased risk of externalising behavioural disturbance (Frick et al., 1993; Beitchman & Young, 1997).

• Nonverbal LD associated with internalising symptoms (Rourke & Fuerst, 1992)
Psychiatric Symptoms Associated with SLD (cont’d)

• Presentation changes with age
  • preschool- over activity, attentional difficulty, wetting/soiling
  • early school years- emotional and behavioural symptoms
  • adolescence-antisocial behaviours
Indicators for Psychometric Assessment

• Disparity in educational attainment in different subject areas.
• Parents and child confirming that child has difficulty in particular skill or subject (following directions, holding utensils, riding a bike, doing particular homework).
• School has noticed child’s academic difficulty and child has an IEP, is statemented, given LSA support
• Family history of learning/academic difficulty.
Implications for Treatment

• Treatment Efficacy
  • Multi-modal treatments that include SLD remediation, psychotherapy, parent parent training are more effective than any one type of treatment alone (Hechtman et al., 1996; Satterfield et al., 1981; Satterfeld et al., 1987)
  • Diagnosing SLD contributes to more positive parental attributions of children (Cohen et al., 1993)
  • Psychotherapy that takes into account language ability is more effective with SLI (Osman, 1999; Silver, 1993)
Implications for CAMHS

Resources

• Identification of SLD
  • decrease re-referral
  • decrease treatment time
  • more efficient use of multi-professional communication.
Case Study: Jay

PHASE 1: L.D. INDICATED, NOT ASSESSED

- **May 2000** Age 5 years, GP refers to Brookside for disruptive and non-compliant behaviour in school only
  - Behaviour difficulty due to parental separation
- **Oct 2000** Assessed at Brookside
  - Angry when forced to do tasks in school
  - School feel he’s not achieving potential
  - J. upset on return to mother from visits with father
  - Normal pregnancy, normal delivery, achievement of milestones normal, socialises well by mum’s report and has two close friends
- **Dec 2000** Block of 3 play sessions difficulty focusing on literacy tasks and completing work
  - Conclusion J. distractible and changes activities quickly.
Case Study: Jay

PHASE 2: L.D. FLAGGED AGAIN, WHOSE REMIT? (1.4 years later)

- **Jan 2001** Brookside moves to close case.
  - School teacher writes J. always needs adult with him to get work done
- **July 2001**
  - school: J. sits on edge of group, won’t read to LSA, won’t complete task. Behavioural support teacher brought in.
  - Brookside: “behaviour is remit of education need to refer to Ed”
- **August 2001**
  - Mum writes to Brookside that problem in school continues, disruptive, poor attention, level 3 IEP, Parent Partnership contacted, J. wants to be with mum all the time
- **Sept 2001** GP re-refers. J. is lagging behind in school. Notes that father and an uncle have severe dyslexia
Case Study: Jay

PHASE 3: NEUROPSYCH ASSESSMENT STARTS

- **October 2001** Ed Psych (CA = 6 years and 6 months)
  - WISC-III (Weschler Intelligence Scales)
    - Information 13 Picture Completion 14
    - Similarities 14 Coding 5
    - Arithmetic 12 Picture Assembly 11
    - Vocabulary 14 Block Design 10
    - Comprehension 15 Object Assembly 8
  - WORD (Wechsler Reading Dimensions)
    - Basic Reading 6 years
    - Spelling 6 years

Conclusions:
- possible PDD
- high level of ability
- needs structure
- curriculum needs to develop social skills and use T.E.A.C.C.H. (treatment and education of autistic and related communication handicap children)
Case Study: Jay

• **April 2002**  Referred for second opinion re PDD
  • peer difficulty in school, anxious about extreme noises, poor communication skills
  • conclude not PDD: normal social interaction, normal communication, no stereotyped behaviours, well-developed imaginary play, normal developmental history

• **July 2002**  NEPSY (A Developmental Neuropsychological Assessment)
  • Attention/Executive Functions  113
  • Language  105
  • Sensorimotor  89
    • (finger tapping 12, imitating hand positions 8, visuomotor precision 6)
  • Visuospatial  103
  • Memory  105
Case Study: Jay

PHASE 4: NEUROPSYCH INTEGRATED INTO TREATMENT
(2.8 years after referral)

• Conclusions:
  • graphomotor weakness
  • specific learning disability of Written Expression

• Plan Jan. 2003:
  • psychotherapy referral with aim of targeting self-esteem issues relating to school performance
  • advice school to lessen writing demands, use dictaphone and computer
  • mum to do copying exercises with J. refer to OT for further assessment of visuo-motor difficulty
    • visual closure and visual tracking difficulty, laboured writing and poor shoulder stability - OT to visit school, pencil grip and spring scissors, alternative methods of recording
Case Study: Tom

- May 2000  Referred by GP. Teacher finds T. fidgety, poor organisation, dislikes change, poor in social groups, PDD or ADHD?
- Nov 2000  Assessed by Brookside
  - normal developmental milestones
  - many friends
  - ADOS done, not PDD
  - school report: concentration poor, fidgets, falling behind academically
Case Study: Tom

• Wechsler Intelligence Scale
  • information 17 picture completion 10
  • similarities 16 coding 11
  • arithmetic 17 picture arrangement 12
  • vocabulary 11 block design 16
  • comprehension 16 object assembly 17
  • VERBAL IQ 132 PERFORMANCE IQ 121
  • FULL SCALE IQ 120

• Wechsler Objective Reading Dimensions
• Wechsler Objective Language Dimensions 90-136
• Wechsler Objective Numerical Dimensions
“We would definitely have the tests again. For the first time someone identified that [Tom] had very strong positives and he has been able to build his self-confidence since then.

Last year [Tom]’s class teacher read your report to see if there were any pointers to working with Jamie in English.”
Age at Referral for Neuropsych

Age

Absolute Number

Age

Absolute Number

Age at Referral for Neuropsych

Age

Absolute Number

Age

Absolute Number

Age
CAMHS Cases Referred for Global Learning Disability

Medical notes indicate:

- Multiple developmental problems evident early in development.
- Majority have birth complications (premature, hypoxia, seizures . . .)
- Referral for testing toward end of primary school.
- Neuropsychology for majority indicates uneven profiles not global impairment.
- All have multiple environmental risk factors.
Joni Holmes, Duncan Astle, Francesca Woolgar, Tom Manly and Susan Gathercole.
Prematurity and Mental Health

- Small for Gestational Age/Very Preterm/Very Low Birth Weight associated with later psychiatric hospitalization or psychiatric illness not mediated by childhood factors

- Risk increased:
  - male
  - family history of psychiatric disorder in a first-degree relative, suggesting a direct effect of early life factors on adult mental health.

- A need for anticipatory guidance and early intervention that might help to prevent or ameliorate potential psychopathology.

Monfils Gustafsson W et al. (2009); Walshe M et al. (2008); Wiles NJ et al. (2005); Hack M (2004)
Integration of Tests with Treatment

- Presenting problem test findings
  - problem determines test and test results need to tell us something about presenting problem

- Test results need to be communicated understandably and with functional aim to family and all other professionals.

- Decisions about when to test and who tests need to be made with family and other professionals. These decisions can be made throughout treatment and not just at initial assessment.

- Psychotherapeutic approaches need to incorporate child’s level of ability and may need to focus on the psychological consequences of having a learning disability
Comorbidity of SLD and Psychiatric Symptoms: Hypotheses

- **Developmental Immaturity:** general developmental delays (Goodyer, 2000; Beitchman et al., 1989; Tallal et al., 1989).

- **Sequential Comorbidity:**
  - SLD+ADHD → learning difficulties → reading problems (Frick et al., 1991)

- **Failure Hypothesis:**
  - school failure → low self-esteem → aggression

- **Differential treatment** (fast learners attended to)

- **Susceptibility:** SLD is associated with ED
  - Family of BP+RLD higher risk of externalising problems (Willicutt & Pennington, 2000)
  - 75% of spelling + ADHD due to shared genetic influence (Stevenson et al., 1993)
  - 70% of reading +ADHD due to shared genetic influence (Light et al., 1995)
Special thanks to:

• Rachel Yates
• Dr. Sarah Grice
• Rebecca Pollack
Current Tests Held by Cambridge CAMHS Psychology

- Baby Progress Guides
- Bayley Scales of Infant Development
- Beery Visual Motor Integration
- Behavioural Rating inventory of Executive Function
- Bender Visual Motor Gestalt Test
- Benton Visual Retention Test
- British Ability Scales (BAS)
- British Assessment of Dysexecutive Syndrome (BADS)
- Children’s Memory Scale
- Crichton Vocabulary Scale
- Graded Non-Word Reading Test
- Harris Test of Lateral Dominance
- Illinois test of Psycholinguistic Abilities
Current Tests Held by Cambridge CAMHS Psychology (cont’d)

- Leiter Performance Scales
- Merrill Palmer
- Motor ABC
- Mullen Scales of Early Learning
- Kaufmann Assessment Battery for Children
- Neale Analysis of reading Ability
- NEPSY (A Developmental Neuropsychological Assessment)
- Raven’s Colored Progressive Matrices
- Rey Complex Figure Test
- Reynell Developmental Language Tests
- Rivermead Behavioural Memory Test
- Test of Everyday Attention for Children (TE-EACH)
Current Tests Held by Cambridge CAMHS Psychology (cont’d)

• Test of reception of Grammar (TROG)
• Tower of London
• Vineland Adaptive Behaviour Scales
• Wechsler Individual Achievement Test (WIAT)
• Wechsler Intelligence Scale for Children (WISC-III)
• Wechsler Objective Language Dimension (WOLD)
• Wechsler Objective Numerical Dimension (WOND)
• Wechsler Objective Reading Dimension (WORD)
• Wechsler Pre-School and Primary Scale of Intelligence (WPPSI-R)
• Wisconsin Card Sorting Test
• Snijders-Oomen Non-verbal Intelligence Test
Choosing Neuropsych Tests: a decision tree

- What are the current difficulties?
- Have previous tests provided a baseline measure of overall ability?
- Do we need to repeat the tests done previously in order to identify changes in performance?