The diagnosis and treatment of reading disorders: The role of working memory

Tim Hannan FAPS
Disclosure statement

I have no financial interests or commercial relationships to disclose.

Employer:  University of Western Sydney
Egypt,  ~ 5000ya
China ~ 4000ya
Indus Valley ~ 3000ya
Developmental cognitive disorders
A taxonomy of common conditions
Orton (1937)

- developmental alexia
- developmental agraphia
- developmental word deafness
- developmental motor aphasia
- abnormal clumsiness
- stuttering
Developmental cognitive disorders

- intellectual disability
- sensory impairments
  - visual impairment
  - auditory impairment
- motor disorders
- learning disorders
  - language disorders
  - dyslexias (reading disorders)
  - dysgraphias (spelling - writing disorders)
  - dyscalculias (arithmetic disorders)
- attention-deficit hyperactivity disorder
- autistic spectrum disorders
- other disorders
Diagnosis

The role of identifying cognitive variables
Competencies

1. theory of cognition
Cognitive systems

- perceptual systems
- motor functions
- language
- memory
- spatial processing
- attention & executive functions
- quantitative
- social cognition
Competencies

1. theory of cognition
2. psychological assessment
   • test administration and interpretation
   • psychometrics
Tests

- intelligence
- language
- reading, spelling and writing
- arithmetic
- memory
- spatial abilities
- executive functions
Test knowledge

- normative data
- psychometrics
  - reliability
  - validity
- administration & scoring
- interpretation
Competencies

1. theory of cognition
2. psychological assessment
   - test administration and interpretation
   - psychometrics
3. knowledge of common disorders
   - cognitive profile
   - epidemiology
Developmental cognitive disorders

- intellectual disability
- sensory impairments
  - visual impairment
  - auditory impairment
- motor disorders
- learning disorders
  - language disorders
  - dyslexias (reading disorders)
  - dysgraphias (spelling - writing disorders)
  - dyscalculias (arithmetic disorders)
- attention-deficit hyperactivity disorder
- autistic spectrum disorders
- other disorders
Developmental dyslexia

The nature of reading disorders
“Dyslexia is a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading, comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge.”
“Dyslexia is a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading, comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge.”
Specificity

- the child with a LD has a deficit in cognitive functioning which is specific to one domain, such that deficits do not extend to other areas of cognitive functioning
- e.g., the child with dyslexia has deficits specific to reading, which do not extend to other cognitive functions
“Dyslexia is a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading, comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge.”
Neurobiology

- increased prevalence within families
- genetic studies
- neuropathology
- neuroimaging
“Dyslexia is a specific learning disability that is neurobiological in origin. **It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities.** These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading, comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge.”
Phonological decoding → Word recognition → Reading comprehension
Phoneme awareness

Rapid naming

Phonological coding

Orthographic coding

Phonological memory

Semantics

Grammar

Word recognition

Oral comprehension

Discourse specific skills
Dyslexia is a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading, comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge.”
Theories

- intelligence
- visual perception
- auditory perception
- phonological processes
- cerebellar deficit
Phonological impairment

- children with dyslexia have deficits in phonological aspects of language and working memory
- these deficits underlie poor development of reading, and deficits in certain other aspects of cognitive functioning
Visuo-spatial sketchpad ➔ Central executive ➔ Phonological loop
Speech input

| Phonological store |

| Articulatory rehearsal |

Non-speech input
Dyslexia

- primary deficits
  - phonology / working memory
- secondary deficits
  - reading
  - spelling
  - writing
  - verbal fluency
  - verbal learning
  - acquired verbal knowledge
Dyslexia and SLI

- poor decoding
  - phonology
  - “specific reading disorder”
- poor comprehension
  - grammar
  - “reading disorder - poor comprehender”
- broad deficits
  - phonology, grammar, semantics
  - “SLI” or developmental language disorder
<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Language Disorder</th>
<th>&quot;Poor Comprehender&quot;</th>
<th>Reading Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral Language</td>
<td>phonology</td>
<td>x</td>
<td>0</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>grammar</td>
<td>x</td>
<td>x</td>
<td>o</td>
</tr>
<tr>
<td></td>
<td>semantics</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pragmatics</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Written Language</td>
<td>graph-phon conversion</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>word recognition</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>text comprehension</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>spelling</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>writing</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Memory</td>
<td>verbal working memory</td>
<td>x</td>
<td>0</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>verbal learning</td>
<td>x</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Crystallised</td>
<td>general knowledge</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Quantitative</td>
<td>arithmetic</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
Identification
Early identification

• importance of identifying those children who skills are weaker than peers
  • ~ 8% children are slow to develop these skills
  • ~ 2% significant and lifelong difficulties

• intervention before Year 2 maximises outcome
Test selection: optimal

- WISC-IV / WPPSI-III (or SB-5)
- WIAT-II (reading, spelling, arithmetic)
- CELF-4 (if concerns over language)
- BASC-2 / CBCL / CBRS
- ABAS-2 (if low IQ)
- Conners-3 (if query re ADHD)
- SSRS (if query re social functioning)
- ADI-R, ADOS, SCQ (if query re ASD)
- BRIEF (if query re executive functions)
Test selection: minimum

- WISC-IV
- WIAT-II (reading subtests)
- BASC-2 / CBCL / CBRS
### Case 28

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VC</td>
<td>110</td>
<td>RLI</td>
<td>115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PR</td>
<td>121</td>
<td>ELI</td>
<td>93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WM</td>
<td>83</td>
<td>LCI</td>
<td>110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>91</td>
<td>LSI</td>
<td>98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td>105</td>
<td>CLS</td>
<td>98</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Case 28

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>WR</td>
<td>80</td>
<td>MR</td>
</tr>
<tr>
<td>PD</td>
<td>91</td>
<td>NO</td>
</tr>
<tr>
<td>RC</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>87</td>
<td></td>
</tr>
</tbody>
</table>
Interventions

What works?
Treatment

- training in phonological skills improves phonological skills and reading in non-dyslexic children
- however more limited improvements in children with dyslexia
- severity of phonological deficit predicts progress
ដ
## Coloured lenses

<table>
<thead>
<tr>
<th>NARA</th>
<th>number</th>
<th>mean effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>4</td>
<td>0.068</td>
</tr>
<tr>
<td>Comprehension</td>
<td>17</td>
<td>-0.093</td>
</tr>
<tr>
<td>Rate</td>
<td>15</td>
<td>0.114</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>0.127</td>
</tr>
</tbody>
</table>
### Coloured lenses

<table>
<thead>
<tr>
<th>WRMT</th>
<th>number</th>
<th>mean effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter identification</td>
<td>11</td>
<td>-0.107</td>
</tr>
<tr>
<td>Word Recognition</td>
<td>10</td>
<td>-0.101</td>
</tr>
<tr>
<td>Comprehension</td>
<td>11</td>
<td>0.105</td>
</tr>
<tr>
<td>Rate</td>
<td>13</td>
<td>0.015</td>
</tr>
</tbody>
</table>
“The etiology of [learning] difficulties is multifactorial, reflecting genetic influences and abnormalities of brain structure and function.... Visual problems are rarely responsible for learning difficulties. No scientific evidence exists for the efficacy of eye exercises ("vision therapy") or the use of special tinted lenses in the remediation of these complex pediatric neurological conditions.”

A Joint Statement of the American Academy of Pediatrics, American Association for Pediatric Ophthalmology and Strabismus, and American Academy of Ophthalmology
Sensory integration therapy

“... reveal absolutely no unique benefits, regarding any of the tested outcome areas, conveyed by SI therapy to the children with learning disabilities (and purported SI dysfunction) who served as subjects in those studies... the current fund of research findings may well be sufficient to declare SI therapy not merely an unproven, but a demonstrably ineffective primary or adjunctive remedial treatment for learning disabilities and other disorders”

Hoehn & Baumeister (1994)
### Sensory-motor interventions

<table>
<thead>
<tr>
<th></th>
<th>number</th>
<th>mean effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word recognition</td>
<td>36</td>
<td>-0.02</td>
</tr>
<tr>
<td>Comprehension</td>
<td>33</td>
<td>-0.06</td>
</tr>
<tr>
<td>Oral reading</td>
<td>17</td>
<td>-0.04</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>25</td>
<td>-0.01</td>
</tr>
<tr>
<td>Speed/rate</td>
<td>8</td>
<td>-0.04</td>
</tr>
</tbody>
</table>
“You simply can’t kill it. It simply bides its time in exile after being dislodged by one of history’s periodic attacks upon it and then returns, wearing disguises or carrying new *noms de plume*, as it were, but consisting of the same old ideas doing business in the same old way”.

Mann (1979)
Diagnoses

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>language disorder</td>
<td>8</td>
<td>6%</td>
</tr>
<tr>
<td>reading disorder</td>
<td>6</td>
<td>4%</td>
</tr>
<tr>
<td>intellectual disability</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>“low IQ” (≤ 85)</td>
<td>20</td>
<td>14%</td>
</tr>
<tr>
<td>average IQ (86-100)</td>
<td>36</td>
<td>26%</td>
</tr>
<tr>
<td>2^{nd} quartile (101-119)</td>
<td>40</td>
<td>29%</td>
</tr>
<tr>
<td>1^{st} quartile (120+)</td>
<td>28</td>
<td>20%</td>
</tr>
</tbody>
</table>
VC < PR (10+)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>.25</td>
</tr>
<tr>
<td>Specificity</td>
<td>.70</td>
</tr>
<tr>
<td>PPP</td>
<td>.05</td>
</tr>
<tr>
<td>NPP</td>
<td>.94</td>
</tr>
</tbody>
</table>
Does low VC and low WM predict the presence of a language disorder?
VC, WM $\leq 91$ and VC $< \text{PR}$

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>1.00</td>
</tr>
<tr>
<td>Specificity</td>
<td>1.00</td>
</tr>
<tr>
<td>PPP</td>
<td>1.00</td>
</tr>
<tr>
<td>NPP</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Guidelines

- if both VC and WM ≤ 91 and PR>VC, probable language disorder (but consider exclusions)
- if FSIQ 80-85, don’t diagnose language disorder unless > 15-20 points between FSIQ and CLS
- if FSIQ < 80, don’t diagnose a (specific) language disorder
Information for diagnosis

- cognitive functioning
  - language
  - intelligence
  - academic achievement
  - specific cognitive functions
- behavioural and emotional functioning
  - behavioural problems
  - mood
- social functioning
  - social interaction
  - social understanding
DSM-5 - proposed

- Learning Disabilities (new category)
  - Dyslexia
  - Dyscalculia
- Communication Disorders (no change)
  - Expressive Language Disorder
  - Mixed Receptive-Expressive Language Disorder
  - Phonological Disorder
  - Stuttering
  - Communication Disorder NOS
DSM-5 - proposed

- Autistic Spectrum Disorder (revised)
- Attention-Deficit and Disruptive Disorders
  - ADHD (nature of changes uncertain)
  - ADHD NOS
- Developmental Coordination Disorder (minor changes)
Overview

- what are the key features of a reading disorder?
- how does a reading disorder relate to working memory and other areas of cognitive functioning?
- how is a reading disorder identified?
- how is a reading disorder treated?
Print

Visual processor

Phonological processor

Semantic processor

graphemic route

Seymour (1990)

morphemic routes