Understanding comorbidity between dyslexia and other developmental disorders

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Attention & motor skills in children at risk of dyslexia

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Dyslexia

- Reading and spelling deficit affecting 3-7% of school aged children
  - Core phonological deficit

- Co-occurring disorders:
  - SLI (McArthur et al., 2000)
    - Separable from dyslexia?
  - ADHD (Willcutt & Pennington, 2000)
  - DCD (Rochell & Talcott, 2006)

- Shared etiological risk factors?

- May affect the profile of difficulties in children with dyslexia and their response to intervention
Dyslexia & ADHD

- Symptoms of inattention, hyperactivity & impulsivity (DSM V; APA, 2010)
  - Core deficit in behavioural inhibition > executive functions (Barkley, 1997)
    - Sustained attention, Response variability, Working memory (visuo-spatial), Temporal processing (Castellanos & Tannock, 2002)
  - Prevalence rate 5-7% (Polanczyk, Silva de Lima, Horta, Biederman & Rohde, 2007)

- 15-35% with dyslexia also have ADHD (Shaywitz et al., 1992; Willcutt & Pennington, 2000)
  - Common causal mechanisms (Shared etiology)
    - Cognitive level (McGrath et al., 2010; Willcutt, Pennington, Olson, Chhabildas & Hulslander, 2005)
    - Biological level (Light, Pennington, Gilger, & DeFries, 1995; Stevenson et al., 2005)
Dyslexia & DCD

• Difficulties in motor performance that are unexpected given the child’s age and opportunities for skill acquisition (DSM-V; APA 2010)
  • Prevalence rates vary widely (5-18%) (Geuze, Jongmans, Schoemaker & Smits-Englesman, 2001)

• Over 50% of children with dyslexia meet criteria for DCD (Kaplan et al., 1998) and DCD is frequently comorbid with other developmental disorders e.g. SLI and ADHD (Visser, 2003; Hill, 2001)
  • Common causal mechanism
    • Genetic (Regehr & Kaplan, 1988)
    • Neuropsychological e.g. Timing (Wolff et al., 1984; 1990)
    • Marker of atypical brain development (Kaplan et al., 1998)
Findings from at risk studies

• Some at risk children are slower to reach early developmental motor milestones (Viholainen et al., 2006 - Jyvaskyla project)
  • 3 yrs - language difficulties (they had smaller vocabularies and poorer inflectional skills)
  • 7 yrs - slower readers

• At risk children who received a diagnosis of dyslexia had more symptoms of inattention/hyperactivity than those who did not receive a diagnosis (Snowling, Carroll & Muter, 2007)

• Complex interplay between disorders
  • Multiple deficit models (e.g. Pennington, 2006) suggest that comorbidity between disorders is expected if they share risk factors
Research questions

• Do children at risk of dyslexia have weaknesses in their early attention/motor skills?
  – FR and LI compared to TD

• What are the relationships between children’s attention/motor skills and their early language/literacy skills?

• Do children’s attention/motor skills contribute to their literacy outcomes over and above known predictors of literacy?
  – Are children with additional comorbid difficulties most at risk?
The study

Oct 2007 Recruitment begins

March 2008 Phase 1 begins
Feb 2009 Phase 2 begins
Feb 2009 Phase 3 begins
Feb 2010 Phase 4 begins
Sept 2011 Phase 5 begins

3:09
4:08

~30%

TD = 82
FR = 83
LI = 40

FR = 59
FRLI = 24

LI = below SS 85 or criterion on 2/4 language tests (CELF BC, EV, SS + TEGI)
### The groups

<table>
<thead>
<tr>
<th></th>
<th>TD (82)</th>
<th>FR (59)</th>
<th>LI (40)</th>
<th>FR+LI (24)</th>
<th>F</th>
<th>p</th>
<th>Post-hoc</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T1 Age (mths)</strong></td>
<td>45</td>
<td>46</td>
<td>44</td>
<td>45</td>
<td>2.40</td>
<td>ns</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>T2 age (mths)</strong></td>
<td>56</td>
<td>57</td>
<td>55</td>
<td>57</td>
<td>1.49</td>
<td>ns</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>NVIQ(ss)</strong></td>
<td>114</td>
<td>109</td>
<td>98</td>
<td>100</td>
<td>13.63</td>
<td>sig</td>
<td>(TD=FR) &gt; (FRLI=LI)</td>
</tr>
<tr>
<td><strong>SES Postcode rating (%)</strong></td>
<td>68</td>
<td>65</td>
<td>55</td>
<td>51</td>
<td>3.44</td>
<td>.02</td>
<td>None</td>
</tr>
<tr>
<td><strong>% males</strong></td>
<td>54</td>
<td>54</td>
<td>68</td>
<td>75</td>
<td></td>
<td></td>
<td>Chi Sq = 5.26, ns</td>
</tr>
</tbody>
</table>
Motor tasks

- Fine motor skills
  - Posting coins
  - Bead threading
  - Bike trail

- Balance

Movement ABC
(Henderson & Sugden, 1992)
Executive Function tasks

• Executive function
  • Complex inhibition/Behavioural regulation
    • Head Toes Knees and Shoulders task (Burrage et al., 2008)

• Memory
  • Block recall (Pickering & Gathercole, 2001)
  • Word recall

• Selective attention
  • Apples task (Breckenridge, 2010)

• Sustained attention
  • Auditory Continuous Performance task

• Simple reaction time
T2 Motor skills

Fine Motor skills
- LI, FRLI > TD
- LI > FR

Bike Trails
- LI, FRLI > TD

Balance

Z score Time (sec)

*= worse than FR
* = worse than TD
T2 Executive Function

**HTKS - complex inhibition**

- TD
- FR
- LI
- FRLI

**Memory**

- Visuo-spatial
- Verbal

- × = worse than FR
- * = worse than TD

**Visual search - selective attention**

- Omission errors
- Commission errors

**ACPT - sustained attention**

- Omission errors
- Commission errors
T2 Reaction time

Simple RT (ms)

- × = worse than FR
- * = worse than TD

Mean RT vs. SD RT
# T2 Partial correlations (FR group)

<table>
<thead>
<tr>
<th></th>
<th>NVIQ</th>
<th>Language</th>
<th>LSK</th>
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<tbody>
<tr>
<td>Receptive Language</td>
<td>.31</td>
<td></td>
<td></td>
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<tr>
<td>LSK</td>
<td>.37</td>
<td>.34</td>
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<tr>
<td>Fine Motor</td>
<td>-.22</td>
<td>-.29</td>
<td>-.39</td>
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<tr>
<td>Balance</td>
<td>.14</td>
<td>.21</td>
<td>.21</td>
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<tr>
<td>Sustained attention</td>
<td>-.37</td>
<td>-.46</td>
<td>-.39</td>
</tr>
<tr>
<td>Selective attention</td>
<td>-.33</td>
<td>-.11</td>
<td>-.07</td>
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<tr>
<td>HTKS (Inhibition)</td>
<td>.42</td>
<td>.38</td>
<td>.39</td>
</tr>
<tr>
<td>Visual-Spatial Memory</td>
<td>.41</td>
<td>.38</td>
<td>.32</td>
</tr>
<tr>
<td>RTSD</td>
<td>-.24</td>
<td>-.23</td>
<td>-.36</td>
</tr>
</tbody>
</table>

Controlling for age; \( r > .24 \) sig at \( p < .05 \), \( N = 63 \)
Who is most at risk in the FR group?

<table>
<thead>
<tr>
<th>Step</th>
<th>Predictors of T2 LSK</th>
<th>Unique predictors</th>
<th>$R^2$</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Age</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T1 LSK</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NVIQ</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T1 DEAP (Speech)</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T2 Non-Word Rep</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T2 Sentence structure</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T2 Alliteration Matching</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>T2 HTKS (Behavioural inhibition)</td>
<td>ns</td>
<td>.55</td>
</tr>
<tr>
<td>2</td>
<td>T2 ACPT omissions (attention)</td>
<td>ns</td>
<td>.57</td>
</tr>
<tr>
<td>2</td>
<td>T2 RT variability (attention)</td>
<td>* (3%)</td>
<td>.58</td>
</tr>
<tr>
<td>2</td>
<td>T2 Fine Motor</td>
<td>* (3%)</td>
<td>.58</td>
</tr>
</tbody>
</table>
T2 Summary & conclusions

- Children with LI continue to show weaknesses in motor skills and executive functions when they are 4 yrs
  - Specific or non-specific difficulties?
  - Children with FRLI have weaknesses in attention compared to TD controls (ACPT and RT variability)
    - Evidence of multiple risk factors?

- RT variability (key endophenotype of ADHD) and fine motor skills predict LSK over and above language skills
Thank you for listening

Thank you to the families

And to the other members of the research team
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