Dyslexia and Comorbid Disorders

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Overview

Part 1:
- Definition of comorbidity
- Dyslexia and comorbid disorders: Prevalence
- Dyslexia and dyscalculia: specific and overlapping risk factors

Part 2:
- Comorbidity: why should we care? – Example: Dyslexia and ADHD
- Implications for practice: diagnosis
- Implications for practice: intervention
Comorbidity

Definition:
- Co-occurrence of two or more different disorders in the same individual
- Two or more disorders co-occur more often than we would expect by chance (e.g., Kain, Landerl, & Kaufmann, 2008; Pennington, 2006)

“True” comorbidity: exclude artefacts (e.g. Angold et al., 1999; Caron & Rutter, 1991)
1. Sampling bias: Representative samples
2. Rater bias: Standardized tests - objective testers
3. Symptom overlap → Practical implications for diagnosis

Tim’s mum gave him seven biscuits. Tim ate three of them and gave two biscuits to his sister. How many biscuits are left over?

$$7 - 3 - 2 = 2$$
Calculation of comorbidity rates

Base rates:
RD 7.0% and MD 6.1%

Population based sample:
N = 2586 - Grades 2 to 4

Standardized tests:
• literacy
• maths (calculation)

Expected by chance:
N = 2586
cases expected cases observed observed / expected
RD x MD: 0.4% 10 41 4.1

Landerl & Moll, JCPP 2010
Dyslexia and comorbid Disorders

Homotypic and heterotypic comorbidity

High co-morbidity rates between Dyslexia and:

- Mathematic Disorder (MD)
- Language deficits:
  - Specific Speech Disorder (SSD) and
  - Specific Language Impairment (SLI)
  → different time points of diagnosis
- Developmental Coordination Disorder (DCD - Dyspraxia)
- Attention Deficit (Hyperactivity) Disorder AD(H)D
Dyslexia (RD) and comorbid Disorders

Maths Disorder (MD)
RD: 17-70% with MD
MD: 11-56% with RD
(Badian, 1983; Barbaresi et al., 2005; Dirks et al., 2008; Gross-Tsur et al., 1996; Landerl & Moll, 2010; Lewis et al., 1994; von Aster et al., 2007)

Specific Speech Disorder (SSD)
Risk for later RD is mediated by comorbid LI (Relative risk 4.3 – 8.9)
Relative risk is ns in SSD without LI
(Review: Pennington & Bishop, 2009)

Specific language Impairment (SLI)
SLI: 31-36 % develop later literacy difficulties (Catts et al., 2005)
Overlap: ~ 50% (McArthur et al., 2000)
Dyslexia (RD) and comorbid Disorders

DCD – Developmental Coordination Disorder
- ~ 50% of children with dyslexia meet criteria for DCD (Kaplan et al., 1998)
- DCD comorbid with other developmental disorders e.g. SLI and ADHD (Visser, 2003; Hill, 2001)

→ Discussion: Atypical brain development (ABD) - Kaplan et al. (1998)

AD(H)D – Attention Deficit Hyperactivity Disorder
AD(H)D and RD: 25-40% (e.g., Pennington, Willcutt & Rhee, 2005; Gilger, Pennington, DeFries, 1992)

SUMMARY:
About 1/2 of children with Dyslexia will experience comorbid deficits
Comorbidity is the norm rather than an exception!
## Dyslexia and Dyscalculia

Difficulties are rather distinct

<table>
<thead>
<tr>
<th>315.00 Reading Disorder</th>
<th>315.1 Mathematics Disorder</th>
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</thead>
<tbody>
<tr>
<td>Letter-sound knowledge</td>
<td>Learning numbers</td>
</tr>
<tr>
<td>Decoding</td>
<td>Counting principles</td>
</tr>
<tr>
<td>Reading fluency</td>
<td>Calculation</td>
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<tr>
<td>Spelling</td>
<td>Place-value</td>
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<tr>
<td><strong>Language: phonological deficit</strong> (review: Vellutino, Fletcher, Snowling, &amp; Scanlon, 2004)</td>
<td><strong>Processing numerosities</strong> (Butterworth, 2011)</td>
</tr>
</tbody>
</table>

Comorbidity?  
– what components of maths?  
– shared risk factors?
Triple Code Model

Preverbal system:
- Subitizing
- Comparison
- Approximate calculation

Arabic Numeral:
- Multi-digit operations
- Parity

Language system:
- Counting
- Addition
- Multiplication tables

Dehaene, 2000
Disentangle “Maths” - Examples

4 + 2 = ?
4 x 2 = ?
4 - 2 = ?
12 + 23 = ?
15 + 26 = ?

Tim’s mum gave him seven biscuits. Tim ate three of them and gave two biscuits to his sister. How many biscuits are left over?

Which choice shows what this figure will look like if the graph paper is rotated 180 degrees?
Disentangle – Basic number skills

Mean RT in ms

Number of dots

MD
Control

Five 5
Arithmetic abilities in adults with dyslexia

Simmons & Singleton (2006; 2007):
Students with and without dyslexia – FIQ matched

Dyslexic group poorer in:
- Slower RT for addition and subtraction (multiplication marginal)

No group difference in:
- accuracy of number facts

Hypothesis: Dyslexics not impaired in other areas of maths, e.g., subitizing, estimation, number comparison ...
Number processing in adults with dyslexia

Göbel & Snowling (2010):

Students with and without dyslexia – age and FIQ matched
Dyslexic group poorer in:
- Counting: marginally more errors in dyslexic group
- RT for speeded addition orally presented
- RT for forced-choice computerized addition (exact calculation)
- RT multiplication

No group difference in:
- Subtraction
- Symbolic number comparison
- Odd/Even
- Spatial tasks (mental rotation)
Number processing in children

Moll, Göbel, & Snowling (in preparation):

4 groups of children - aged 6 to 11: age-matched N = 89
- 21 RD: children with reading disorder
- 17 MD: children with maths disorder
- 19 RD+MD: children with comorbid difficulties
- 32 TD: typically developing children

Testbattery:
- Addition and Subtraction (timed)
- Dot counting: subitizing (1-3) and counting range (5-7)
- Numberline
- Magnitude comparison
Number processing in children

Addition [items correct/sec] Subtraction

\[\begin{align*}
&\text{RD} \\
&\text{MD} \\
&\text{RD+MD} \\
&\text{TD}
\end{align*}\]

\[\begin{align*}
&\text{RD} \\
&\text{MD} \\
&\text{RD+MD} \\
&\text{TD}
\end{align*}\]

TD > RD = MD = RD+MD
RD > RD+MD

Moll, Göbel, & Snowling (in preparation)
Number processing in children

**Dot counting [msec]**

**Subitizing:** 1-3

**Counting:** 5-7

Moll, Göbel, & Snowling (in preparation)
Number processing in children

Magnitude comparison (%corr)

RD = MD > RD+MD = TD

Numberline (deviation)

RD = TD > MD = RD+MD

Moll, Göbel, & Snowling (in preparation)
Triple Code Model

Preverbal system:
- Subitizing
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- Approximate calculation

Language system:
- Counting
- Addition
- Multiplication tables

Arabic Numeral:
- Multi-digit operations
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Dehaene, 2000
**Cognitive level:** Domain-specific deficit

(Landerl, Fussenegger, Moll, & Willburger, 2009)

4 groups: dyslexia only, dyscalculia only, comorbid, controls

**Dyslexia:** phonological deficit (review: Vellutino, Fletcher, Snowling, & Scanlon, 2004)

Deficits in PA and RAN in two groups with dyslexia - but not in group with dyscalculia only.

Memory deficits, i.e. in comorbid group

**Dyscalculia:** deficit in number module / number sense (Butterworth et al., 2011; Wilson & Dehaene, 2007)

Deficit in Magnitude comparison, Numberline, and number comparison in two dyscalculic groups - but not in dyslexia only group
Dyslexia and Dyscalculia

Cognitive level: Shared risk factors?

*Potential common cognitive risk factors: predictors of maths*

1. Long-term phonological representations – mixed findings
   - No relationship between PA and maths achievement (Passolunghi et al., 2008)
   - Relationship between PA and small problem size number facts, but not for large problem size: retrieval versus procedural (De Smedt, Taylor, Archibald, & Ansari, 2010)

2. Verbal short term and working memory? (Passolunghi et al., 2008)

Further research necessary to identify specific and shared risk factors
SUMMARY:

Evidence for dissociations on behavioural and cognitive level

Evidence for specific risk factors: Dyslexia ≠ Dyscalculia
→ phonological deficit versus number processing deficit

Dyslexia: → impact on verbal aspects of maths
→ shared cognitive risk factor?

Important: differentiate between specific causal core deficits and additional / shared risk factors between disorders
Comorbidity - why should we care?

1. Unrecognised comorbidities can result in:

→ false causal reasoning!
→ Consequence: intervention that is not specific to the deficit
Comorbidity – why should we care?

Examples – unrecognised comorbidities:

**Temporal processing deficit in ADHD and ADHD + RD, but not RD**

**Visual and Auditory TOJ:** explained only small amount of variance in reading after controlling for attention skills

→ Deficits in temporal processing are linked to attention difficulties
  - not core deficits of dyslexia

→ Some dyslexic children might be poorer due to co-occurring attention difficulties (attention = important to assess)

→ Training these skills will NOT improve literacy skills
Comorbidity - why should we care?

2. Risk and protective factors inform about compensatory strategies

Example: Dyslexia and Dyscalculia: poor visual and verbal memory – compensatory memory strategies may fail

Good oral language skills are a protective factor for children at family risk of dyslexia (Gallagher, Frith, & Snowling, 2000)

3. Comorbid disorders influence symptoms on the behaviour level

Example: Dyslexia with oral language difficulties: deficits in decoding (word and nonword reading) and spelling plus deficits in comprehension

4. Symptom overlap – important for diagnosis to avoid wrong conclusions
Comorbidity - why should we care?

Example – symptom overlap:

Assessment results

WISC-IV:
- Verbal Comprehension Score = 92 (normal range: 85 – 115)
- Perceptual Reasoning Score = 108
- Working memory (digit span, Letter-number sequences) Score = 86
- Arithmetic: scaled score = 6 (normal range: 7-13)

→ Maths difficulties?

- BAS-II: Number skills = 110
- WIAT: Reading = 89
- WIAT: Spelling = 82

Difficulties due to other deficits than the measured construct
Implications for practice - diagnosis

- Analysis of task demands! e.g. word problems in Maths tasks?
  → “Pure” tasks in addition to achievement tests, to assess the different components of maths (similar to literacy).

- Are deficits general (i.e. poor oral language skills) or specific to language of maths (add, plus, take-away, minus, multiply....)

- “True comorbidity” or consequence?
  i.e. ADHD or attention difficulties as a consequence of RD (secondary?)

- Specific and shared cognitive risk factors to understand the behavioural profile
  → Detailed comprehensive profile important - not only diagnosis
  → Strength and weaknesses
## Components Literacy and Maths

<table>
<thead>
<tr>
<th>Literacy</th>
<th>Cognitive skills</th>
<th>Basic number skills</th>
<th>Maths achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Reading accuracy</td>
<td>Phonological awareness</td>
<td>Number sense: e.g. Estimation, NC</td>
<td>Maths achievement - standardized</td>
</tr>
<tr>
<td>Nonword reading accuracy</td>
<td>RAN</td>
<td>Calculation: separate lists</td>
<td></td>
</tr>
<tr>
<td>Word and nonword reading speed</td>
<td>Verbal STM, Verbal LTM</td>
<td>Counting principles</td>
<td>Number facts</td>
</tr>
<tr>
<td>Spelling</td>
<td>Language- vocabulary</td>
<td>Number bonds</td>
<td>Place value</td>
</tr>
<tr>
<td>Writing</td>
<td>Working memory</td>
<td>Reading and writing numbers</td>
<td>Written numeracy - procedures</td>
</tr>
<tr>
<td>Reading comprehension</td>
<td>Visual-spatial skills</td>
<td></td>
<td>Maths reasoning - word problems</td>
</tr>
<tr>
<td></td>
<td>Sequencing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Processing speed</td>
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</tr>
</tbody>
</table>
Implications for practice - diagnosis

- Assessment: include different components
- Assessment: If indication of comorbid disorders - if possible include in assessment or refer to specialist
- Information about comorbid disorders (parental questionnaire)

Issues:
(1) Time limitations versus comprehensive assessment
(2) Expertise

→ stepwise procedure:
  1. Questionnaires
  2. Screening
  3. Referral GP → CAMH (i.e. ADHD)
Questionnaires

Attention / Behaviour:

- SDQ: [http://www.sdqinfo.com](http://www.sdqinfo.com) in English and Welsh
  Parent and Teacher: P/T 3/4 and 4-16
  Self completion: S11-17
  (Attention/Hyperactivity; Emotion; Peer problems; Conduct problems; Prosocial behaviour)
- CBCL (Achenbach)
- SWAN (Swanson et al. 2004: Categorical and dimensional definitions and evaluations of symptoms of ADHD: The SNAP and the SWAN rating scales)
  2 scales: (1) Attention and (2) Hyperactivity/Impulsivity
- Conners Rating Scale
- BRIEF: Parent / Teacher version
Developmental Coordination Disorder (DCD):

- **DCDQ-07** (Wilson et al., 2009): [http://www.dcdq.ca](http://www.dcdq.ca)  Age 5-15
  (3 scales: control during movement, fine motor/handwriting, general coordination)

Language: plus tests (vocabulary)

- **CCC-2** (Bishop, 2003): Age 4 - 16
  (Language: 4 subscales and pragmatics: 6 subscales)

Maths: tests!

- 1-min addition and subtraction
- Achievement test (e.g., WIAT-II)
Implications for practice - intervention

Intervention / recommendation depend on cognitive profile:

(1) Deficit specific intervention:

**Dyslexia:** Phonological awareness, letter-sound knowledge, blending (reading nonwords), sight word reading, textbook reading, word analysis – spelling

**Dyscalculia:** Counting, number reading and writing, and diagnostic specific training (number bonds, place value system...)

(2) Accounting for co-occurring difficulties:

  e.g. **ADHD:** training slots shorter, structure with clear timing, behavioural training....
THANK YOU

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