Understanding the "whirling ball of comorbidity":
Why do seemingly distinct learning difficulties tend to co-occur?

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Overview of Presentation

- Colorado Learning Disabilities Research Center
- Do learning difficulties in reading, math, and written language co-occur in the same children?
  - How often?
  - Why should we care?
- What causes "comorbidity" among these seemingly distinct academic difficulties?
  - Genetic and environmental influences
  - Cognitive factors
- Implications of comorbidity
  - Assessment and intervention
  - Future directions

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CLDRC Projects
(2011-2016)

- Project I: Twin Studies of Reading Difficulties and ADHD
  (Erik Willcutt, John DeFries, Sally Wadsworth)
- Project II: Reading, Writing, and Phonological Processes
  (Richard Olson, Jan Keenan)
- Project III: Executive Functions in Learning Disabilities and ADHD
  (Bruce Pennington, Erik Willcutt, Akira Miyake)
- Project IV: Genomic Analyses
  (Shelley Smith, Jeffrey Gruen)
- Project V: Reading and Listening Comprehension
  (Jan Keenan, Richard Olson)
- Project VI: Longitudinal Twin Studies of Reading Difficulties and ADHD
  (Sally Wadsworth, John DeFries, Richard Olson, Erik Willcutt)
An Overview of the CLDRC

- School-based screening to identify twins with difficulties in reading and writing or elevated symptoms of ADHD
  - 27 districts within 150 miles of Denver/Boulder
  - 8 - 18 year old
  - Over 5,000 twins and siblings
- 6 Research Projects
  - 12 hours of initial testing across 4 projects
  - 5-year follow-up (Wadsworth)
  - Molecular genetic analyses (Shelley Smith, Jeff Gruen)
- New directions: fMRI
  - ADHD (Banich, Willcutt)
  - RD/MD (Petrill, Willcutt)

CLDRC Measures
(project or projects)

- IQ (Project I)
- Academic achieve. in reading, math, and written language (I - III, V)
- Cognitive measures related to reading, math, and written language
  - Phonological and orthographic processing (II)
  - Language and listening comprehension (V)
  - Writing mechanics (II)
- Other cognitive measures
  - Processing speed (I, III)
  - Naming speed (I)
  - Executive functions (III)
  - Motivational processes (III)
- Psychopathology and functional impairment
  - ADHD (I, III)
  - Achenbach CBCL, TRF, YSR (III)
- Family and Environmental risk factors
  - Parental learning difficulties and ADHD (III)
  - Potential environmental risk factors across development (I, II, III)

CLDRC Academic Achievement Measures

- "untimed" word reading
  - PIAT Reading Recognition (Project I)
  - Time-limited word recognition (Project II)
- Single-word reading fluency
  - Test of Word Reading Efficiency (Project II)
- Reading Comprehension
  - PIAT Comprehension (Project I)
  - Gray Oral Reading Test (Project V)
  - Woodcock-Johnson III Passage Comprehension (Project V)
  - QRI (Project V)
  - Barnes (Project V)
- Written Language
  - Writing Copy (Project II)
  - WJ-III Writing Fluency and Writing Samples (Project II)
  - WRAT Spelling (Project I)
  - Test of Written Language IV (Project I)
  - Other new writing measures (Project II)
- Math
  - PIAT Math (Project I)
  - WRAT Math (Project I)
  - WJ-III Applied Problems (Project I)

Moderate to high correlations between different aspects of academic achievement

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Comorbidity between specific learning disorders (Cutoff = 10th percentile of population)

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<tr>
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<td>Math</td>
<td>50%</td>
<td>45%</td>
<td>40%</td>
<td>45%</td>
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Twin studies disentangle the genetic and environmental influences on a trait of interest

- Heritability ($h^2$): The extent to which individual differences in a trait are due to genetic influences.
- Shared (Common) Environment ($c^2$): The extent to which individual differences in a trait are due to environmental influences that similarly affect both twins in a pair.
- Nonshared Environment ($e^2$): The extent to which individual differences in a trait are due to environmental influences that are specific to the individual.
Nearly all of the covariance between each pair of achievement measures is due to shared genetic influences (similar to results reported by Bauer, et al., 2010; Hart et al., 2010; Olson et al., 2013; Trzeciwinski et al., 2006; Willcutt et al., 2000, 2003, 2007, 2010).

Genetic and environmental risk factors specific to reading and writing.

**Key Neuropsychological Constructs**

- Processing speed
  - Naming speed (letters, colors, numbers, objects)
  - Motor / nonverbal responses (e.g., Wechsler Coding and Symb. Srch)
- Phoneme awareness: detect and manipulate the phonemic constituents of speech
- Working memory: retain and manipulate information in memory
- Set shifting: flexibly shift cognitive set
- Handwriting production: motor mechanics of writing
- Important missing construct: numerosity / number-sense

**Cognitive correlates of learning difficulties**

(Betjemann et al., 2009; McGue et al., 2011; Willcutt et al., 2010, 2011, 2012; in press a, in press b)

- Reading
  - Phoneme Awareness
- Writing
  - Writing Mechanics
- Verbal Working Mem.
- Math
- Set shifting

**Understanding the co-occurrence of learning difficulties in reading, math, and writing**

- Do learning difficulties in reading, math, and written language co-occur in the same children? - Yes, much more often than expected by chance
- Why should we care? - Comorbidity is associated with greater difficulties in multiple important domains
- What causes this comorbidity? - Shared genetic influences lead to general weaknesses in processing speed and verbal working memory - Other genetic and environmental influences lead to distinct cognitive weaknesses that distinguish dimensions / disorders.
**Conclusion:**

**Clinical and Educational Implications**

- **Comorbidity matters**
  - An assessment should include a screen for each aspect of learning (and ideally for other issues such as ADHD, anxiety, etc.)
  - Comorbid cases often exhibit greater impairment
  - Each comorbid disorder may require a separate intervention

- **Accommodations for ubiquitous slow processing speed**
  - Extended time on tests / assignments
  - Shortened assignments
  - "Processing pauses" with reiteration of key points
  - Other ideas?

- **Find a niche that takes advantage of an individual's strengths**