Neurodevelopmental Disorders of Language and Reading

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Dyslexia
- Pattern of learning difficulties characterized by problems with accurate or fluent word recognition, poor decoding and poor spelling abilities
- ... specify additional difficulties with reading comprehension or maths reasoning

Language Disorder
- Persistent difficulties with the acquisition and use of language across modalities ... due to deficits in comprehension or production that include:
  - reduced vocabulary
  - limited sentence structure (grammar/morphology)
  - impairments in discourse (to explain/describe a topic or have a conversation)
Limitations of traditional views

- **Categorical diagnoses**
  - continuous, dimensional disorders

- **Developmental disorders**
  - LD primarily described in preschool/school years
  - dyslexia ‘diagnosed’ in school children and adults

- **Specificity and modular**
  - can occur at all IQ levels
  - does not take account of co-occurring conditions
Dyslexia and Language Disorder

• Three hypotheses regarding relationship:
  – Language disorder is developmental precursor of dyslexia
  – Dyslexia is a mild form of language disorder
  – Language disorder and dyslexia co-occur (co-morbidity)
Variable manifestation

- Heterogeneity without clear subtypes
  - Different types of language impairment
  - Different types of reading disorder
- Co-occurring difficulties may be seen in aspects of speech, motor co-ordination, attention and personal organisation, but these are not, by themselves, markers of language disorder or dyslexia
Language is a complex system

- Receptive versus expressive language
- Comprehension versus production
- Structural versus pragmatic difficulties
- Speech sound disorders
  - Linguistic (phonological)
  - Motoric (articulation)
Reading: a simple view

reading comprehension = decoding \times linguistics comprehension

letter knowledge,
phonological awareness

oral language skills,
particularly vocabulary and grammar
The robin is a bird with a bright red face, neck and breast. You can find it in gardens, parks and woods all year round.
Robins make their nests in a hole in a tree stump, bank or wall. Sometimes they nest in pots, or even the pockets of an old coat. Their eggs are pale with reddish spots.
Robins like to feed on insects and worms. They also eat seeds, berries and food scraps.
Cats are the main danger to robins, but robins are also a danger to each other when they fight over food and land.

Questions
1. What do a robin’s eggs look like?
2. Name two things that robins eat.
3. What does ‘food scraps’ mean?
4. What is the main danger to a robin?
Variation in reading skills

Beyond phonology

'poor comprehender'

'dyslexia'

Phonology
Relationship between ‘SLI’ and dyslexia
(after Bishop & Snowling, 2004)

Dyslexia + poor reading comprehension

Poor comprehender

Normal Reader

Language

Dyslexia
Dyslexia and LI

More than one trajectory to reading disorder

• Studies of children at family-risk of dyslexia
• Preschool profile of dyslexia
• Language as a foundation for reading
• Who becomes dyslexic?
• A causal model: multiple risk factors
• Implications for screening and intervention
FINDINGS FROM FAMILY RISK STUDIES OF DYSLEXIA

Snowling & Melby-Lervåg: A Meta-Analysis
Family-Risk Studies

• Recruit children who have a first degree relative with dyslexia

  Usually a parent (some studies include younger siblings of children with dyslexia)

• Follow from preschool

• Children assessed around Year 3 and classified:
  – FR-dyslexia
  – FR-No dyslexia
  – TD control (not-at-risk; low-risk)

• Retrospective analysis of group and subgroup differences at earlier developmental stages
Prevalence

Study name

Boets, Wouters, van Wieringen et al. 2007, 29%
van Bergen, de Jong, Plakas et al. (2012) 30%
vан Bergen, de Jong, Regtvoort, et al. 2011 32%
Pennington & Lefly, 2001 34%
Torppa, Lyytinen, Erskine et al. 2010 35%
Elbro, Borstrøm & Peterson, 1998 37%
Blomert & Willems, 2010 44%
Boets, Vandermosten, Poelmans et al. 2011 44%
Carroll, Mundy & Cunningham, 2014 44%
Ho, Leung & Cheung, 2011 44.7%
de Bree, Wijnen & Gerrits, 2010 47%
Elbro & Petersen, 2004 50%
Smith, 2009 58%
Scarborough, 1991 65%
Snowling, Gallagher & Frith, 2003 66%

Mean Prevalence 45%
Infancy

Preschool

Grade 2

Compared with controls

FR + / FR- Dyslexia

Dyslexia + poor Reading Comprehension

Dyslexia

Not ‘Dyslexic’

Prevalence 45%

Family Risk Dyslexia
Infancy

Atypical Auditory/ Speech Processing

Family Risk Dyslexia

Dyslexia + poor Reading Comprehension

Dyslexia

Spelling & NW Reading deficits

Prevalence 45%
Infancy

Preschool

Grade 2

Family Risk Dyslexia

Atypical Auditory/ Speech Processing

Delayed Speech and Language

Dyslexia + poor Reading Comprehension

Dyslexia

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Prevalence 45%
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Dyslexia

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Prevalence 45%

Compared with controls
Atypical Auditory/Speech Processing

Delayed Speech and Language

LI persists

Dyslexia + poor Reading Comprehension

Dyslexia

LI delay resolves

Spelling & NW Reading deficits

Prevalence 45%

Compared with controls

Family Risk Dyslexia

Infancy

Preschool

Grade 2
Studies of children at FR of dyslexia show:

- Familial Dyslexia associated with preschool impairments in *language and* phonological skills.
- ‘Dyslexia’ more likely to be diagnosed in children with ongoing language difficulties at end of preschool (vocab and comprehension).

‘Broader Phenotype’

- FR children who are ‘not dyslexic’ show mild impairments in phonological skills and decoding.

**Dyslexia : a Dimensional Disorder**

- No clear cut-off for ‘Dyslexia’; a dimension – ranges from mild (unaffected) to severe (diagnosed).
Dyslexia and LI

More than one trajectory to reading disorder

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• Who becomes dyslexic?
• A causal model: multiple risk factors
• Implications for screening and intervention
• Family Risk of Dyslexia
• Pre-school SLI
• Children at low-risk of RD
Family risk of dyslexia

No

Yes

LI classification
Below criterion 2/4 language tests

TD
N=69

LI
N=32

FR+LI
N=29

FR
N=83
Speech and language delays in preschool

Nash, Hulme, Gooch & Snowling, 2013
Co-morbidities?
Motor and executive attention

Co-occurring deficits in children at risk of dyslexia: motor delays and poor attention at 3-4 years

Gooch, Hulme, Nash & Snowling, JCPP 2013
Impairments relative to TD control
Preschool

Articulation (Speech)
Word and Nonword Repetition
Morphology

Language skills:
Vocabulary
Comprehension
Grammar

Executive Skills:
Attention
Inhibition
Fine-motor

Nash, Hulme, Gooch & Snowling, 2013
Gooch, Hulme, Nash & Snowling, 2013
• Children at family risk of dyslexia and children with preschool LI experience phonological deficits
  – PD = shared risk factor for poor decoding
• Children with preschool LI have problems with vocabulary and grammar
  – Oral language problems = risk factor for poor reading comprehension
• Executive and motor deficits commonly co-morbid with LI, less so with FR
• Can be expected to affect learning in the classroom
Language Foundations

- Articulation (pcc)
- Word repetition
- Nonword repetition
- Vocabulary
- Sentence recall
- Receptive grammar
- Basic concepts

Age 3½
Language as Predictor of Reading-Related Precursor Skills

Age 4½
Phoneme Awareness (PA), letter knowledge (GPC) and Rapid Naming (RAN) as precursors of decoding.
Predictors of Reading Comprehension

Hulme et al., 2016, Psych Sci
Doi: 10.1177/0956797615603702
• Language is the foundation for learning to read
  – Crucial for the development of phonological awareness
• The effect of language on decoding is via Phonological Awareness and letter knowledge
  – directly affects reading comprehension
• Phonology and Language Skills predict individual differences in learning to read/dyslexia
Dyslexia and LI

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Risk factors:
- Family-risk
- Poor language
- Poor phonology
- Poor executive-motor
Outcomes at T5

- **Dyslexia**: ...‘poor decoding and poor spelling abilities’ [DSM5]
- -1.5SD below the mean of the TD group on a composite of word reading/spelling (SS <= 88)
- Children at family risk of dyslexia (caused by poor phonology)
- Children with preschool LI (effects of poor language, mediated by PA/LSK deficits)
- Children with FR+LI (poor language mediated by PA/LSK deficits, + PA deficits)
### Dyslexia Outcomes by Risk Group

**Language Impaired**
- **LI +**: 40%
- **LI -**: 7%

**Typical Language**
- **FR +**: 26%
- **FR -**: 26%
“I’m right there in the room, and no one even acknowledges me.”

<table>
<thead>
<tr>
<th>Development of Language</th>
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<tbody>
<tr>
<td>LI (age 3½)</td>
</tr>
<tr>
<td>TD control</td>
</tr>
<tr>
<td>FR</td>
</tr>
<tr>
<td>LI</td>
</tr>
<tr>
<td>FRLI</td>
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</table>
Trajectories of language

- Data from t1, t3, t5:
  - Typical Language: not LI
  - Resolving LI
  - Persisting LI
  - Emerging LI

Snowling, Duff, Nash & Hulme, 2016 JCPP
<table>
<thead>
<tr>
<th>Trajectory [language]</th>
<th>N</th>
<th>% males</th>
<th>% FR dyslexia</th>
<th>% SSD</th>
<th>SES</th>
<th>Comorbid?</th>
<th>Dyslexia outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL</td>
<td>145</td>
<td>54%</td>
<td>46%</td>
<td>14%</td>
<td>.24a (.66)</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(66%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Resolving</td>
<td>12</td>
<td>75%</td>
<td>50%</td>
<td>42%</td>
<td>.05a (.70)</td>
<td>NO</td>
<td>‘Broader Phenotype’</td>
</tr>
<tr>
<td></td>
<td>(6%)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Emerging</td>
<td>21</td>
<td>48%</td>
<td>76%</td>
<td>48%</td>
<td>-.06a (.79)</td>
<td>46%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(10%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persisting</td>
<td>42</td>
<td>79%</td>
<td>48%</td>
<td>57%</td>
<td>-.32 (.84)</td>
<td>YES</td>
<td>41%</td>
</tr>
<tr>
<td></td>
<td>(19%)</td>
<td></td>
<td></td>
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</tbody>
</table>
Outcomes – taking account of who is LI at age 8

<table>
<thead>
<tr>
<th></th>
<th>Dyslexia by status at age 3</th>
<th>Dyslexia by status at age 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low risk (TD)</td>
<td>7%</td>
<td>8.5%</td>
</tr>
<tr>
<td>FR</td>
<td>26%</td>
<td>23%</td>
</tr>
<tr>
<td>LI</td>
<td>26%</td>
<td>33%</td>
</tr>
<tr>
<td>FRLI</td>
<td>40%</td>
<td>52%</td>
</tr>
</tbody>
</table>

Dyslexia more likely if LD persists until school age
• Risk of a dyslexia outcome is approximately equal in those at family risk of dyslexia (‘phonological’ impairments) and in those with preschool LI (at 3½)

• Dyslexia outcome is more likely in those with LI in school years (i.e. persistent and emerging profiles)

• Co-occurring FR-LI carries higher risk of dyslexia outcome, especially when LI is persistent
A disorder on the language continuum

TOWARD A CAUSAL MODEL OF DYSLEXIA: MULTIPLE RISKS
Dyslexia runs in families

- biology

‘Phonological’ Deficit

- cognition

Decoding (Fluency) Deficit

- Behaviour
Persisting Language Deficit
[risk factor 2]

Phonological Deficit
[risk factor 1]

Attention/EF deficit
[risk factor 3]

Multiple Genes

Dyslexia Phenotype
## Multiple pathways to ‘Dyslexia’

<table>
<thead>
<tr>
<th></th>
<th>Normal Reader</th>
<th>Dyslexia [+]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD (low risk)</td>
<td>N=68</td>
<td>N=5 7%</td>
</tr>
<tr>
<td>FR</td>
<td>N=64</td>
<td>N=22 26%</td>
</tr>
<tr>
<td>LI at 3½</td>
<td>N=40</td>
<td>N=20 33%</td>
</tr>
<tr>
<td>School concerns</td>
<td>N=12</td>
<td>N=3 20%</td>
</tr>
</tbody>
</table>
Pathways to ‘Dyslexia’

• More than one trajectory to poor decoding
  – A heritable form of dyslexia associated with preschool phonological difficulties
    • Some of this group experience late-onset language difficulties as a consequence of PD
  – A consequence of an underlying language disorder, with co-occurring executive and motor difficulties, which persists
  – Environmental factors associated with speech or language delay?
Dyslexia and LI

More than one trajectory to reading disorder

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‘Screening’ for Dyslexia

Logistic Regression

Executive Function
Language
Phonology
Family
Risk

Dyslexia
Normal Reader

Thompson et al., 2015 JCPP

3.5 yrs...6.5 yrs...8 yrs
Screening for Dyslexia

RISK FACTOR 1
Family-Risk

RISK FACTOR 2
Language

low -> high

Family Risk & ‘Core Predictors’

Core Predictors
- Phon Aw
- Letter Kn
- Rapid Naming
Risks associated with Language Disorder

Persistent
• Gender
• Speech delay/disorder
• Executive and motor difficulties
• Lower PIQ
• Low SES

Late-Emerging LI
• Family risk of dyslexia
• Speech delay

41% dyslexia
‘Critical Stage Hypothesis’
Bishop & Adams (1990)

46% dyslexia
Criteria and terminology for language impairments in children: striving for consensus

Dorothy V. M. Bishop,
University of Oxford

Speech, Language and Communication Needs

- Areas of Impairment:
  - Syntax
  - Semantics
  - Word retrieval
  - Pragmatics
  - Verbal learning/memory

- Phonology

- Dysarthria
- Dyspraxia
- Articulation disorder
- Orofacial structural deficits
- Voice disorders
- Fluency disorders
- Lack of familiarity with ambient language
- Language Disorder associated with biomedical condition X
- Needs secondary to hearing impairment

- ASD*

- Speech Sound Disorder

* ASD is sometimes treated as an alternative to, rather than part of, SLCN
Implications for Intervention

Oral Language Skills are critical to Literacy Development as a foundation for both Decoding and Reading Comprehension.

http://www.youtube.com/rallicampaign

CAMPAIGN TO RAISE AWARENESS OF LANGUAGE LEARNING IMPAIRMENTS

http://www.youtube.com/rallicampaign
Summary

• Dyslexia and Language Impairment
  – Both heritable, life-time persistent, language learning impairments
  – Show similarities and differences in oral and written language profiles
  – Shared risk factors for reading impairment but developmentally distinct
  – Overlapping comorbidities
  – Differences in severity of underlying abilities
    • Continuous distribution of phonological and semantic skills
Dyslexia and Language Disorder

• Three hypotheses:
  – Language disorder is developmental precursor of dyslexia
    • Critical age hypothesis – dyslexia is more likely if language difficulties persist until age of reading instruction
  – Dyslexia is a mild form of language disorder
    • ‘mild’ dyslexia (broader phenotype associated with resolved Language impairments
  – Language disorder and dyslexia co-occur (co-morbidity)
Conclusions

- Dyslexia is a disorder on the language continuum; not all children with dyslexia have co-occurring language disorder but many experience slow language development.
- Phonological and broader language skills predict individual differences in word-level reading skills in TD and LI groups.
- The risk of dyslexia is elevated in children at family risk and children with preschool LI.
  - FRLI carries higher risk of literacy problems.
- Dyslexia and LI share risk factors for poor literacy but may follow different trajectories.
- Effective interventions can promote language and reading skills in the early years and circumvent a downward spiral of poor reading and poor educational attainments.
Credits!

Children, Families and Schools – thank you!

Wellcome Team

- Charles Hulme
- Emma Hayiou-Thomas
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- Lorna Hamilton
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- Glynnis Smith
- Lindsey Bowes
- Denise Cripps
- Ruth Toureau
## Co-morbidity between Dyslexia & LI

<table>
<thead>
<tr>
<th></th>
<th>No Dyslexia [-]</th>
<th>Dyslexia [+]</th>
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<tbody>
<tr>
<td>No LI [-]</td>
<td>N=155&lt;br&gt;74.5%</td>
<td>N=28&lt;br&gt;13.5%</td>
</tr>
<tr>
<td>LI [+]</td>
<td>N=29&lt;br&gt;13.9%</td>
<td>N=22&lt;br&gt;10.6%</td>
</tr>
</tbody>
</table>