Why can you read this?

Neuroscience Perspectives on Disparities in Reading Development

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May 20, 2010
SES and Cognitive Development

Literacy

• Process of extracting meaning from written symbolic characters

• Evolutionarily recent
  • Unlike speaking, does not develop naturally
  • Requires active teaching and learning

• Far-reaching ramifications
  • Educational
  • Social
  • Economic
  • Health
Genetic and Environmental Factors

• Strong genetic basis (Gabrieli 2009)
  • 68% concurrence reading disability in identical twins
  • 50% have an affected sibling, parent, or child
• However, higher heritability among families with higher education (Friend et al 2008)
  • Environmental factors important, especially the context of limited resources
NYC: Failure of Basic Proficiency

- SES gradient in reading-related experience (Bradley et al 2001, Raz and Bryant 1990)
- Reading resources predictive of early reading ability (Bradley et al 2001, Whitehurst 1997)
Phonological Awareness

- Understanding the sound structure of language
- “CAT” - /k/ = /AT/
- Preliterate child’s skill excellent predictor of later reading ability
- Children who struggle with phonological awareness often have difficulty acquiring reading
Normal reading development

- Both cognitive and sociodemographic factors important
- But how do these cognitive and sociodemographic factors relate?
Phonological awareness and reading

Phonological awareness (CAT - /k/ = /at/)

Noble et al, 2006a
SES x phonological awareness awareness interaction

Noble et al, 2006a

Phonological awareness (CAT - /k/ = /at/)

Reading

SES

highest third

lowest third

Noble et al, 2006a
Normal reading development

- Cognitive and sociodemographic factors interact
- How do these factors explain brain development in reading impairment?
Neural Basis of Reading Development

Phonological processing

Access to visual representations of words

McCandliss and Noble 2003
Primary deficit in phonological awareness

Decreased ability to translate sounds into letters and vice versa

Reading Impairment: Summary
Are all reading impairments the same?

• Notably, none of these studies examined the effects of a child’s social context on brain development

Struggling reader, few resources = ? = Struggling reader, plentiful resources
SES, Reading Development, and the Brain

- 38 NYC 1st-3rd graders
- Socioeconomically diverse
- All below average phonological awareness
Functional MRI (fMRI)

- In response to an increase in neuronal activity, local oxygenation increases → more intense MR signal

- Can measure the blood-oxygen level dependent (BOLD) signal at thousands of points in the brain

www.fmrib.ox.ac.uk
www.functionalmri.org
combined area under graphs = convolution at time T = BOLD response

- time \( T_1 \)
- time \( T_2 \)
fMRI

- Can map which areas respond according to the predicted model

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Methods

• Phonological awareness measured outside the scanner
• Assessed brain activation during reading in the scanner
• Able to ask:
  • Among struggling readers, where is brain activity during reading correlated with phonological awareness skills?
  • Are there differences in this brain-behavior relationship according to SES?
Correlation with Phonological Awareness: Left occipito-temporal cortex

Interaction $R^2 = 0.21$

$P < 0.005$

Noble et al, 2006b
Correlation with Phonological Awareness: Bilateral perisylvian cortex

Noble et al, 2006b
Interpretations

• In children with lower phonological skill:
  • “Typical” brain-behavior relationships observed among children from lower SES backgrounds
  • “Atypical” brain-behavior relationships observed among children who struggle despite resources of higher SES backgrounds. (May in part be compensatory?)
  • Suggests that all struggling readers are not the same
District Scores
Percentage of 4th Grade Children Failing Basic Proficiency Standards

- > 70%
- 60% - 70%
- 50% - 60%
- 40% - 50%
- < 40%
<table>
<thead>
<tr>
<th>Speculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low SES</td>
</tr>
<tr>
<td>Good reader</td>
</tr>
<tr>
<td>Typical neurobiology, neurobiology, compensated atypical neurobiology?</td>
</tr>
<tr>
<td>Struggling reader</td>
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<tr>
<td>Typical underlying neurobiology, but lacking optimal resources for development?</td>
</tr>
<tr>
<td>Atypical neurobiology, but maybe able to compensate?</td>
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</tbody>
</table>
Conclusions

• Reading development is a complex interaction of cognitive, social and neurobiological factors
• Not all struggling readers are the same
  • Higher SES – mostly atypical neurobiology?
  • Lower SES – mostly experience-based?
• Taking a child’s background into account will be imperative in designing interventions
Future Directions

- Epidemiologic Approach
  - Quantify the association between SES, phonological awareness, and literacy over time
  - Identify modifiable environmental factors that increase vulnerability to deficits – social, material, chemical

- Interventional Approach
  - Center- and Home-based
  - Pediatric Clinic-based
Acknowledgements

- Martha Farah
- Bruce McCandliss
- Virginia Rauh
- William Fifer
- Ezra Susser
- Jeanne Brooks-Gunn
- Helena Duch
- Cassie Landers
- Carmen Rodriguez
- Mary McCord
- Larry Stanberry
- Richard Mayeux