Educational Neuroscience:

Identifying the Neural Substrates of Cognition and Learning

Bruce McCandliss, PhD
Vanderbilt University

Linking Education and Neuroscience
Connecting Education and Neuroscience

How do the brain systems individual learners differ?

Connecting Education and Neuroscience

How do the brain systems individual learners differ?
How do educational experiences drive changes in these systems?
Electrophysiology

Expertise Brain Response in Skilled Readers

English Visual Word

Unfamiliar Control Symbols

Maurer, Brandeis & McCandliss (2005)
Educationally Relevant Individual Differences

Skilled Adult Readers

Maurer, Brandeis & McCandliss (2005)

NEUROPROGNOSIS

AN APPROACH THAT USES BRAIN MEASURES TO PREDICT CLINICAL OUTCOME, FUTURE ACADEMIC ACHIEVEMENT, OR FUTURE SOCIAL/EMOTIONAL FUNCTIONING. THIS INCLUDES PROGNOSIS OF A NATURAL COURSE OF A CONDITION OR AN INTERVENTION.

Hoeft, McCandliss ... Gabrieli, UNDER REVIEW
Pre-readers’ brain response to speech predicts future reading skills

Neural systems predicting long-term outcome in dyslexia

Fumiko Hoelsch, Bruce D. McCandliss, Jessica M. Black, Alexander Gantman, Nahal Zakerani, Charles Hulme, Heikki Lyytinen, Susan Whitfield-Gabrieli, Gary H. Glover, Allan L. Reiss, and John D. E. Gabrieli
Linking experience driven changes to education:

Focusing Attention
Children’s phonological awareness predicts brain activity for word reading

Noble et al., (2008)

Educational Research: Curriculum/Teaching Effects

Educational Activities
Activities that draw attention to letter-sound relationships

Effect Size
Typical .48
At Risk .74

Ehri et al., (2001)
Educational Research: Curriculum/Teaching Effects

**Educational Activities**
Activities that draw attention to letter-sound relationships

<table>
<thead>
<tr>
<th></th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical</td>
<td>.48</td>
</tr>
<tr>
<td>At Risk</td>
<td>.74</td>
</tr>
</tbody>
</table>

Ehri et al., (2001)

**Teacher Observations**
Reading skill growth linked to amount of time teachers focus attention on letter-sound relationships


---

Word Level Focus Condition

- ‘cat’
- 4 sec.
Grapheme-Phoneme Focus Condition

'kuh' 4 sec.  'a'

'cat'

'tuh'

English Word

Symbol
Bridging Laboratory Research and Educational Intervention in Children
Software Based Intervention


Change in Standardized Test Scores - Reading Novel Words

Change in Standardized Test Scores - Reading Novel Words

University Based Study

Randomized Active Control Study in Schools


Reading intervention impacts brain activity

McCandliss et al., (2001)
Educational neuroscience: The early years
Bruce D. McCandliss
Department of Psychology and Human Development, Vanderbilt University,

As developmental cognitive neuroscience expands its exploration of mechanisms of change at the cognitive and neural system level, a focus is beginning to emerge on the role of educational experiences in shaping the specific functional circuits that give rise to complex cognitive skills such as reading or math. Such studies mark the emergence of educational neuroscience, an interdisciplinary field that tackles questions that stretch beyond the normal boundaries of what neuroscience or education research alone can address, and also, this field pursues insights that are of potential value to the goals of both fields of inquiry. The report by Born et al. (1) in this issue of PNAS falls squarely within this interdisciplinary area by studying changes in the brain activity of kindergarten children across a series of several functional MRI (fMRI) scans as they engage in different educational activities.

crossed exposure to letters? Although these questions may not be addressed directly by this initial study, such questions are now tractable in a way that they were not before given the tight link between educational experience and changes in brain activity shown here, because educational neuroscience studies are beginning to contrast different educational approaches within the same learning domain. Directly relevant to this point, and perhaps providing further evidence for a rising zeitgeist in support of educational neuroscience, another fMRI study of preschool children published this year (4) contrasted the impact of two educational experiences on occipito-temporal regions associated with recognizing letters. Unlike the Born et al. (1) study, James (4) directly investigated the possibility that the response that an educational activity with letter symbols encourages in a child

Relating Educational Neuroscience to Multiple Domains

Number and Math
Relating Educational Changes to Changes In Multiple Neural Systems

Number and Math

Executive Function Skills

“five”

3 4