A systematic approach to Educational Neuroscience: Research within the London-based CEN

AERA 2010, Denver, 1st May 2010
10:35am-12:05pm

Andy Tolmie (IoE): Educational neuroscience: Some key working principles

- Recent history of the Centre for Educational Neuroscience (EN)

  - Tenets
    - EN is not reductionist
    - EN is a multi-domain, multi-level and multi-disciplinary study of development and learning across lifespan
    - EN is about training a new type of scientist

Alice Jones & Essi Viding (Goldsmiths): The neuroscience of callous-unemotional subtype of conduct problems: Implications for intervention and education

- Children with callous-unemotional traits form an identifiable subgroup of children with conduct problems
- Research identifying the sub-group includes behavioural genetic, neuroimaging, and behavioural data
  - Deficits in recognising distress emotions
  - Lack of empathy
  - Typically developing mentalising abilities (ish)
- Pilot intervention for these children:
  - Reward system is developing normally (ish)
  - Punishment ineffective – focus on rewarding socially acceptable behaviours
  - Increase awareness of others’ needs and perspectives

Brian Butterworth (UCL) and Diana Laurillard (IoE): A new approach to dyscalculia intervention using adaptive learning technologies

- Developmental dyscalculia affects ability to enumerate sets and order sets by magnitude (a parietal lobe system)
- Twin data: parietal abnormality heritable and predicts arithmetical ability
- Intervention: Technology Enhanced Learning
  - Interactive and adaptive tasks emulating specialist learning environment for targeted practice, personalised to needs, with meaningful feedback
  - Pivoted in years 1-4
  - Scalable for roll-out
  - Learner model (record of performance) and Teacher model (rules for adapting task)
    - Time-based Rule (to check whether performance is fluent): apply time pressure + criterion for sufficient speed
    - Iteration Rule (to check whether performance is accurate): increment task difficulty level when accuracy sufficient

Sashank Varma (University of Minnesota): Discussant

- Example views to expect! Varma, Bruce and Schwartz (2008)
  - Scientific concerns re EN
    - Neuroscience methods too narrow
    - Brain localisation doesn’t advance education
    - Reductionism is inappropriate
    - Levels of description (macro- vs micro-level)
  - Pragmatic concerns re EN
    - Neuroscience methods too expensive
    - Neuroscience not far enough advanced to inform education
    - Should education ‘cede control’ to neuroscience?
    - Risk of neuromyths
- Concerns as opportunities
  - Innovative designs for neuroscience to study educational issues
  - Neuroscience is prompt new instructional theories
  - Reductionism does not have to be eliminative
  - Research on neuroeducation
  - Spur new funding
  - Already signs of success for EN (e.g., dyslexia)
  - Neuromyths = ready demand for brain-based theories
Sensitive periods in brain development
Implications for Educational Policy

Prof. Michael Thomas
Birkbeck, University of London, UK
AERA Denver 1st May 2010

Overview

• What changes in the brain with age?
  – How does this change our ability to learn?

• Are there ‘sensitive periods’ for learning?
  – What skills need to be learned early?
  – What skills need to be learned late?
  – Learning after a sensitive period has closed

• The curriculum

What changes in the brain with age?

• General principle:
  – Human brain initially produces surplus resources for learning to give flexibility to respond to environmental conditions
  – Resources are expensive to maintain: the brain then prunes away unused resources to save on metabolic costs

Grey and white matter

Density of synapses

Gray Matter Development

What changes in the brain with age?

- Functionally
  - Brain regions become more tuned to resemble their adult functional specialisations
  - The brain slowly learns more abstract representations of knowledge
  - ‘Executive functions’ improve (behavioural control, inhibition, emotional regulation, attention)

Sensitive periods

- The idea that brain plasticity (learning ability) reduces after a certain age [somewhat suddenly!]

3 hypotheses about reductions in plasticity

Current knowledge

- Sensitive periods
  - Associated with loss of neural resources (grey matter)
  - Close gradually
  - Rarely close completely (adults can still learn)

- Reductions in plasticity
  - Not uniform across systems / abilities (e.g., PFC last)
  - In part driven by learning – not at a fixed age
  - Occur after brain regions adopt adult function

Late L2 learners of English

- Chinese Early Arrivals
- Chinese Late Arrivals
- Spanish Early Arrivals
- Spanish Late Arrivals

Current research

A hierarchy of systems

- The brain is a hierarchy from perceptual / motor systems to abstract systems
  - Sensitive periods are mainly found in perceptual and motor systems
  - Less evidence for sensitive periods in higher order systems for abstract thought

- Late learned complex behaviours may be restricted by a reduction in perceptual / motor plasticity
  - E.g. Phonology in a second language

- No evidence for sensitive periods in literacy or numeracy per se

Examples of SP effects

- How learning itself can reduce plasticity:

- Literacy
  - Dyslexia can be caused by poor phonology
  - If you haven’t fixed poor phonology by the time you learn to read, it becomes harder to repair [Bau et al., 1999]

- Numeracy
  - Acquisition = integration of Number words + Object attention system + Quantity estimation systems
  - Bilinguals who become dominant in an L2 still use L1 for mental arithmetic [Wang et al., 2007]

- Bilinguals who become dominant in an L2 still use L1 for mental arithmetic

- Sensitive periods are mainly found in perceptual / motor systems to abstract systems
  - E.g. Phonology in a second language
What skills need to be learned early?

- Those that rely on low-level perceptual or motor skills
  - Learning multiple languages
  - Musician
  - Gymnast

What skills need to be learned late?

- Order is as important as rate
- Cannot learn abstract before perceptual
- Learning to learn:
  - Self-regulation aids learning [PFC]
  - Meta-cognitive abilities accelerate learning [integrative networks]
- Training attention helps: Transfer effects
  - But more useful at 6 than 4
  - Brain voltage potentials show differential response to training
  - Later maturation of PFC?

Efficiency of prefrontal attention network after 5 days of training

- For 4-year-olds, training produced an EEG pattern similar to the untrained 6-year-olds [frontal Fz]
- For 6-year-olds, the effect of training was to produce a more adult-like pattern [central Cz]

After a sensitive period is closed

- Learning is still possible (but harder)

<table>
<thead>
<tr>
<th>Child Learner</th>
<th>Adult learner</th>
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<tbody>
<tr>
<td>Exploration</td>
<td>Intense training</td>
</tr>
<tr>
<td>Many tasks at once</td>
<td>Cease interfering tasks</td>
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<tr>
<td>Natural exposure</td>
<td>Exaggerate key dimensions</td>
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<tr>
<td>Attention</td>
<td>Attention + motivation</td>
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<tr>
<td>Implicit learning</td>
<td>Use of strategies</td>
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<tr>
<td>Social context enhances learning</td>
<td>Social context enhances learning</td>
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</tbody>
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Curriculum

- Early exposure to relevant perceptual stimuli / motor skills most important [reduction in synapses]
- Self-regulation key to learning in the classroom [development of PFC]
- High-level systems show little evidence of sensitive periods [association cortex]
  - Timing of literacy / numeracy more flexible
  - Order more important than timing (perceptual before abstract)
- Middle childhood meta-cognitive skills accelerate learning [emergence of integrative networks]
- Future: training regimes tailored to mechanisms causing reduction in plasticity [neurocomputation]

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http://www.psyc.bbk.ac.uk/research/DNL/