Benjamin Vautier (1850). Children leaving school

Educational Neuroscience

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Lecture 9, 19.10.2020

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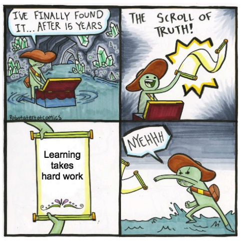
Roadmap for today's lecture

- Educational Neuroscience: definition and aims
- Emerging findings in Educational Neuroscience: Examples from recent studies
- The counterargument: Practical and principled problems with Educational Neuroscience



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Learning outcomes

1. Critically describe the aim of the emerging field called Educational Neuroscience
2. Provide examples from recent studies on literacy and numeracy to illustrate the educational relevance of neuroscientific investigations
3. Outline challenges of applying neuroscientific findings in education
4. Define and provide examples of neuromyths
5. To describe and evaluate evidence for and against the view that "neuroscience rarely offers insights into instruction above and beyond psychology"

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What is Educational Neuroscience

- A new emerging discipline ("scientific community") arising from combination of three previously unconnected disciplines
  - Education
  - Psychology
  - Neuroscience

Understand how the mind works

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In the classroom ....

- Understanding how the mind works involves understanding how to teach skills and give knowledge to children

Rising influence of neuroscience on economics, law, education etc

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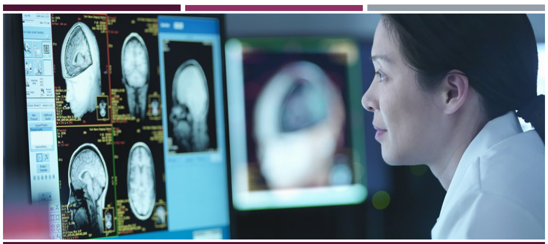

NEUROSCIENCE

SCIENCE OF THE BRAIN AND THE NERVOUS SYSTEM

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Neuroscience

- How brain cells signal/connect to each other
- How systems comprising multiple brain cells work
- How the brain evolved (e.g., how developing brain cells differentiate themselves into visual vs. auditory brain cells)
- (Developmental) Cognitive Neuroscience: e.g. what happens in the brain when we have emotions/thoughts, when we create music, or when we read and write

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Some relevant insights

- **Experience-dependent plasticity:** Process by which connections between neurons (cells that constitute fundamental unit of our brain) are strengthened when they are simultaneously activated
  - Overall pattern of neural development is very similar across genders, though pace differs (Giedd & Rapoport, 2010)
  - After brain injury, functions differ in how amenable they are to rehabilitation with some functions not being relearnable at all (Corrigan & Yodufsky, 1996)

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EDUCATIONAL PSYCHOLOGY

Scientific discipline that is concerned with understanding and improving how students acquire a variety of capabilities through instruction in classroom settings

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- **The art of teaching?**
  - There is an element of truth to this, but we cannot merely be creative, not everything works
- **Teaching as a science?**
  - Not exactly a science either… Both humans and the environment around them are ever changing

Using science and creativity to enable each student to be the best student they can be, that is, reach their maximum potential

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Practical requirements of educational research

- To help learners who fail in “basic” skills such as language, literacy and numeracy
- To use technology enhanced learning to provide more productive learning experiences for children diagnosed with developmental disorders
- To engage teachers in exploring new pedagogies that capture the benefits of neuroscience
- To differentiate between pedagogical forms that are neurologically meaningful

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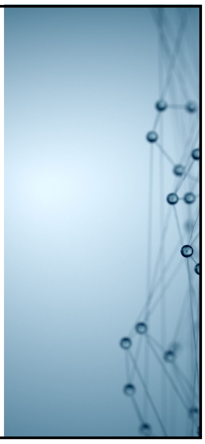
What is Educational Neuroscience

- A new emerging discipline (“scientific community”) arising from combination of three previously unconnected disciplines
  - Education
  - Psychology
  - Neuroscience
- Aim: Join forces to answer the question of how we can promote better learning



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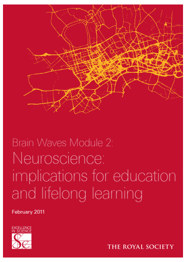
The Royal Society's Brain Waves project



- Four 'modules' from the Royal Society's Brain Waves project which aimed to investigate developments in neuroscience and their implications for society.
- Module 2: Brain Waves 2. Neuroscience: Implications for education and lifelong learning

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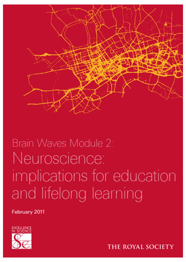
The Royal Society's Brain Waves project



- Education is about enhancing learning
- Neuroscience is about understanding the mental processes involved in learning
- An analogy from medicine
  - Educational practice can transform neuroscience in the same way that biological science transformed medical practice about 100 years ago

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Emerging findings in Educational Neuroscience

- Identification of individual differences in learning as seen in ….
  - Brain structure (MRI)
  - Brain function (ERPs, fMRI)
  - Genes

Important for educational policy but also identification of learning disorders

- Training (e.g., using brain stimulation ("neuromodulation") techniques such as tDCS) (Cohen Kadosh et al. (2010)
- Use of technologies to facilitate learning work (work by Daphne Bavelier)

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Identification of individual differences

- **Brain structure**
- Comparisons of the developmental pathways of the first 5 years of life for children with and without familial risk for dyslexia. Can we differentiate through abnormal neural structures and patterns of activation in the reading network?
- Yes. Even in very young children before they have learnt to read (i.e. cause rather than effect)
- Earliest differences between groups (1) a few days after birth and (2) 6 months in brain ERPs to speech sounds and in head-turn responses (at 6 months) conditioned to reflect categorical perception of speech stimuli

Lyytinen et al. (2001).

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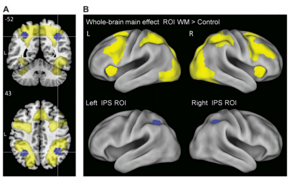
Identification of individual differences

- **Brain function**



Brain activation in the parietal cortex during visuo-spatial working memory task predicts arithmetic performance 2 years later, over and above behavioural measures of working memory and IQ

Dumonteil & Klingberg (2012)

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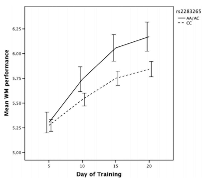
Identification of individual differences

- **Genes**
- Genetic variation in the dopamine receptor 2 (DRD2) gene region influences improvements during working memory training in children and adolescents



Söderqvist et al. (2014)

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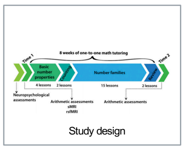
Identification of individual differences

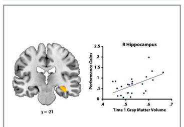
Extra study slide

Supekar et al (2013).

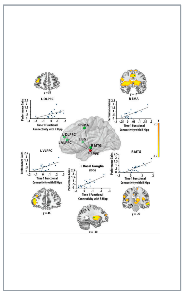
Pretutoring structural and functional brain measures (hippocampus and connectivity between hiccopcampus, PFC, and basal ganglia) but not behavioural measures could predict individual differences in arithmetic performance improvements with tutoring



Study design



Study design



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- Differences in brain structure or brain activity and genes predict individual differences in learning
- Why do you need these type of brain data instead of looking at behaviour performance?
  - In some occasions, the neuro-imaging data predict more variance than behavioural measures of performance (more powerful)
    - If you can go closer to the neurosubstrates of these processes, you might be more sensitive to individual differences
  - More sensitive early measures?
    - We can test very young children on skills that have not yet developed and/or on things that very young children cannot be easily tested behaviourally (e.g. literacy, numeracy)

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Critical evaluation from current insights

- Insights on why things that work do work in improving learning (rather than suggestions on what could work)
- Few ‘magic bullet” insights
  - The equivalent of this in medicine would be breakthroughs such as vaccination or penicillin
  - Accumulation of small improvements that eventually lead up to a ‘revolution’
  - Multiple small effects (risk factors), e.g. as seen on lectures 4 & 6 (re: genetic influences on developmental language disorder and developmental dyslexia)

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Critical evaluation from current insights

- Multiple small effects of ….
  - Working memory/executive function training
  - Sleep (used to consolidate knowledge)
  - Dietary habits
  - Meditation or exercise
- Broad rather than topic-specific influences
- Influences relevant across species
  - Although, education is not relevant for animals, we can use animal models to improve understanding of such influences

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Questions to consider….

- To what extent can neuroscience findings generate pedagogical design?
- Can the methodological requirements of neuroscience sharpen descriptors of pedagogical tasks?
- Can the practical requirements of pedagogy focus the investigations of neuroscience?
- Can we really bridge the gap between the two areas?

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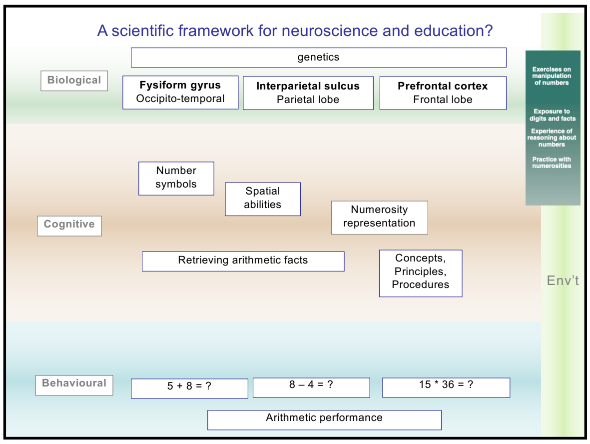

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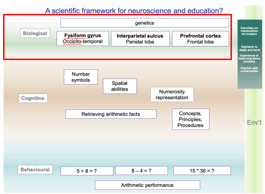
Two broader concerns

- A **reductionist view** that emphasizes the role of brain at the expense of a holistic understanding of human beings and their interactions with the environment
- A **deterministic view** that our neurological inheritance sets us on a path that is unchangeable



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Three types of arguments against EN

- A priori arguments against the relevance of neuroscience to education (Bowers, 2016)
- Criticisms of the current practical operation of the field
  - E.g., controlled experimental situations needed in the field are far from the context of naturalistic classroom behaviour and therefore of questionable validity.
- Doubts about the viability of neuroscience methods for diagnosis of disorders or prediction of individual differences
  - High cost, practicality much poorer compared to existing, simpler behavioural methods (Bishop, 2013, 2014).

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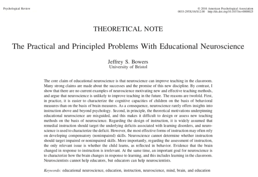
Bowers (2016)


THEORETICAL NOTE

The Practical and Principled Problems With Educational Neuroscience

Jeffrey S. Bowers
University of Bristol

- "My claim is that neuroscience is irrelevant to the design and evaluation of teaching"
- Key message: 'successes' in the field of Educational Neuroscience have been (a) trivial, (2) misleading, or (3) unwarranted
- Criticism exaggerated by equating neuroscience with fMRI

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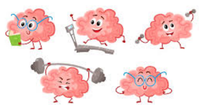
From Neuroscience to Education: Challenges

- Applying neuroscientific findings in Education is hard

1. Neuroscience vs. neuromyths
2. Environmental variability
3. Ethical considerations



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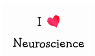
Everyone loves a bit of neuroscience



Teachers included. Implies that they regard understanding the importance of mechanisms of learning as something that should inform their practice…

- Brain training, learning styles and brain preference, brain-based learning etc.
- Parallel world of pseudo-neuroscience: What is evidence-based vs. scientifically unfounded can be unclear

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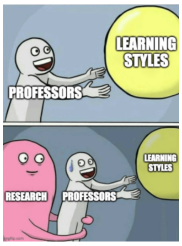
Neuromyths



- A (brain) image is 1000 words…
- But one needs more than 1000 words to describe a brain image
- Educational neuromyths: Poorly drawn extrapolations that inflate neuroscience findings
- Both unscientific and educationally unhelpful
- Need for myth busting

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Neuromyths (Howard-Jones, 2014)

- Misconceptions about the brain and education among teachers and the public that are either not yet supported by the data or actively contradicted by existing science
  - Adopting a ‘growth mindset’ leads to better student outcomes
  - Some children are left-brain thinkers and other are right-brain thinkers
  - Drinking a lot of water improves brain’s ability to concentrate
  - Teachers should match the presentation of teaching materials to students’ individual ‘learning styles’

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2. Environmental variability

- Education is intrinsically a social, classroom-based phenomenon. This has implications in terms of (neuro-based) interventions and their effectiveness
- Variability between schools, teachers, individuals etc.



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3. Ethical considerations

- Education is a pathway out of poverty: Complex ethical issues surrounding practice in the field, with implications as important as those in medical sciences
- Lalancette & Campbell (2011)
  - Neuroethical considerations on methods
    - Data confidentiality, stigmatization, incidental findings
  - Considerations regarding the application of findings
    - E.g. increasingly widespread use of prescription drugs in order to provide cognitive enhancement (methylphenidate/Ritalin used to enhance attention) support studies of their effect on learning

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Varma et al. 2008: A bridge too far?

Table 1
Summary of Concerns and Opportunities

Aspect	Concern	Opportunity
Scientific		
1. Methods	Neuroscience methods do not provide access to important educational considerations such as context.	Innovative designs can allow neuroscience to study the effects of variables of interest to education, such as context.
2. Data	Localizing different aspects of cognition to different brain networks does not inform educational practice.	Neuroscience data suggest different analyses of cognition and may therefore imply new kinds of instructional theories.
3. Theories	Reductionism is inappropriate.	Reductionism is appropriate if it is not eliminative.
4. Philosophy	Education and neuroscience are incommensurable.	Neuroscience may help to resolve some of the incommensurables within education.
Pragmatic		
5. Costs	Neuroscience methods are too expensive to apply to education research questions.	Educationally relevant neuroscience might attract additional research funding to education.
6. Timing	We do not currently know enough about the brain for neuroscience to inform education.	There are already signs of success.
7. Control	If education cedes control to neuroscience, it will never regain its independence.	Ask not what neuroscience can do for education, but what education can do for neuroscience.
8. Payoffs	Too often in the past, neuroscience findings have turned into neuromyths.	People like to think in terms of brains, and responsible reporting of cumulative results can help them.

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Educational Neuroscience

- New exciting field that aims to bring together three disconnected disciplines
- Impact across learners and practitioners
  - Better learning environments throughout the lifespan means more fulfilled and effective learners
  - Training of current and future teachers
- To date, little research has had on impact on educational delivery.
  - Partly reflecting lack of expertise across these field
  - Time will tell if EN can fulfill its ambitious aims

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Q & A ON PRE-RECODED LECTURE & SEMINAR

- Please go to Menti.com
- The digit code **61 80 75**

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Core & recommended reading

- Butterworth, B., Varma, S., & Laurillard, D. (2011). Dyscalculia: from brain to education. *Science, 332*, 1049-1053.
- Kadosh, R. C., Soskic, S., Iuculano, T., Kanai, R., & Walsh, V. (2010). Modulating neuronal activity produces specific and long-lasting changes in numerical competence. Current Biology, 20(22), 2016-2020.
- Dumontheil, I., & Klingberg, T. (2012). Brain activity during a visuospatial working memory task predicts arithmetical performance 2 years later. *Cerebral Cortex, 22(5)*, 1078-1085.
- Howard-Jones, P.A. (2014). Neuroscience and education: Myths and messages. Nature Reviews Neuroscience, 15, 817–824.
- Lyytinen, H., Ahonen, T., Eklund, K., Guttorm, T. K., Laakso, M. L., Leinonen, S., ... & Richardson, U. (2001). Developmental pathways of children with and without familial risk for dyslexia during the first years of life. Developmental Neuropsychology, 20(2), 535-554.

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Core & recommended reading

- Supekar, K., Swigart, A. G., Tenison, C., Jolles, D. D., Rosenberg-Lee, M., Fuchs, L., & Menon, V. (2013). Neural predictors of individual differences in response to math tutoring in primary-grade school children. Proceedings of the National Academy of Sciences, 110(20), 8230-8235.
- Söderqvist, S., Matsson, H., Peyrard-Janvid, M., Kere, J., & Klingberg, T. (2014). Polymorphisms in the dopamine receptor 2 gene region influence improvements during working memory training in children and adolescents. Journal of Cognitive Neuroscience, 26(1), 54-62.
- Thomas, M. S., Ansari, D., & Knowland, V. C. (2019). Annual research review: Educational neuroscience: Progress and prospects. Journal of Child Psychology and Psychiatry, 60(4), 477-492.

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Core & recommended reading

- **The great Educational Neuroscience debate!**
- Bowers, J. S. (2016). The practical and principled problems with educational neuroscience. Psychological Review, 123(5), 600.
- Howard-Jones, P. A., Varma, S., Ansari, D., Butterworth, B., De Smedt, B., Goswami, U., ... & Thomas, M. S. (2016). The principles and practices of educational neuroscience: Comment on Bowers (2016).
- Gabrieli, J. D. E. (2016). The promise of educational neuroscience: Comment on Bowers (2016). Psychological Review, 123(5), 613–619
- Varma, S., McCandliss, B. D., & Schwartz, D. L. (2008). Scientific and pragmatic challenges for bridging education and neuroscience. Educational Researcher, 37(3), 140-152.

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