The UnLocke Project: from brain inhibition to maths and science practice

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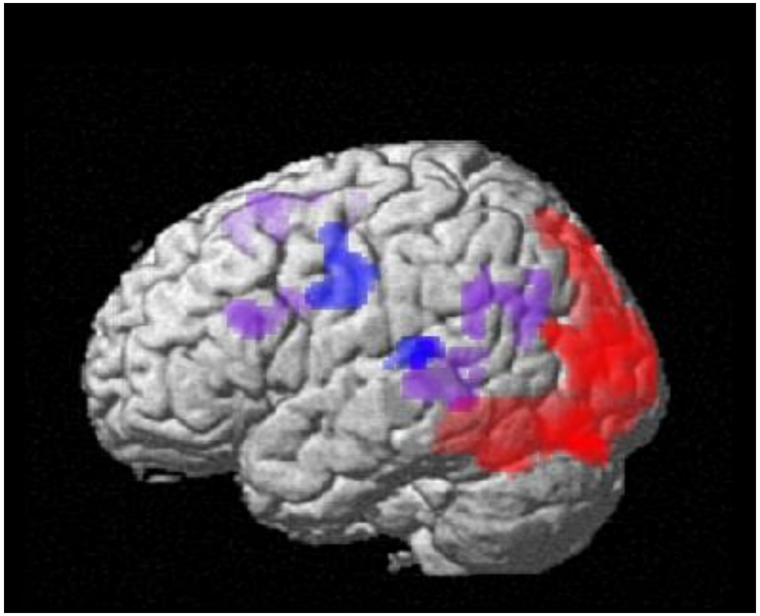
Exploring Reasoning in the Brain

Functional imaging (e.g. fMRI) measures "current processing" *within an individual*

Structural images appear to reflect: "learning" "ability" possibly "potential" differences ***across individuals***



Exploring Reasoning in the Brain

- Almost all work carried out with adolescents and young adults
- Difficulties of working with children include noise, motion artefacts, lack of structural templates.
- Lowest ages typically 6 years of age

The Key lessons about reasoning in the brain…

- Findings are consistent with the idea that reasoning involves the use of executive functions

- Executive functions can be dissociated into *Evaluative* and *Executive* components involving the AC and DLPFC respectively

- AC identifies conflict and DLPFC resolves conflict

Latest News….

MIND, BRAIN, AND EDUCATION

MIND, BRAIN, AND EDUCATION

Differences in Brain Activation Between Novices and Experts in Science During a Task Involving a Common Misconception in Electricity

Steve Masson[1], Patrice Potvin[1], Martin Riopel[1], and Lorie-Marlène Brault Foisy[1]

ABSTRACT— Science education studies have revealed that students often have misconceptions about how nature works, but what happens to misconceptions after a conceptual change remains poorly understood. Are misconceptions rejected and replaced by scientific conceptions, or are they still present in students' minds, coexisting with newly acquired scientific conceptions? In this study, we use functional magnetic resonance imaging (fMRI) to compare brain activation between novices and experts in science when they evaluate the correctness of simple electric circuits. Results show that experts, more than novices, activate brain areas involved in inhibition when they evaluate electric circuits in which a bulb lights up, even though there is only one wire connecting it to the battery. These findings suggest that experts may still have a misconception encoded in the neural networks of their brains that must be inhibited in order to answer scientifically.

For at least 30 years, researchers in science education have studied people's spontaneous conceptions about how nature works (Duit & Treagust, 2012). These studies have shown that these intuitive conceptions are often opposed to the scientific knowledge taught in schools (Liu, 2001). For example, many people believe that heavier objects fall faster (even in the absence of air resistance, which is false), or that it is warmer in summer because the Sun is closer to the Earth (which is also false). If these misconceptions were not so difficult to change, they would not be a problem. However, one of the most robust findings of science education research about misconceptions is that they are particularly hard to change (Duit & Treagust, 2012; Periago & Bohigas, 2005; diSessa, 2006; Vosniadou, 2012; Wandersee, Mintzes, & Novak, 1994), which poses a serious challenge for science teachers who try to change their students' misconceptions into scientifically valid knowledge.

The problem of the persistence of nonscientific conceptions during science education has led to a field of research called "conceptual change" (for a review, see Duit & Treagust, 2012; diSessa, 2006; Vosniadou, 2008, 2012). This field tries to understand why students' misconceptions are hard to change, what changes during conceptual change, and how to facilitate the learning of unintuitive scientific concepts. Over the years, researchers in this field have proposed several theoretical models to answer these questions (Carey, 2009; Chi, 1994; Giordan & DeVecchi, 1987; Mortimer, 1995; Nussbaum & Novick, 1982; Posner, Strike, Hewson, & Gertzog, 1982; diSessa, 1993; Smith, 2007; Stavy et al., 2006; Vosniadou, 1994).

Most of these models (Carey, 2009; Chi, 1994; Duit & Treagust, 2003; Giordan & DeVecchi, 1987; Nussbaum & Novick, 1982; Posner et al., 1982; Smith, 2007; Vosniadou, 1994) share a common postulate according to which conceptual change is hard to achieve not only because students must abandon their initial misconceptions, but also because they must radically restructure their knowledge structure in order to accommodate new scientific concepts and theories. For example, according to Duit and Treagust

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Background

- Science and maths learning requires *inhibiting prior beliefs and direct perceptual solutions*
- DLPFC & ACC implicated in scientific reasoning
- Improved inhibitory control is a key factor in cognitive development– *and is impaired in low SES children*
- Knowledge in neural networks is embedded in domain-specific contexts
- Previous domain-general executive control interventions have had mitigated success and limited transfer

The Unlocke Project

- Details can be found at

  http://www.unlocke.org/

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Demo of the Unlocke software:

https://drive.google.com/file/d/0B8eZJxdTwZq3Tkh0VWxpRmtLSEU/view

The Unlocke Project

- **Phase 1 (Months 0-18)**: establish **optimal** mode of delivery (individualised or whole class)
- **Phase 2 (Months 18-36):** deliver intervention in two staggered 1-term batches
- **Phase 3 (Months 36-48):** closing the loop

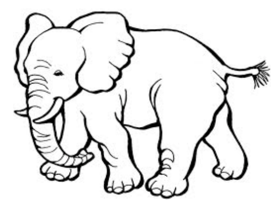
The Unlocke Project

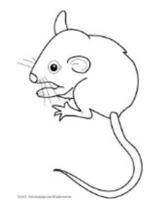
- Target Years 3 & 5
- 6000 children in full intervention over 100 schools
- 12 minutes of training 3 times weekly for one term
- PSHE social skills control (Hawthorne effect)

The Unlocke Project

- **Examples Science judgements**:

(i) Are elephant cells BIGGER/SMALLER/THE SAME SIZE *as mouse cells?*





(ii) When a candle melts, does the resulting wax weigh MORE/LESS/THE SAME *as before?*

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- **Examples Maths judgements**:

(i) Does the red arc bend MORE/LESS/THE SAME *as the clear arc?*

(ii) Is 2/3 MORE/LESS/THE SAME *as* 4/6?

Some challenges

- Sufficient IT resources
- Fitting into the timetable
- Fitting into the lesson plan
- Consistency of usage

Some great responses… some less great…

Thank you for your attention!