Response to Dougherty & Robey on neuroscience and education: Enough bridge metaphors – interdisciplinary research offers the best hope for progress

Michael S. C. Thomas

Director, University of London Centre for Educational Neuroscience

Address for correspondence:

Professor Michael S. C. Thomas

Centre for Educational Neuroscience

Department of Psychological Science,

Birkbeck College,

Malet Street, Bloomsbury

London WC1E 7HX, UK

Email: m.thomas@bbk.ac.uk

Web: http://www.educationalneuroscience.org.uk/

Tel.: +44 (0)20 7631 6386

Fax: +44 (0)20 7631 6312

Dougherty and Robey (D&R) argue that the idea that neuroscience can have a direct impact in the classroom is ‘a bit far-fetched’ (p.401), following other commentators such as Bishop, 2014, and Bowers, 2016; and that investment of limited research funds in the cognitive and social psychological sciences is more worthwhile. In this commentary, I argue that for education, interdisciplinary research offers the best hope of progress at the interface of the learning sciences; and that we should reject arguments that isolate scientific disciplines and pit them against each other.

Interdisciplinary research

Arguments against educational neuroscience (henceforth ‘EN’; the field is also known as mind, brain, and education) have repeatedly appealed to bridge metaphors to characterise the relationship between the disciplines of neuroscience, psychology, and education. This argument-by-metaphor has become misleading and unhelpful. It leads to confusing and illogical propositions – for instance, in D&R, that understanding of mechanism is independent from understanding of behaviour (p.401-2); that neuroscience is only making a contribution to education if its influence is ‘direct’ and ‘original’; that the way neuroscience findings should impact on educational interventions is by ‘scaling them up’ (p.402); or that the contribution of neuroscience is to provide ‘neural correlates of interventions’ (p.403) rather than helping build an understanding of how intervention works. It is important to state clearly: interdisciplinary research is about integrating constraints from multiple levels of description to produce better theories at all levels.

D&R appear to construe education as only concerning behaviour and behavioural change in classroom settings (for which 'neuroscience is not event needed'; p.403). However, a narrow focus on behaviour undermines the contribution of psychology as well. Indeed, Willingham (2018) has recently argued that what is important for education is not psychological theory; instead, the goal should be for teachers to be familiar with behavioural observations in the classroom – consistent developmental patterns in children's thinking, motivation, and emotion. Many in the learning sciences would argue that it is essential go beyond behaviour to an understanding of underlying mechanism.

Psychology is not enough

For D&R, the necessary and sufficient mechanistic understanding is to be offered by psychology. However, psychology on its own is not enough. Psychology that is unconstrained by neuroscience risks positing *possible cognitive systems*, rather than *the actual one delivered by the brain* (Thomas, Ansari & Knowland, 2018).

The central example offered by D&R of the failure of 'brain-training' approaches is in fact exemplifies just this point. It is a failure of psychology and its tendency towards domain-general theoretical constructs such as 'working memory'. The neuroscience contribution to brain training is little more than that the brain is malleable and behaviour can be changed through training. It has been known since the beginning of the 20th Century that training of abilities rarely leads to improvement of different abilities, so-called far transfer (Thorndike & Woodworth, 1901). Yet, inspired by the traditional computational theory of mind and influenced by the high correlation between ability test scores, much of the latter part of the 20th Century saw psychological theories determinedly positing domain-general mechanisms. If domain-general mechanisms are trainable, far transfer would be the norm. These psychological theories therefore led to the expectation of and frequent pursuit of far transfer effects, at odds with a slew of empirical data. In contrast, from a neuroscience perspective, knowledge is stored in the connections between neurons (that is, *content is built into structure*). This implies domain-specific circuits, and the likelihood of mainly near-transfer effects after behavioural training. Far transfer would be expected from interventions that improve the functioning of all neurons, such as improved nutrition or energy supply. Putting issues of commercial exploitation aside, the failure of 'brain training' approaches, then, does not stem from neuroscience; it stems from psychology pursued independently of neuroscience. It is an example of why we need interdisciplinary science to inform education.

Legitimate criticisms of educational neuroscience

Of course, educational neuroscience is a fledgling field, and there are legitimate criticisms that can be made of it. Here are some of them, drawn from a recent review of the field (Thomas, Ansari & Knowland, 2018):

(1) EN must amount to more than re-labelling with brain structures effects that are well known from behavioural psychology. It must progress psychological theory, it must point to ways to improve brain health.

(2) As Bishop (2014) argues, neuroscience methods are still limited in their sensitivity and specificity as screening or diagnostic tools for deficits. They can only complement more traditional behavioural and social markers of risk. However, some neuroscience measures may be available

earlier, such as infant EEG measures of auditory processing to predict later dyslexia risk (Guttorm et al., 2009), or available-at-birth DNA measures to predict possible educational outcomes (Plomin, 2018), which increases the opportunity for intervention or more targeting monitoring of more traditional risk markers

(3) While EN bears on learning, learning is only one aspect of education that influences outcomes, others include institutional, professional, curricular, political, economic and societal (Bronfenbrenner, 1992)

(4) EN needs to improve the quality of the dialogue between teachers, psychologists, and educators to ensure the discussion is genuinely two-way, e.g., through co-designing studies with teachers to improve the relevance of research and increase of the chance of changing practice in the classroom

(5) EN's progress has been gradual. Researchers (e.g., Howard-Jones et al., 2016; Thomas, Ansari & Knowland, 2018) have been clear on the complexity of the challenge of linking the classroom phenomenon of 'learning' with learning in the brain, which is the interplay of perhaps eight different neural systems. Much of the groundwork in EN will consist of understanding why the educational methods that work do indeed work (Thomas, 2013) in order to ultimately improve them.

Spurious criticisms of educational neuroscience

There are also spurious criticisms:

(1) That to contribute, the influence of neuroscience on education must be 'direct', circumventing psychology. The influence *can* be direct – for

example, animal models of the effect of air pollution on brain function are able to demonstrate the causality of the link between air pollution and cognitive ability, while human studies are stuck with guessing from correlations (Donaldson et al., 2005; Sunyer et al., 2015). Neuroscience can speak directly to brain health, in the sense that cognition is delivered by a biological organ with certain energy and nutritional needs. But as D&R agree, neuroscience also contributes indirectly to education via its influence on psychology. Both are valuable.

(2) That to contribute to education, the insights of neuroscience must be entirely original. The fact that there may be pre-existing folk theories about, say, the importance of a good night's sleep does not undermine the possible contribution of the neuroscience of sleep to informing consolidation effects on learning, via understanding the interactions between hippocampal and cortical structures. Even when behavioural effects are already known, they can be improved by understanding mechanisms at lower levels of description. To take an example from medicine, it was known three hundred years ago that chewing the bark of the Cinchona tree was effective in alleviating the symptoms of malaria. Via the extended contributions of the natural sciences – biology, physiology, biochemistry, pharmacology – the US Centers for Disease Control and Prevention now list a range of medicinal treatments for malaria. Understanding mechanism can improve something that already works.

(3) That so-called neuromyths, or commercial products that use neuroscience as window-dressing, or contextual framing effects of placing brain images

in educational articles, have any bearing on the potential of the interdisciplinary learning sciences. These are distractions.

Is the brain really far too complex?

Finally, D&R endorse Bruer's (1997, 2006) view that 'the brain is far too complex and we know far too little about how it works for this knowledge to be useful for education' (p.401). This pessimism is unwarranted. We understood a good deal about the broad principles of brain function, and certainly enough to begin to draw implications for learning (see, e.g., www.howthebrainworks.science). While interdisciplinary research and evidence-based translation are challenging, they are the best hope for accelerating progress in education.

References

Bishop, D.V.M. (2014). *What is educational neuroscience?* Available from: https://figshare.com/articles/What_is_educational_neuroscience_/1030405

Bowers, J.S. (2016). The practical and principled problems with educational neuroscience. *Psychological Review*, *123*, 600–612.

Bronfenbrenner, U. (1992). Ecological systems theory. In U. Bronfenbrenner (Ed.), *Making human beings human: Bioecological perspectives on human development* (pp. 106–173). Thousand Oaks, CA: Sage Publications Ltd.

Bruer, J. T. (1997). Education and the brain: A bridge too far. *Educational Researcher*, *26(8)*, 4–16.

Bruer, J. T. (2006). Points of view: On the implications of neuroscience research for science teaching and learning: Are there any? *CBE-Life Sciences Education*, *5*, 104–110.

Dougherty, D. R., & Robey, A. (2018). Neuroscience and education: A bridge astray? *Current Directions in Psychological Sciences*, Volume 27 Issue 6, 401-406. https://doi.org/10.1177/0963721418794495

Donaldson, K., Tran, L., Jimenez, L.A., Duffin, R., Newby, D.E., Mills, N., ... & Stone, V. (2005). Combustion-derived nanoparticles: A review of their toxicology following inhalation exposure. *Particle and Fibre Toxicology*, *2*, 10.

Guttorm, T.K., Leppanen, P.H.T., Hamalainen, J.A., Eklund, K.M., & Lyytinen, H.J. (2009). Newborn event-related potentials predict poorer pre-reading skills in children at risk for dyslexia. *Journal of Learning Disabilities*, *43*, 391–401.

Howard-Jones, P., Varma, S., Ansari, D., Butterworth, B., De Smedt, B., Goswami, U., . . . & Thomas, M.S.C. (2016). The principles and practices of educational neuroscience: Commentary on Bowers. *Psychological Review*, *123*, 620–627.

Plomin, R. (2018). *Blueprint: How DNA makes us who we are*. Allen Lane.

Sunyer, J., Esnaola, M., Alvarez-Pedrerol, M., Forns, J., Rivas, I., Lopez-Vicente, M., ... & Querol, X. (2015). Association between traffic-related air pollution in schools and cognitive development in primary school children: A prospective cohort study. *PLoS Medicine*, *12*, e1001792.

Thomas, M.S.C. (2013). Educational neuroscience in the near and far future: Predictions from the analogy with the history of medicine. *Trends in Neuroscience and Education*, *2*, 23– 26.

Thomas, M.S.C, Ansari, D., & Knowland, V.C.P. (2018). Annual Research Review: Educational neuroscience: progress and prospects. *Journal of Child Psychology and Psychiatry*. doi: 10.1111/jcpp.12973. [Epub ahead of print]

Thorndike, E.L., & Woodworth, R.S. (1901). The influence of improvement in one mental function upon the efficiency of other mental functions (I). *Psychological Review*, *8*, 247– 261.

Willingham, D.T. (2018). Unlocking the science of how kids think: A new proposal for reforming teacher education. *Education Next, 18*, http://educationnext.org/unlocking-science-how-kids-think-new-proposal-for-reforming-teacher-education/ (downloaded 11/4/18).