Forging a new path for Educational Neuroscience:

An international young-researcher perspective on combining neuroscience and educational practices

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Abstract

The use of neuroscience to improve education has been considered by researchers and practitioners alike. However, workable solutions that lead to improvements in research and practice are yet to emerge. As newly qualified educational neuroscientists, our experiences dictate that the progress in this field relies upon 'Educational Neuroscience' being recognised as a distinct discipline. We therefore present a four-stage practical approach that concretely describes the role of the educational neuroscientist and details how neuroscientific knowledge can be practically assessed in the classroom. Using this approach, junior scientists will become empowered to replace the 'bridge' between education and neuroscience with a stronger, distinct Educational Neuroscience highway that is built in parallel to the existing paths.

Introduction

The use of neuroscience to improve education has often been considered (Butterworth & Kovas, 2013; Meltzoff, Kuhl, Movellan, & Sejnowski, 2009). Neuroscientists and educators have recently begun to evaluate how to transfer brain-based research to the classroom (Alibali & Nathan, 2010; Goswami, 2006). What benefit, if any, can neuroscience add to understanding learning processes, improving educational practices and enhancing student outcomes?

Here we report the analysis and discussions of an international group of junior researchers during the 3rd Latin American School for Education, Cognitive and Neural Sciences (Brazil, 2013). The School's rigorous selection procedure offers 50 post-doctoral fellows or graduate students the opportunity to work alongside academic leaders from across the globe, to consider the integration of education, cognition and neuroscience. As young professionals in research and practice, we are positioned to propose fresh solutions to the challenges faced in using neuroscientific research to improve education, and in educating world-class neuroscientists. Until now, our perspectives have not been formally voiced.

Our discussions focused on the "bridge" between laboratory-based neuroscience research and education (Bruer, 1997), and led to a four-stage process that encourages educational neuroscientists to apply and translate their research into the classroom. Using this four-stage process, we argue that young laboratory-based scientists will become empowered to replace the bridge metaphor with a stronger, distinct *Educational Neuroscience* highway that is built in parallel to the existing neuroscience and education paths. This metaphorical highway reflects the notion that educational neuroscience can no longer be thought of as a mere bridge connecting two existing fields, but must be afforded the status of an autonomous discipline.

Brief Review of the Current State of Affairs

The debate on how knowledge from laboratory research can be implemented in practice is neither new, nor restricted to integrating neuroscience and education (Fischer, 2009). For example, in the treatment of leukaemia, research biologists provide the details of a cancer mechanism (such as chromosomal abnormalities) and medical practitioners report on the efficacy of resulting treatments (Ferrara & Schiffer, 2013). However, the debate has recently been fuelled and focused on education due to rapid advances in neuroscientific methods, an increased understanding of the learning brain, and increased funding opportunities (Butterworth & Kovas, 2013; Meltzoff, et al., 2009; OECD, 2007; Sporns, 2013). Two main issues in this debate concern *whether* knowledge about how the brain works is relevant for educational practice, and – assuming this is the case – *how* neuroscientific findings can be applied to the classroom appropriately.

1A) Is Translation Possible?

Concerning the first issue, an increasing number of researchers agree that it is time to consider the implications of neuroscience for education (Ansari, Smedt, & Grabner, 2012; OECD, 2007) rather than dismiss the combination of these fields as “a bridge too far” (Bruer, 1997; Turner, 2011). This observation is confirmed by increasing support for combining neuroscience and education at the institutional level, both in the academy and among grant agencies. Additionally there is evidence that neuroscience can contribute unique insights to education beyond traditional behavioural findings (Butterworth & Kovas, 2013; Meltzoff, et al., 2009).

1B) Lost in Translation

Despite evidence favouring the potential utility of neuroscience within education, miscommunication and poor collaboration may have prevented the fluid integration of these disciplines (Devonshire & Dommett, 2010). Miscommunication has resulted in the spread of ideas that are poorly justified, and scientific facts that are distorted, outdated, or misinterpreted (Geake, 2008). Problematically, misinterpretations often give rise to 'neuromyths'(Goswami, 2004). Popular neuromyths assert that children are either right-brained or left-brained or that they only use 10% of the brain (Della Sala, 2007). It is difficult to trace and dispel these myths because at face value, many appear factually correct.

The consumption of misinformation can generate a knowledge imbalance between researcher and educator, with the neuroscientist problematically viewed as being able to provide 'quick fixes' to failing educational practices. Given that the bridge between neuroscience and education is not sustainable, there is an urgent need for a workable solution to overcome the spread of neuromyths and assist in the accurate translation of neuroscientific findings.

2) How to Translate?

The second issue to be considered is *how* education and neuroscience can be combined fruitfully. To date, this question remains unanswered. This may be because the combination of neuroscience and education has been regarded as a one-way street from neuroscience to education (De Smedt & Verschaffel, 2010). Therefore, neuroscientific research that investigated learning processes was often irrelevant to classroom practices. Recently, the claim has been made that neuroscience and education should be regarded as a two-way street (Turner, 2011). Notwithstanding attempts to achieve bidirectionality (Alibali & Nathan, 2010; Goswami, 2006), no clear guidelines document how to successfully conduct educational neuroscience research. Here, we present a four-stage process that provides a concrete proposal for addressing this problem and details the role of the educational neuroscientist. In our opinion, if young scientists explicitly consider the translatability and applicability of their work, the construction of a unique *Educational Neuroscience* highway is achievable.

A New Approach to Conducting Educational Neuroscience Research

Our four-stage process is the first of its kind to be developed from teachers' and researchers' suggestions. At the Latin American School, neuroscientists emphasized the need for rigorous and established research methods while educators expressed the desire for practical and relevant tools to teach 30 children in the classroom. Here, we combine these voices. Our approach is not intended to replace neuroscience techniques such as functional magnetic resonance imaging (fMRI) or electroencephalography, but it should be added to the educational neuroscientist's toolkit. At the heart of our approach is the notion that the educational neuroscientist not only engages in neuroscience research, but also assumes responsibility for translating that research or assessing its educational applicability. As a result, the term 'educational neuroscientist' demands re-definition as one who assesses the application of neuroscientific findings to education, or at least considers how neuroscientific findings might translate to educational contexts.

The Four-Stage Cyclical Approach

This approach views the educational neuroscientist as a dual research scientist, who is cognisant with neuroscientific and educational research techniques. While the neuroscientific study of educationally-relevant domains currently enjoys success (see dyslexia research using fMRI and electroencephalography: Colon, Notermans, de Weerd, & Kap, 1979; Gabrieli, 2009) the translation and assessment of neuroscience research in the classroom does not. The four-stage approach therefore speaks to the latter.

1) Identify an Educational Need: Researchers and teachers work together to identify an educational need that neuroscience has the potential to help answer. The educational neuroscientist carefully researches the existing literature or conducts empirical neuroscience research to identify the novel insights that neuroscience can offer.

For example, early-level teachers may desire a tool that predicts mathematical competence, in order to provide interventions where needed (Nosworthy, Budgen, Archibald, Evans, & Ansari, in press). The educational neuroscientist could suggest a magnitude comparison task (Holloway & Ansari, 2009). Experimentally, fMRI research has implicated the intraparietal sulcus in the representation of numerical magnitudes: the size of numbers, in both symbolic and non-symbolic formats (Pesenti, Thioux, Seron, & De Volder, 2000; Shuman & Kanwisher, 2004). This region is activated in number comparison tasks where representing numerical magnitudes is essential and children with deficits in mathematics show abnormal activation patterns within these regions (Ansari, 2008).

2) ***Develop a Research Proposal:*** At this stage, the educational neuroscientist develops a research proposal that translates or assesses neuroscientific findings within educational settings. Note that the proposed study will likely not involve neuroscience per se, but reflects the translation of neuroscience in a manner that can be applied or assessed within the classroom. Educational neuroscientists must work with educators to draw on the educators' wealth of practical knowledge regarding existing classroom practices and the feasibility of the proposed project.

Using the mathematics measurement tool as an example, the educational neuroscientist might suggest that a magnitude comparison task and a variety of other mathematical tests be administered to students, and their mathematical performance tracked throughout the academic year. This design would uncover whether the magnitude comparison task should be implemented as a screening tool. Together, the educator and educational neuroscientist should discuss whether the proposal is feasible within the school setting.

3) Test in the Classroom: During this step, the educational neuroscientist empirically assesses whether findings derived from the laboratory can be used to improve educational practice or student outcomes. The educational neuroscientist should maximize differences (the recruitment of a variety of participants: classrooms, teachers, students) to enhance generalizability of the findings (Brown, 1992; El-Hani & Greca, 2012). Following successful small-scale intervention studies, larger randomised control trials would be necessary to implement wide-scale changes in practice (Ansari, et al., 2012).

Returning to the mathematics example, the educational neuroscientist would carry out the proposed research project while maximizing differences. Results from the screening measures could be combined with students' mathematics performance scores to assess whether the screening task is reliably associated with school performance.

4) Communicate and Evaluate: The final step in this process requires collaborative reflection to evaluate the research findings. As shown in Figure 1, the evaluation feeds into Step 1 in an iterative manner, thereby enhancing the ultimate utility of the research.

Using the example of the mathematical screening tool, teachers and researchers might evaluate whether the tool helpfully predicts classroom achievement and what might be done to improve it. From a slightly different perspective, this stage of the cycle could also trigger laboratory-based research. For example, a sub-sample of children identified (via the screening tool) as requiring additional support could be invited to participate in a neuroimaging experiment to better understand the neural correlate of the children's deficit, and to trace learning trajectories.

[INSERT FIGURE 1 ABOUT HERE]

Figure 1. A graphical representation of the four-stage research cycle that should be adopted by educational neuroscientists.

A New Generation. A New Discipline.

Despite the relative infancy of educational neuroscience, laboratories and research groups are being established, and graduate students are completing doctoral training programs in this emerging discipline. We are therefore, for the first time, at a point where a new generation of researchers view themselves as educational neuroscientists. This is a unique position because the field of educational neuroscience has – until recently – been inhabited by cognitive (neuro)scientists with an interest in education or education professionals with an interest in neuroscience. It is our suggestion that a new, uniquely trained group of researchers (such as ourselves) has the power to tackle important questions generated in the classroom, and to overcome the fallacy that neuroscientific findings are only useful within the laboratory.

Unlike other commentaries, we propose shifting the focus from cross talking and interdisciplinary training to approaching educational neuroscience as a discrete discipline with uniquely trained professionals. Consider two issues highlighted above concerning difficulties in translation and communication; if researchers are trained as educational neuroscientists, translation should not be a problem. Rather, the utility of neuroscience within the school context would become these academics' primary focus. Communication difficulties should also be lessened if future generations are trained to speak the new language of educational neuroscience. Finally, our re-conceptualisation of this field would help to address the 'grand challenges' of neuro-education recently identified (Butterworth & Kovas, 2013).

Conclusion

In sum, we predict that the "bridge" between education and neuroscience will eventually become redundant. Rather than continuing to create links between two diverse fields, a more efficient and beneficial way of approaching the problem is to build a new and distinct *Educational Neuroscience* highway that sits in parallel to the existing education and neuroscience tracks. A new generation of educational neuroscientists – who take responsibility for translating or applying their science – should prove instrumental in the construction of this path.

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