Neuroscience and education-an incompatible relationship

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Abstract

To date there has been little opposition to the growing influence of cognitive neuroscience in education from the education profession itself. However there is growing criticism from the fields of psychology and philosophy. This paper aims to summarize the central arguments found in literature critical of the claims made by cognitive neuroscientists who advocate its potential to improve education. The paper is organised around three sections which draw together assessments from psychology, philosophy and sociology of education. The first, "Brain, Mind and Culture", lays out the general argument against neuro – education and evaluates two common assumptions made by advocates of neuro-education: that there is a causal relationship between brain and mind; and that learning is a central tenet of education. The second section, "Promises and Problems", critically considers an example of neuro-educational research, and then goes on to discuss how neuro-education has detrimental consequences for two necessary conditions of liberal subject based education; disciplinarity and pedagogic authority. The final section, "Discourses of Risk, Vulnerability and Optimal Outcomes", considers wider sociological literature to locate neuro - education within its contemporary cultural context. The paper concludes with a summary of the main philosophical and moral objections to neuro-education.

Keywords: cognitive neuroscience, education, subject based education, culture, discourse

Introduction

Neuroscience emerged in the 1960s (Abi-Rached & Rose, 2010) but the development of cognitive neuroscience, and its application to education, is a more recent phenomenon. The distinction between neuroscience and cognitive neuroscience is that the former is concerned with the biological workings of the brain; its application falls within medicine in improving diagnosis and treatment of dysfunctions caused by disease or trauma. Cognitive neuroscience is concerned with mapping biological workings of the brain to cognitive mental functions that underpin subjectivity such as "vision, spatial cognition, audition and music, emotions, intuition, memory, motor function, language and consciousness" (Geake & Cooper, 2003, p. 9). Neuro-education or Mind Brain Education (MBE) refers to the application of findings, or the language, of cognitive neuroscience to educational questions and problems. The last quarter of a century has seen a significant expansion of cognitive neuroscience in Britain and America (Espinosa-Tokuhama, 2010).

- 1990 US President launched The Decade of the Mind, an initiative designed to support work in the fields of brain research, to facilitate dissemination of findings and increase public awareness of neuroscience studies.
- 1999 The OECD's Learning Sciences and Brain Research project established.
- 2001 Harvard's first Masters programme in Mind Brain and Education (MBE) begins.
- 2004 International Mind Brain and Education Society (IMBES) established
- 2005 Centre for Neuroscience in Education established at the University of Cambridge.
- 2006 the SAGE Centre for the Mind was established at the University of California.
- 2007 The Centre for the Future of the Mind established at Oxford University.

- 2007 The Teaching and Learning Research Programme (TLRP), the largest ESRC funded project in Britain publishes Neuroscience and Education: Issues and Opportunities, a Commentary.

- 2007 The OECD ʻs Centre for Educational Research and Innovation publishes *Understanding the Brain: The Birth of a Learning Science* where authors claim, "An international and interdisciplinary effort will play a decisive role in resolving recurring problems in education." [1]

Brain, Mind and Culture

A main assumption underlying neuro-educational claims is that both cognitive neuroscience and education are concerned with learning; this is the alleged common ground between biology and culture. Few serious cognitive neuroscientists would deny that culture has an important role in education; and from this perspective any knowledge about the biological processes of learning can only expand and enrich existing knowledge of cultural aspects of education. Educational psychologists, Byrnes and Fox (1998) for example, regard neuroscience as enabling psychology to give fuller accounts of mental processes involved in cognition; others think it makes psychology more "biologically plausible" (Ansari, Coch and De Smedt, 2011, p. 37)

To some degree the argument that cognitive neuroscience can shed light on either psychology or education draws its appeal from technical advances. Improvements in brain scanning equipment means it is possible to capture images of electro-chemical activity in the brain in real time and in increasingly naturalistic environments. From these technical developments it is inferred that neuroscience allows more direct access to learning processes than possible before (Espinosa-Tokuhama ibid.). Or as leading British cognitive neuroscientist, Goswami writes, "Improved knowledge about how the brain learns should assist educators in creating optimal learning environments." (2008, p. 381).

John Bruer, president of the James McDonnell Foundation in St. Louis and author of *Education and the Brain: a Bridge Too Far* (1997) is critical of the idea that cognitive neuroscience provides new knowledge of cognitive processes that surpasses existing knowledge from other fields, especially that of cognitive psychology. He points out that the main concepts used in cognitive neuroscience have been developed, and derive their meaning, from cognitive psychology. Merely mapping these concepts onto descriptions of neural networks and patterns, which is the methodology behind most cognitive neuroscientific claims in education, does not constitute the theoretical integration capable of yielding new or better knowledge. He concludes that it may be possible for neuroscience and cognitive psychology to enter into a fruitful relationship from which a second bridge to education *may* be possible in the future.

Despite his important criticisms Bruer does not discount the possibility that education could be informed by neuroscience in principle. Stephen Rose is one of the few neurobiologists who makes the more general objection to the idea that mind has its origins in the biological processes of the brain (Rose, 2005). This idea is tacitly affirmed by Goswami in her claim that improved knowledge about the brain's workings can somehow be used to improve "learning environments". Her statement makes sense only if two contestable assumptions or prior beliefs are accepted: firstly that the brain is the same type of phenomenon as the mind; and secondly, that learning is the central aim of education. More fundamental objections to the claims of neuro-education are found in literature from philosophy of mind and education which are discussed below.

Brain = mind?

Tallis makes a substantive point of objection; he argues that cognitive neuroscience assumes the brain is the source of mind and it's achievements (Tallis, 2011). If this is the case then mind has to have an existence *outside, and independent of,* the brain. Without this separation, knowledge of either would be impossible, and we do have knowledge of both. In conflating brain and mind the ontological distinction between *objects of study* and *subjects who* study, necessary for any knowledge, would have no basis and there could be no

[1] http://www.oecd.org/edu/ceri/understandingthebrainthebirthofalearningscience.htm

knowledge of anything. Clearly this is not the case. Consequently if brain and mind are categorically different, and the brain is a biologically discrete entity, it cannot give rise to the mental contents of mind, which "relate to the states of individuals *together with the complex set of social and cultural phenomena in which individuals are embedded"* (Davis, 2013, p. 32). The contents of mind may be locatable in individual brains, but they are not bound by the brain's temporal and spatial limitations. For the mind's content does not comprise of neural correlations; its products are in the totality of a society's ideas, values, and practices. Concrete manifestations of mind include intellectual/cultural objects whose meaningful existence long outlives the brain's lifespan. This fact attests to the independence of mind from brain.

Furthermore, if brain and mind are different categories, then it is open to question whether the same empirical and theoretical methods of investigation can be fruitfully applied to both. The methods, concepts and language of scientific experiment were developed through the effort to gain knowledge of the physical world and its laws. Knowledge progresses in this field mainly by means of reducing secondary characteristics and limiting the role of subjective interpretation, and through this it gains a high level of abstraction and generalization (Cassirer, 1957; Johan Muller, 2012; Polanyi, 2012). McGilchrist calls this a closed conceptual system because its meanings are bound within a self-referential theoretical system where each concept/word or symbol has precise meanings within it. But this form of knowledge leaves little room for ambiguity and cannot break out into meanings from life outside its conceptual framework (McGilchrist, 1982, pp. 36–37). [2]

Philosopher of Education R.S.Peters made the point that education has no intrinsic values; it is expressive of whatever values a society upholds (R. S. Peters, 2007). This could also be extended to the content of education; the knowledge content of education is whatever forms of knowledge a society thinks is worth upholding and transmitting to the next generation. In this light education is not a discrete entity, nor is it subject to natural laws; it owes its existence entirely to human intentional effort in the realm of culture. Arguably, whatever characteristics education may share with nature (the banal fact that it involves biological beings for example), it's unique, foundational characteristics, which are of an intellectual and moral nature place it firmly within the realm of culture. As an object of culture not nature, education is most fully understood as an organic unity where the meaning of any discrete empirical part, whether test results or teaching styles, is gained by an iterative process of studying and considering the interrelationships of part/s to each other; and part to the whole (Oakeshott, 1971). Consequently understanding of education requires a more integrative and iterative mode of thought than possible through scientific methods. The humanities and social sciences allow more scope for imaginative and inferential thinking through which a better, fuller and more nuanced understanding of education can be achieved.

Learning = the main aim of education?

At first glance, it seems to be common sense that education is about learning. Moreover the influence in education departments of Vygotsky and Piaget's ideas of learning being a social process would seem to accord with a more public or collective concept of education. However, Biesta argues against learning as the central criterion in education; for him learning and education are incompatible (Biesta, 2010) because learning has an individual unit of analysis – the pupil's mind; whereas education should be more concerned with *what* is taught. It is the knowledge content of education that distinguishes learning in education from learning that people do as a matter of course in their lives. Educational knowledge is the proper concern of the public and educators whereas to a large extent, learning depends upon responsibility and dispositions, which are the property of individuals. Consequently learning processes are legitimate objects of study within the field of developmental psychology, but their place in education is more problematic

[2] By way of illustration compare the chemical symbol 'Au' which has specific meanings pertaining to physical characteristics; the word 'gold' however has a far wider range of possible meanings which require a greater level of imaginative interpretation. Its meanings are dependent upon both its linguistic context and the subjectivity the reader brings.

Where learning is the main organising principle of education, the consequences can be anti-educational as the profession focuses more on psychological development of individual pupils rather than public knowledge that has been academically and publicly validated. Furthermore, learning based education is also ethically problematic as it is essentially a mental event *within* an individual's mind, and to try and shape this in any way, can only be intrusive of pupils' inner lives and personalities. This was Bernstein's criticism of progressive education (Bernstein, 1975). This point is developed by Smith (2002) in his critique of the concept of well-being in education. The alternative concept of education as a distinct form of public cultural transmission centres upon *the content* of learning, which in the case of liberal subject based education, has to be knowledge derived from academic disciplines with their concomitant methods (Hirst, 1965; Phenix, 1962)In this conceptualization of education, if a subject has been publicly judged worthy of inclusion in the school curriculum, then it is worth teaching irrespective of learning outcomes which are likely to be varied and inconsistent for good reasons.

In order to judge whether neuro-education can offer education better or new knowledge an example from the work of leading British cognitive neuroscientist and a founder of the Centre for Neuroscience in Education at Cambridge University, Usha Goswami, is critically evaluated.

Promises and Problems

Many cognitive neuroscientists make strong claims about both the positive potential of neuroscience to improve a range of social endeavours, including education. Jack Shonkoff, Director at the Centre for the Developing Child at Harvard, for example, asserts:

> Advances in neuroscience, molecular biology, epigenetics, and the behavioural and social sciences indicate that the foundations of educational achievement, lifelong health, economic productivity and responsible citizenship are formed early in life.
> (Shonkoff 2011, 1)

And Goswami writes:

> Although the field of educational neuroscience is relatively new, there are a number of principles of learning demonstrated by empirical studies, that can safely be incorporated into education and teaching.
> (Goswami 2008, 387)

Difference of tone and style notwithstanding, cognitive neuroscientists on both sides of the Atlantic agree that in principle education would benefit from knowledge and insights from neuroscience (Ansari & Coch, 2006; Ansari, D, Coch, D and De Smedt, B., 2011; Blakemore, Frith, & others, 2001; Carew & Magsamen, 2010; Geake & Cooper, 2003; Goswami, 2006; Goswami, U., 2008; Howard-Jones. P, 2008; Immordino-Yang, McColl, Damasio, & Damasio, 2009; Pickering & Howard-Jones, 2007; Tokuhama-Espinosa, 2010)

The following sub-sections consider whether principles from neuro-education can be "safely incorporated in education and teaching". The first draws on literature from educational psychology and history of literacy to assess whether neuro-education offers any practical help for teachers. In the second I consider recent work from the sociology of education and knowledge to discuss problems created by neuro-education for academic practice. The third sub-section compares neuro-education with traditional liberal education as defined in literature from the philosophy of education, and discusses the implications for pedgagogic authority

Does Neuro-education Work?

Goswami proposes there are six principles of learning, one of which is that "Learning is Multi-Sensory" (Goswami, 2008, p. 388). She refers to brain images from a study, which suggests that when children are first taught to write letters (as opposed to recognizing letter visually), there is localized neural activity in areas associated with motor activity. The same localized activity occurs in subsequent tests even when

children only look at letters. From this she concludes that deeper learning is more likely to occur if multisensory experiences are activated.

Even if Goswami's conclusions about multi-sensory learning prove to be correct, it is not a new knowledge. In 1921 American educational psychologist Grace Fernald developed the visual-auditory-kinaesthetic-tactile (VAKT) technique for remedial literacy teaching through her work with patients suffering brain damage and trauma (Taschow, 1970). The idea of multisensory learning is not new, what *is* new however is that a technique initially used for a minority experiencing difficulties due to specific medical conditions, is considered to be applicable to *all* children and for *all* teachers.

Referring to a study on novice readers by Turkeltaub, Goswami writes that 'logographic' strategies for teaching literacy skills would be unhelpful (2008, p. 383). [3] . Although she refrains from explicitly stating it, her interpretation strongly implies support for a particular type of pedagogic technique (phonics) over other methods. But it is not clear why phonological awareness would render other strategies "unhelpful". In 1967 Margaret Peters explained why visual memorization of letter strings, as well as auditory and phonological recognition is important in initial teaching of spelling and reading. This is because of the highly irregular phonological character of the English language (Peters, 2013). The ability to recognize and remember common letter strings and whole words visually helps children to make more accurate guesses when confronted with material that contains unfamiliar words.

In a similar vein Pollock and Pressey (1925) warn that an overemphasis on phonics tends to delay children's introduction to more complex, meaningful literary material. In their investigation of pupils who were experiencing difficulties in reading, they observed fluent and struggling readers whilst reading. They found that the former group's eye movements did not retrace along lines of text, nor did their eyes rest on every word; their eye movements were smooth. From this they concluded *not* that more research was needed to into the physical aspects of reading, but that the quality of literature was crucial as it was here that a pupil's volition could be sparked, without which reading was likely to remain a chore.

The key assumptions and values embedded in Pollock and Pressey's approach, and absent in neuro - education, is that both pupils and teachers have volition and intentions that are their own, and that understanding and respecting the expressive powers of literature is more important than any single technique when teaching children how to read. In comparison neuro - education offers little new or better knowledge about education or its practice; rather it tends to re-present humanities based knowledge in the language of science. Its promise may be empty but neuro-education presents profound problems for education to which I now turn.

Neuro-education and Academic Practice

In his discussion of the role of knowledge in academia, sociologist Rob Moore identifies a new and growing phenomenon he calls "hyperdisciplinarity" (Moore, Christie, & Maton, 2011). He argues it is distinguishable from established interdisciplinary academic practices where scholars across disciplines collaborate in formal and informal ways as part of their everyday work. Interdisciplinary work emerges through *discipline-based* scholars pursuing questions and problems intrinsic to their field of study. Hyperdisciplinary projects, on the other hand, bring together different academic groups and stakeholders to work on problems often identified and framed from outside academia. Such collaborations are assumed to result in better, more reliable or applicable knowledge, but often exert distorting pressures on the intellectual integrity of singular disciplines, which is where conceptual breakthroughs are made which contribute to existing knowledge in the field (Muller & Young, 2013)

[3] Goswami bases her conclusion on brain images that show neural activity in part of the brain area associated with recognizing sound and from this surmises that phonological awareness plays a part in reading. So far so good, but she then goes on to conclude from this that written word/letter based methods would be unhelpful without giving any grounds for her conclusion. For the study she refers to see *The Neurobiological Basis for Reading: A Special Case of Skill Acquisition* by Turkeltaub PE, Gareau L, Flowers DL, Zeffiro TA, Eden, G. F. (2003)

Arguably an example of a hyperdisciplinary project is that of the University of Bologna's recently established Joint International Cognitive Neuroscience PhD Programme, a collaborative course involving universities from France, America and the Britain. One of its six research areas is described as focusing on:

> the functional and neural mechanisms underlying social cognition and social behaviour. Research deals with social decision making, moral cognition and neuroeconomics. Ph.D. students will focus on neural underpinning of economical or moral decision-making during social interactions in healthy and brain damage patients. [4]

The traditional subjects of such a course would comprise of politics, moral philosophy, economics and sociology. These are subjects with a long history and incorporate different opposing theoretical positions and nuances. When considered and re-conceptualized from the point of view of neural processes the historical perspective and intellectual richness of these subjects tends to disappear. Neural patterns are volatile and change constantly whereas established academic knowledge has been formed over centuries. It is unlikely that these subjects could be understood or explained in terms of neural correlations without severely distorting or reducing their substantive content.

What tends to happen in hyperdisciplinary work is that parts of disciplinary knowledge are de-contextualized and applied to an extrinsic problem in ways that restrict rather than generate, open-ended intellectual inquiry. Standish makes a similar point in relation to the truncated character of literature reviews in contemporary models of academic research (Standish, 2001). In this light Hart and Mareshcal's claim that the fundamentally interdisciplinary character of cognitive neuroscience means it can provide theoretical knowledge of greater explanatory power (Hart, 1983; Mareschal et al., 2007) is highly contestable.

Neuro-education and Pedgagogic Authority and Liberal Education

The second problem with neuro-education is that it rests on a deficit model of teachers. The incursion of values and criteria from external sources has already undermined the ability of teachers to act as sources of pedagogic authority (Furedi, 2009; Williams, 2013). In liberal humanist education a pedagogic authority is an adult who is a central pivot in introducing pupils to academic knowledge and concomitant practices through which they enter into a broader cultural conversation as adults. The conceptualization of education as a process of cultural transmission has been viewed negatively by some, Pierre Bourdieu for example, believed this meant education was primarily an ideological tool for political elites (Bourdieu & Passeron 1977). But others have understood it differently. Philosophers Hannah Arendt, Charles Bailey, Paul Hirst, Michael Oakshott and R.S. Peters, for example, argue that education's role as a form intergenerational cultural transmission is positive as it is the means though which a public culture is affirmed in the present, and the means with which the young may enter it more fully in the future as educated adults. Then they will be better able to decide what they may wish to change, maintain or abolish according to knowledge and values they have freely chosen (Arendt, 1993; Bailey, 2009; Hirst, 1965; Oakeshott, 1971; Peters, 2007).

In this account liberal education has a strong association with the possibility of extending spheres of freedom; and the teachers' role in this form of education is that of a pedagogic authority the basis of which has rested in large part upon mastery of their subject. Until recent times such authority has underpinned the profession's claim on public trust (Christie, 2004; Frowe, 2005). The importance of teachers having a deep understanding of their subject is rarely fully acknowledged. It is often regarded as a nice cherry on the top at best, something nice but not essential providing a teacher can fulfil an ever-expanding remit of demands from non-educational sources or just maintain a semblance of order in the classroom. The epistemological characteristics of academic knowledge- primarily those of conceptual condensation and formal abstraction, make it necessarily unfamiliar and more intellectually demanding than everyday knowledge, which has a wider range of contextual supports. The endeavour of making such knowledge meaningful in school subjects offers the potential to acquire a more objective mental position which make it more possible to scrutinise conventional thoughts, opinions and knowledge of everyday life (Moore & Young, 2001; Muller, J., & Young, M., 2008; Wheelahan, 2012; Young, 2007). This is what is meant by the transformative power

[3] http://neuroscience.psice.unibo.it/index.php?option=com_content&view=article&id=56&Itemid=47

of liberal education (Bailey, ibid: Barrow, 2009; Hirst, ibid; Peters, 2007). Historically, its potential power has been tacitly recognised in the restriction of such knowledge to those groups deemed sufficiently loyal to the dominant beliefs and values of their time. [5]

Neuro-education represents a fundamental break with this educational tradition. It redirects the profession's focus away from disciplinary knowledge towards becoming literate in cognitive neuroscience. Teachers are urged to read and follow instructions from scientists and public relation intermediaries in order to become "intelligent consumers of research", (Goldacre, 2013, p. 7). This assumes the problem is teachers' gullibility, a main interpretation of Weisberg's often cited study that found explanations with irrelevant neuroscientific information were more likely to be believed by non-experts (Weisberg et al., 2008). Many cognitive neuroscientists believe that teachers' susceptibility to neuro-myths is exacerbated by the activities of commercial educational companies, or unscrupulous media, who use neuro-scientific terminology to promote their products or sell stories (Busso & Pollack, 2014; Goldacre, B., 2013; Goswami, 2004). [6] Although their desire to limit damage to the reputation of science is laudable their arguments place teachers in a default position of ignorance. The idea that a quick, basic understanding of neuroscience is either possible or desirable undermines the value of the teachers' own subject knowledge and also trivialises the work of neuroscience which requires a lengthy period of induction in scientific knowledge. In attempting to make education 'teacher-proof', neuro-education leaves little for teachers to do qua teachers (Davis, 2013).

Despite the growing debunking of neuro-myths such as phrenoblysis (Marsh, 1985), and the lack of new or better knowledge in education, cognitive neuroscientists continue to call for educational policy and teacher training to be informed, or transformed by cognitive neuroscience (Ansari, Coch, and De Smedt, 2011; Carew & Magsamen, 2010), and the education profession continues to look to science for ideas. [7] To shed light on the question of why the education profession is so ready to accept the authority of neuroscience, I consider recent sociological work on social policy and contemporary cultural trends to discuss how these serve to legitimise the authority of neuro-education at the expense of liberal education.

Discourses of Risk, Vulnerability and Optimal Outcomes

Risk and Vulnerability in Education

Sociological work that considers the question of risk consciousness emphasises contemporary cultural and political trends that give rise to negative interpretations of human agency in diverse areas of life. Even our most intimate family relations are reframed as if the family is necessarily a site of competing individual interests which if given free rein, would lead to harmful consequences (Furedi, 2006, 2008a, 2008b; Lee et al., 2014; Wastell & White, 2012). A near continuous anxiety arises as the culturally dominant understanding of risk changes from probabilistic (open to rational evaluation and judgement) to possibilistic (a more free-floating existential sense of risk) (Furedi, 2008a, p. 653).

This theme of risk is taken up in Abi-Rached and Rose's work where it is argued that the discourse of risk depends upon classifying individuals as a permanent source of double risk, to themselves and to others (Abi-Rached & Rose, 2010; Rose, 2010). The autonomous conduct of people is problematic, and increasingly

[5] For example, both Plato and St Augustine thought that dialectics should be taught only once pupils had attained a high level of academic knowledge, but also after they had proven their commitment to truth, which was conceived of within religious cosmologies.

[6] One example of a neuro-myth is that of 'phrenoblysis' discussed by Fischer and Daley (2007). Phrenoblysis was a term created to explain an apparent link between intense electrical activity in the brain and growth in head circumference. In the 1970s and 80s certain American states used the idea of 'phrenoblysis' to advise education departments that teachers should delay introducing complex concepts until pupils were ready in terms of brain growth

[7] For example, recent neuroscientific research in the sleep patterns of adolescents(Gozal & Kheirandish-Gozal 2012) has been used by some British schools to change the start of the school day (Tait 2013). Others even attempt to include cognitive neuroscience in their studies of art and Shakespeare (Changeux 1994; Changeux 2011; Thierry et al. 2008)

there is recourse to neurobiological explanations. These have an allure of authority, certainty and suggest that it is possible to control nearly all variables, and thus 'optimize outcomes'. In education discourses of risk and vulnerability underpin the trend towards greater prescription of teachers' practice and also the reclassification of pupils' difficulties as medical or psychological conditions. Dyslexia is one such example.

The term dyslexia suggests a discrete condition with definable and largely agreed upon features. In this scenario pupils are presented as being 'at risk'; this overemphasises and misconstrues the nature of the problem. Goswami, for example, writes of identifying "neural markers for phonological sensitivity, such as brain responses to auditory cues for rhythm, to identify who is *at risk* of later difficulties" (Goswami 2006, 4, my emphasis). This creates a climate where it becomes an acceptable educational aim to find 'biomarkers' for potential future 'risks' in order that early preventative interventions can be devised. Molfese's work, for example, scans babies' brains for 'biomarkers' of future dyslexia (Molfese & Molfese, 1997; Molfese, 2000). It is ironic that the term dyslexia was originally introduced by psychologists in the early 20th century to oppose the existing biological and medical based understanding of what was then known as congenital word blindness (Tinker, 1932).

Elliot and Gibbs (2008) contest the contemporary medical definition. They argue that dyslexia is a social construction, formally recognized in Britain as a special educational need in the 1993 Education Act. They claim that the re-classification of reading difficulties, most of which are best understood as existing on a continuum of capabilities, into a discrete medical category, alters the conception of pupils and, by implication, the pedgagogic relationship. A pupil struggling with reading and writing could possibly be helped through better methods of instruction, more time or better books. Instead he/she is likely to be too readily diagnosed as bearers of a medicalized condition and the teacher becomes someone required to administer 'a cure' rather than a subject specialist whose knowledge and experience could be used creatively to help the pupil improve. [8]

It could be argued that neuro-education lacks positive intrinsic justification. Its authority lies in part with the established public authority of science, but also in a larger part to the prevalence of the discourses of risk, vulnerability and optimal outcomes. The fundamentally negative view of the world and sense of anxiety that underpins discourses of risk and vulnerability is expressed by Geake and Cooper who see the world as:

> a socially fragmented, unstable and unpredictable world…a world which rewards initiative, independence, self-motivation and self-reliance over obedience to authority and conformity. Its should come as no surprise…..to note that the current era is also marked by unprecedented levels of psychological and behavioural disorders among young people. (Geake & Cooper 2003, p. 12)

They go on to claim that educators should welcome neuroscience because it shows "positive effects of the time at school on neural dendrite growth" (ibid p. 17). This, they argue, can help the profession reclaim the education agenda from the control of politicians. But they simultaneously give up control of the educational agenda; in conceding a causal link between education and biology the authors afford an unwarranted degree of authority to new policy and academic groups versed in neuro-education, who are even less publicly accountable than politicians.

[8] This is not to say that other professions could not or should not be called upon if there is a distinct medical or psychological problem, but rather to propose that any improvement in these aspects would belong more to medicine or psychology rather than education. The proper remit of education is neither medical nor psychological improvement and signs indicative of improvement are likely to be manifest in a more diffuse and varied, qualitative manner; when for example, a pupils express a desire to attempt to read a different, unfamiliar type of book, or in the type of questions they ask.

Conclusion

Emerging from the criticisms of cognitive neuroscience discussed above are the following main points. Firstly, cognitive neuroscience in education is antithetical to older liberal humanist education, which is founded on the value of freedom - a foundational virtue that underpins the whole educational endeavour (Arendt ibid; Bailey ibid; Furedi 2009; Hirst ibid; Peters 2007; Oakeshott ibid; Turner, 2012). If accepted, then there are necessary epistemological and moral conditions for its concrete existence. Whilst freedom in relation to the knowledge content cannot be wide ranging (it should be based on subjects derived from disciplinary knowledge, which also have their own order and implied methods*), the practice* of teaching needs the greatest level of freedom from prescription. [9] This necessary component of freedom is threatened if methods borrowed from science, which seek predictability and generalization, are applied to education.

Secondly, the incursion of cognitive neuroscience in education is part of wider cultural discourses, which rely on negative conceptions of pupils and teachers; it also subsumes all other forms of knowledge and experience within a scientific framework. In this way its application to education exacerbates existing problems in education which have arisen in large part from decades of interventions that have undermined the status of liberal subject based education (Ball, 1995; Ball, 2003; ; Beck, 1999 Chitty, 1997; Furedi, 2009; Galton, 2008; Geerwitz, Mahoney, Hexall, and Cribb, 2009; Geerwitz, 1997).

Busso and Pollack indicate (ibid.) a third broader philosophical problem with the conflation of brain and mind that underpins neuro-education: its underlying conceptualization of people as determined, rather than determining, beings. Kantian influenced philosophers maintain that we are intentional and free-willed beings. If acts arose from a consciousness determined by any external source, including neurons, then we would not be free-willed. And without free will, Berlin argues, people cannot be held responsible for their acts (Berlin, 1969). Leading American cognitive neuro-scientist Gazzaniga simultaneously urges us to abandon the idea of free-will but also wants to retain credibility for legal responsibility; unfortunately he does this by claiming we are hard-wired to be socially responsible as it's in our DNA (Gazzaniga, 2012).

To conclude, the influence of neuro-education is likely to be detrimental for education. Furthermore it serves to legitimize potentially anti-democratic policies not least because it confers authority on a new layer of experts drawn from academia, politics and business who are more removed from formal and informal relationships with the public than existing institutions and personnel. Consequently this paper concludes that education's legitimate partner is not cognitive neuroscience, but existing knowledge rooted in the humanities and social sciences.

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[9] There continues to be a longstanding debate as to the role and status of practical subjects in the curriculum. This paper holds that practical subjects can and should be part of a liberal education, but that there are epistemological distinctions which need to be understood and respected. For a critique of liberal education Apple & Beane, 2007; Lave & Wenger 1991; and White 2010.

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