Educational Neuroethics: A Contribution From Empirical Research

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ABSTRACT— In recent years, educational neuroscience has begun to move into the limelight, suggesting an increased importance on the ethical considerations of educational neuroscience work, or *educational neuroethics*. In a departure from previous work on educational neuroethics, this article focuses on the ethical considerations that are applicable to empirical educational neuroscience research. Neuroethics concepts were compiled through a thorough survey of neuroethics articles. Then, 28 empirical educational neuroscience articles were analyzed through the lens of five categories of neuroethics concepts collected through the literature survey: the scientific enterprise, prediction, neuro-manipulation, social considerations, and philosophical considerations. Three of the five categories (i.e., the nature of scientific investigation, prediction, and social considerations) applied to a subset of the articles. In addition, a fourth ethical issue not stemming from the neuroethics literature, referred to here as brain-based justifications, emerged from the nature of educational neuroscience work. Limitations of this study and future directions for educational neuroethics research are discussed.

Recent years have shown increased momentum in educational neuroscience (e.g., see Kelly, 2011)—also referred to as neuroeducation—a part of the mind, brain, and education (MBE) movement. Educational neuroscience has been conceptualized as both the application of neuroscience findings to education and a bidirectional relationship between cognitive neuroscientists and education stakeholders, whereby techniques, methods, and theories from neuroscience are applied to and inform the creation of educationally relevant questions (Carew & Magsamen, 2010; Fischer, Goswami, Geake, & the Task Force on the Future of Educational Neuroscience, 2010; Geake, 2011; Patten & Campbell, 2011). Scholarship on the potential of this field (e.g., Ansari, De Smedt, & Grabner, 2012)—particularly using cognitive neuroscience methods—and special journal sections devoted to the topic (e.g., *Educational Philosophy and Theory*, *Developmental Cognitive Neuroscience*, *ZDM* in the context of mathematics education) attest to the growing body of research and interest in this area.

This scholarly force begets the need to spotlight conversations on the ethics of educational neuroscience work, the discussion of *educational neuroethics* (Hardiman, Rinne, Gregory, & Yarmolinskaya, 2012). Attention to educational neuroethics is increasing. Only a handful of years ago public discussion of ethical considerations in joining education and neuroscience was sparse, but in recent years there has been a marked increase in attention to these matters (e.g., an August 2012 special section in *Neuroethics*).

Previous literature has framed discussions on educational neuroethics utilizing hypothetical educationally relevant scenarios or examples in which ethical considerations involve the application of neuroscience to education contexts. For example, in some of the earliest writing on the subject, Sheridan, Zinchenko, and Gardner (2005) frame their discussion of the intersection of neuroscience and education through three hypothetical scenarios. The first involves an elementary school teacher faced with a student who has an atypical neurological report based on fMRI scanning. The second involves a neuroscientist-developed product for educational remediation of fractions. The third involves achievement disparities on high-stakes exams resulting from cognitive enhancement from psychopharmacological drugs. Through these scenarios, Sheridan et al. argue that ethical quandaries potentially arise when educators need to also take on the perspective of a neuroscientist, question what should constitute educational effectiveness for products based on (even sound) science, and contemplate the unintended

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educationally related consequences of scientific research, respectively.

Similarly, Stein, della Chiesa, Hinton, and Fischer (2011) illustrate the ethical (versus not) application of neuroscience to education through the presentation of two scenarios. The scenarios contrast the use of a program that combines brain-imaging technology with psychopharmacology for a young child who exhibits concerning behavior problems and a teenage girl discontent with her surrounding culture. Stein et al. use the scenarios to argue that the ethical application of neuroscience is to raise children (i.e., just treatment, considering the whole child in context) rather than design them (i.e., unjust treatment, considering only biologically focused interventions involving the brain).

Beyond hypothetical scenarios, contributions to the educational neuroethics literature include several conceptual discussions. These have ranged from psychopharmacology in schools, particularly for attention deficit hyperactivity disorder (ADHD) treatment or improving academic achievement (Stein, 2010) to the roles of various stakeholders (e.g., researchers, educators, policy makers) in the ethical translation and application of neuroscience findings (Hardiman et al., 2012). Howard-Jones and Fenton (2012) offer a more nuanced reconciliation of ethical issues across neuroscience and education, arguing that educational neuroethics is greater than the sum of the ethical considerations in both fields. Important insights about educational neuroethics have resulted from the hypothetical scenarios and conceptual discussions reviewed above. New approaches to ethical considerations in educational neuroscience work, such as a direct examination of empirical educational neuroscience research, can build on prior work in educational neuroethics and broaden the scope of conversations in the field.

This article seeks to contribute to the growing literature on educational neuroethics by focusing on ethical considerations applicable to empirical educational neuroscience research. In a departure from much of the previous literature, we approached neuroethical considerations from the research(er) perspective. Through the lens of neuroethics, we evaluated the purposes, goals, claims, and conclusions arising from a set of educationally relevant cognitive neuroscience studies in order to distill potentially applicable educational neuroethics concepts. We expected a subset of the neuroethics concepts to apply to the empirical educational neuroscience studies. In addition, we expected that we might find distinct ethical concepts specifically applicable to educational neuroscience research.

METHODS

Neuroethics concepts were compiled through a thorough survey of neuroethics articles. The goal was to establish a set of concepts related to neuroscience research that could then be applied to educationally relevant cognitive neuroscience studies, to determine the subset of neuroethics content that may apply to educational neuroethics.

A total of 28 empirical studies were included in this analysis. Studies were located through PubMed and were included if they (1) used cognitive neuroscience neuroimaging methods, (2) were published in 2009 or later, and (3) concerned an educationally relevant topic (i.e., literacy, numeracy, music learning, ADHD, Autism Spectrum Disorders, emotion). We consider these 28 studies to be exemplars of research in the field, rather than an exhaustive list.

Each article was analyzed through the lens of the categories of neuroethics concepts collected through our literature survey. Concepts could apply to an article in one of three ways. First, a concept applied if it was the explicit goal of the study (e.g., predicting arithmetical performance based on brain activity during a working memory task [Dumontheil & Klingberg, 2012]). Second, a concept applied if authors referred to the concept in their discussion. Lastly, a concept applied if the study's explicit conclusions were ripe for misinterpretation or misuse. Knowing that additional ethical considerations could emerge out of educational neuroscience work, we left open the possibility of ethical themes distinct from the set of neuroethics concepts based on current literature.

RESULTS

Neuroethics Concepts

Table 1 provides an extensive list of neuroethics concepts found in the literature. For ease of analysis and discussion, concepts were grouped into five categories: the scientific enterprise, prediction, neuro-manipulation, social considerations, and philosophical considerations.

Several neuroethics concepts refer to issues that arise from the nature of the scientific enterprise itself. Most neuroethics concepts in this group are applicable to other types of scientific endeavors in addition to neuroscience. As examples, the quandary of reconciling statistical relevance with questions of normativity (Takala, 2010), communication of findings (Illes & Bird, 2006; Kehagia, Tairyan, Federico, Glover, & Illes, 2012), and disclosure of findings (Glannon, 2006; Häyry, 2010; Illes & Bird, 2006; Kehagia et al., 2012; Schlaepfer & Fins, 2010) all surfaced in scholarship on neuroethics.

The concept of prediction refers to the use of neuroimaging to measure brain correlates of psychological traits (Farah, 2005). Such imaging can be used to predict future (presumably undesirable) psychological traits or behaviors. Prediction may also be coupled with early pharmacological intervention, such as to delay advancement of psychosis (Glannon, 2006).

We use the term neuro-manipulation to refer to chemical alterations of the brain. These practices include curing

Table 1
Neuroethics Concepts Applied in the Analysis

Category	*Neuroethics concepts*
The scientific enterprise	• Statistical relevance, uncertainty, and normative dilemmas (Takala, 2010) • Communicating scientific findings (Illes & Bird, 2006; Kehagia et al., 2012) • Generalizing from groups to individuals (Kehagia et al., 2012) • Safety and risk (Kehagia et al., 2012; Sienkiewica, Jones, & Bottomley, 2005) • Selective reporting, particularly in Deep Brain Stimulation (Schlaepfer & Fins, 2010) • Incidental findings (Glannon, 2006; Häyry, 2010; Illes & Bird, 2006; Kehagia et al., 2012)
Prediction	• "Brainotyping" (Farah, 2005), that is, behavioral predictions based on neuroscience findings (Illes & Bird, 2006) • Predictive neuroimaging with pharmacological intervention (Glannon, 2006)
Neuro-manipulation	• Curing (Glannon, 2006; Häyry, 2010; Illes & Bird, 2006; Kehagia et al., 2012) • Enhancement (Farah, 2004, 2005; Illes & Bird, 2006; Moreno, 2003), of neurosurgeons (Warren, Leff, Athanasiou, Kennard, & Darzi, 2009)
Social considerations	• Health and development outcomes such as child-rearing, technological advances, neurotoxicity of food additives (Illes & Bird, 2006; Kehagia et al., 2012), and the impact of poverty and abuse on neurodevelopment (Illes & Bird, 2006) • Direct-to-consumer advertising of neuroproducts (Illes & Bird, 2006) • Neuromarketing (Farah, 2004, 2005) • Brain privacy (Farah, 2004, 2005) • Impact of neuroscience in the workplace or classroom (Illes & Bird, 2006; Takala, 2010)
Philosophical considerations	• Mind and matter, free will, thinking and the brain (Häyry, 2010) • Free will and legal considerations (Kehagia et al., 2012), such as criminal responsibility (Takala, 2010), identity (Moreno, 2003), and consent (Illes & Bird; 2006; Kehagia et al., 2012; Moreno, 2003) • Brain life and brain death (Illes & Bird, 2006) • Empirical to normative claims (Glannon, 2006)

(Glannon, 2006; Häyry, 2010; Illes & Bird, 2006; Kehagia et al., 2012), which is using psychopharmacology to bring the brain toward a more normal state, or cognitive enhancement (Farah, 2004, 2005; Illes & Bird, 2006; Moreno, 2003), which is enhancing the brain beyond normal functioning.

Social considerations include aspects of neuroscience that pertain to social culture or the ramifications of social structure or policy. For example, neuroscience may be used to improve marketing and advertising campaigns (Farah, 2004, 2005) or relate poverty to neurodevelopment (Illes & Bird, 2006). How neuroscience findings are applied to social enterprises such as businesses or classrooms (Illes & Bird, 2006; Takala, 2010) apply here as well.

Lastly, philosophical considerations include neuroethical considerations of metaphysics such as free will and thought (Häyry, 2010) or notions of criminal responsibility (Takala, 2010).

Analysis of Empirical Papers

The analysis revealed three categories of neuroethics concepts that applied to the educational neuroscience research. The most prevalent neuroethics concepts were related to the scientific enterprise. Several neuroethics concepts in this category were relevant to all the empirical studies, regardless of the general purpose of the study. These included *statistical relevance*, *uncertainty of neuroscience*, *communication of neuroscience findings*, and *generalizing from groups to individuals*. A second category of neuroethics concepts that applied to the empirical studies related to prediction. *Pharmacological prediction* was specifically relevant to studies with the goal of predicting the effect of a pharmacological intervention on educational outcomes. *Brainotyping* was relevant to studies aiming to map the brain and to studies aiming to predict behavioral or educational outcomes based on neuroimaging findings. One concept that related to social issues—*the impact of neuroscience in the classroom*—was either directly or indirectly relevant to all the studies in the analysis.

In addition, the analysis surfaced a prominent fourth concept that is potentially unique to the intersection of neuroethics and educational neuroscience and as such was not represented directly in the neuroethics literature. This concept, which we call *brain-based justifications*, involves educational imperatives based on changes in the brain. We discuss each finding in more detail below.

The Scientific Enterprise

Generalizing from the neuroimaging laboratory to the classroom requires careful consideration. The tasks used in the educational neuroimaging research we analyzed often, by necessity, only slightly resembled actual educational challenges. For example, Froyen, Willems, and Blomert (2011) used stimuli of repeated /a/ and /o/ sounds to investigate the role of letter-speech sounds in dyslexia, and Trainor, Marie, Gerry, Whiskin, and Unrau (2012) used a repeated C on a piano to investigate whether infants' musical responses improved after a 6-month intervention; neither stimulus is typically found in authentic educational situations. We also found that generalizing from adult research to children may be of concern. For example, Cloutman et al. (2009) imaged adults with stroke damage in order to identify neural regions associated with deficits in spelling, and Beacher et al. (2012) used fMRI to examine sex-specific effects of autism on brain function in adult men and women.

The uncertainty of neuroscience is of particular concern in the educational realm, where scientific results are used to shape and support educational policy. Vuust et al. (2011) developed a faster Miss Match Negativity (MMN) paradigm to investigate the development of auditory skills and musical expertise. In their paper, the authors suggest "teachers could complement their behavioral test observations with fast ERP recordings, hence tailoring individual ear-training on the basis of individual neural aptitudes" (p. 1097). While the authors also caution against using event-related potentials (ERP) recordings as the sole basis for evaluation in musical education, their caution is related to the nature of music rather than to the uncertainty of neuroscience.

While communication issues were relevant in all the educational neuroscience studies we investigated, they may be especially important in research aiming to make predictions (e.g., predicting math performance based on brain activity 2 years prior [Dumontheil & Klingberg, 2012]) or support an intervention (e.g., comparing brain activation before and after a behavioral treatment for ADHD [Siniatchkin et al., 2012]). Some research topics may warrant special considerations related to communication of findings because of the sensitive nature of the subject. For example, de Zeeuw et al. (2012) used MRI to determine whether the brain characteristics of ADHD vary as a function of IQ. They compared children with ADHD with a control group of typically developing children and found that the basic relationship between IQ and neuroanatomy appears to be altered in ADHD. The authors stressed the importance of their findings for how variance in IQ is handled in neuroimaging studies involving ADHD. However, findings such as these could also influence how IQ and ADHD are handled in practical situations such as the classroom, and perhaps special consideration should be taken when communicating this type of research to the public.

Also relevant to all studies in the analysis is the distinction between neuroimaging results that apply to groups and results that apply to individuals. Neuroimaging research often relies on the statistical power of group results (e.g., an exception would be work on individual differences). Consequently, much of the neuroimaging research typically has more to say about a particular group of people than any individual, as there can be a great deal of variation within a group. This is particularly important to keep in mind when considering how to interpret educational neuroscience research that involves neuroimaging.

Prediction

Brainotyping is a relevant concern for some brain mapping studies, especially those attempting to provide a neurobiological marker or signature for a certain issue. For example, Araujo, Bramao, Faisca, Petersson, and Reis (2012) used ERP to compare brain responses during a reading task between typically developing children and dyslexics, in order to provide "a neurobiological signature for reading failure" (p. 79). They argued that neural markers of dyslexia remain consistent throughout development. Although authors of these studies often do not make explicit behavioral predictions, the step from neurobiological marker to behavioral prediction based on neuroimaging findings is certainly a small one.

Brainotyping was also the main ethical concern in the five studies in our cohort that aimed to predict behavior or ability based on brain structure or activity. Dumontheil & Klingberg (2012) used fMRI to predict math performance 2 years later based on working memory performance and activity in the intraparietal sulcus during a working memory task. Not only did they find that brain activity could predict future math performance, but they also found that imaging data correctly classified significantly more children as poor arithmetic performers than behavioral measures alone. Ethical considerations grow even more significant when labels (such as "poor arithmetic performer") are assigned or decisions made based on imaging results in the absence of behavioral differences, particularly considering the persuasiveness of brain data (e.g., McCabe & Castel, 2008).

One study in our analysis (Wong & Stevens, 2012) used a pharmacological intervention for ADHD to investigate brain activity changes after medication compared to placebo. Pharmacological prediction was therefore a present but not prevalent ethical concern in our analysis.

Social Considerations

As neuroscience is increasingly used to shape and support policy, the impact of neuroscience in the classroom is of general concern to all educational neuroscience. In educational neuroscience, we must by definition include this ethical consideration in every research study, every conversation, and every educational policy decision. The neuroethics concepts that fall under the *social considerations* heading (see Table 1) all apply to fairly specific topics or circumstances, so while some of the social considerations besides the impact of neuroscience in the classroom may apply to some educational neuroscience work, we did not find evidence of them in our analysis.

Brain-Based Justification

Brain-based justification was an ethical consideration that arose out of the empirical educational neuroscience literature we surveyed and may be unique to the intersection of neuroethics and educational neuroscience. Brain-based justification involves assertions about students' behavior or ability that are backed up with a specific finding from neuroimaging research (e.g., we should do *X* because it has Y effect on the brain). We illustrate this concept using four studies.

Trainor et al. (2012) used electroencephalography (EEG) to analyze the effect of a music class intervention on brain development in infants. Looking at musical enculturation, which they defined as the development of perceptual processing specialized for the musical system of a particular culture, they found a significant effect of the intervention, compared to a control class, on both brain response to music and on parent-reported social interaction scores. The authors concluded that infants can benefit musically and socially from early music classes, as well as that musical enculturation begins in early infancy. The brain responses they found could therefore be used to justify a push to begin participatory music classes early in infancy, and, while the authors did not suggest this, the intervention's effect on brain response could potentially be used to justify the use of the particular music classes in the study.

Siniatchkin et al. (2012) used fMRI to compare brain activation during a go/no-go task in an ADHD group and a control group before and after Response Cost and Token approach (RCT) training, a behavioral intervention program that had been shown in previous studies to have a positive clinical effect on ADHD symptoms. After the intervention, the children with ADHD had more pronounced cortical activation of brain structures related to response monitoring and self-control. As in Trainor et al. (2012), the brain response to intervention could be used to bolster the previously demonstrated behavioral effect and justify its use. The study's authors did not make this assertion; rather, they pointed out the limitations of the small sample size in their study and categorized their research as exploratory.

Hoehl, Brauer, Brasse, Striano, and Friederici (2010) used fMRI to investigate the neural processing of angry and happy facial expressions in 5- to 6-year-old children and adults. Importantly, they found brain differences between children and adults even when no differences in behavior were present. Brain differences such as these could be used to support a particular model or theory even in the absence of behavioral differences.

Using EEG, Strait, Hornickel, and Kraus (2011) found that neural sensitivity to regularities in speech provides a common biological mechanism underlying the development of music and reading. The authors suggest that, based on their neuroimaging findings, early childhood musical training might improve both musical and reading abilities. It is important to note that this study was correlational and not predictive in nature, so the authors' suggestion is premature here.

DISCUSSION

In this analysis, we distilled a set of neuroethics concepts and evaluated educationally related empirical neuroimaging studies against those concepts. We found particular ethical considerations across three broad categories in the neuroethics literature, in the realm of the nature of scientific investigation, in prediction, and in regard to the social consideration of the impact of neuroscience in the classroom. Additionally, we found a fourth ethical scenario arising from the aims of educational neuroscience work, here referred to as brain-based justification, in which neuroimaging findings from educationally relevant cognitive neuroscience work may be used to make authoritative statements about students' abilities or behavior.

Many of the ethical concerns that surfaced are in line with burgeoning dialogue in the educational neuroscience community. First, scholars have discussed the importance of communication, both in terms of findings (Howard-Jones & Fenton, 2012) and conversations between researchers and educators (Hardiman et al., 2012). Notions of overgeneralizing laboratory results to classroom contexts are prominent. It is important for researchers doing educationally relevant work to think about moving from laboratory studies and findings to the classroom context (Hardiman et al., 2012) and to guard against false generalizations (Ferrari, 2011). Additionally, the notion that laboratory studies can provide silver bullet solutions from the laboratory into the classroom—or put another way, from the researchers to the teachers—is unrealistic (Ansari, Coch, & De Smedt, 2011; Ansari et al., 2012). Lastly, recent conceptual work in the educational neuroscience community has raised issues of prediction, such as infant screening for risk of developing dyslexia (Howard-Jones & Fenton, 2012). This is particularly timely, considering the prevalence of prediction studies in educational neuroscience work in this analysis.

Of particular interest is the prevalence of brain-based justifications, which we exemplified using four of the articles in our analysis. In some articles, researchers made educational imperatives based on neuroscientific findings. For example, Strait et al. (2011) explicitly suggested that children should study music to improve ability in reading based on their finding that music and literacy aptitude both related to subcortical adaptation to regularities in ongoing speech. In other articles, the nature of the findings leaves the door open for others to justify educational claims with brain results. For example, a supporter of RCT training for ADHD could use Siniatchkin et al.'s (2012) neuroimaging results to justify its use. Several ethical questions arise from the fact that implications of educational neuroscience research may include authoritative statements for future action based on neural findings. At what level of analysis is change appropriate when considering evidence for the effectiveness of an intervention? Should the education community at-large be convinced by evidence of neural differences in the absence of behavioral differences, and if so, under what circumstances? Such questions relate to a similar quandary posed by Sheridan et al. (2005), who raised the issue of deciding what constitutes educational effectiveness for educationally relevant evidence-based products from the teacher perspective. The present case concerns a related researcher perspective, in which researchers need to think about what constitutes educationally relevant or educationally actionable findings. We argue that these considerations and questions need to be part of future educational neuroethics conversations.

This study contributes to a growing body of literature on educational neuroethics, yet has important limitations. The restricted scope of the included studies may emphasize some neuroethics concepts and downplay others. For example, by and large neuroimaging studies require a laboratory environment, ensuring that issues of generalizing laboratory findings to the classroom will be a prominent ethical social consideration that applies to all articles. This analysis was not an exhaustive literature review of educationally relevant cognitive neuroscience work; a different subset of such work may accentuate different concepts or surface additional concepts not found here. Despite these limitations, we believe that this analysis contributes a valuable perspective to the larger discussion about ethics in educational neuroscience research.

As argued here, ethics for educational neuroscience may in part come from those ethical issues that play out in neuroscience research. Ethical issues may also come in part from analogous ethical concerns in educational research (Sheridan et al., 2005; Stein et al., 2011). Yet, as noted above, a complete educational neuroethics would not merely be composed of subsets of ethical considerations in each respective field; rather, the joining of neuroscience and education involves unique ethical considerations both for research and application of findings (Howard-Jones & Fenton, 2012).

Many opportunities to further develop educational neuroethics exist. As noted above, ideas in educational neuroscience have so far taken on two general trends: the application of neuroscience findings to education and neuroscience work to be done in collaboration with educational stakeholders. Prior writing on ethical considerations has mostly concerned the former. Future work in this area can continue to examine ethical concerns that are raised based on different types of educational neuroscience research. One example is to further understand the relevant ethical concerns that have already been established in education and neuroscience, such as the type of empirical work analyzed here. Discovering the unique ethical concerns born out of the partnership between education and neuroscience, although, requires examining ethical considerations arising from collaborations among stakeholders in both fields. While this appears to be uncharted territory in educational neuroscience work specifically, related endeavors on the ethical considerations involved in and arising from MBE collaborations (e.g., Kuriloff, Andrus, & Ravitch, 2011) can serve as inspiration.

CONCLUSION

The recent popularity and promise of educational neuroscience to inform important educationally relevant questions necessitates a focus on the ethical issues that undoubtedly come along for the ride. Hypothetical scenarios, conceptual arguments, and evaluation of empirical research provide three angles from which to amalgamate ethical considerations that warrant attention as research moves forward. We hope that the lessons learned from this evaluation of empirical research from the neuroscience perspective will serve as a model, to be applied both to the field of educational neuroethics from additional viewpoints (e.g., ethical considerations based on the educator's perspective) and to other MBE endeavors (e.g., the role of genetics or epigenetics in helping to answer questions with educational implications).

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