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Defining the Boundaries for Neuroeducation as a Field of Study

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The interdisciplinary field of neuroeducation is built on the connections among neuroscience, cognitive science, psychology, and education in an effort to create a new science of learning that may transform educational practices. The future advancement of neuroeducation, however, is facilitated through clarifying its disciplinary boundaries as a field of study. To this end, a qualitative content analysis was employed to define the state and scope of the field in terms of its own discipline-specific terminology. Drawing on the results of the present study, neuroeducation can be defined as a broad interdisciplinary and multidimensional field concerning matters pertaining to mind, brain and education drawing on theories and methods from a range of disciplines. The main goal of the field is to investigate scientific and pedagogic bases of learning and education utilizing a variety of research methods that are currently used within all the contributing fields. The greatest challenges facing the field are the prevalence of misconnected

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or misinterpreted assertions and lack of a common language among researchers in the field. What is more urgently needed, however, is to train a new generation of professionals who will be able to generate new knowledge and critically evaluate concepts, assumptions, underlying theories and limitations in the field.

Keywords: *neuroeducation; interdisciplinary studies; mind, brain, and education science*

Introduction

Recent research in cognitive science and neuroscience and its relevance to educational theory and practice has provided significant advances in understanding the links among mind, brain, and education. This understanding consequently has led to the formation of a growing field of study that has been labeled by different names such as "Neuroeducation" (e.g., Ansari, De Smedt, & Grabner, 2012; Howard-Jones, 2011), "Mind, Brain and Education" (e.g., Fischer, Daniel, et al., 2007; Schwartz & Gerlach, 2011) or "Educational Neuroscience" (e.g., Campbell, 2011; Geake, 2009). In this study, we use "neuroeducation" to describe it as an interdisciplinary field which is built on the connections among neuroscience, cognitive science, psychology, and education in an effort to create a new science of learning that may transform educational practices.

Regardless of its name, this new academic field holds many attributes of a growing interdisciplinary field, even though it is still in its early stages. There are academic societies (e.g., International Mind, Brain and Education Society; NEnet at the University of Bristol), graduate programs (Harvard Graduate School of Education; Department of Education at Dartmouth College), special interest groups (e.g., Brain, Neurosciences and Education SIG of AERA; Neuroscience and Education SIG of EARLI) which all seek to support and promote the synergic interaction among mind, brain, and education.

There are also two professional journals (i.e., *Mind, Brain, and*

Education and *Trends in Neuroscience and Education*) devoted to bridge the gap between the increasing basic cognitive and neuroscience understanding of learning and the application of this knowledge in educational settings. It should be mentioned that the journal of *Mind, Brain, and Education* was recognized as the 2007 Best New Journal in the Social Sciences & Humanities by the Association of American Publishers' Professional and Scholarly Publishing Division (International Mind, Brain and Education Society & Wiley, 2013). In addition, there exists an increasing interest and emphasis on the role of this new field for a better understanding of education, development and learning (e.g., Ansari, De Smedt, et al., 2012; Battro, Fischer, & Léna, 2008; Campbell, 2011; Fischer, Daniel, et al., 2007; Fischer, Goswami, & Geake, 2010; Gardner, 2008, 2009; Geake, 2009; Stein & Fischer, 2011; Szücs & Goswami, 2007). All these reflect and exemplify the vitality and dynamic advancements of the field.

While the interdiscipline of neuroeducation is growing fast, it is also faced with a number of practical challenges, some of which are endemic to the emergence of any new discipline (Patten & Campbell; 2011; Schwartz & Gerlach, 2011). Patten and Campbell (2011) recount some of these challenges including: a need for more coherent terminology, a struggle to identify and establish theoretical and philosophical foundations, a quest for empirically based practical models, and a requirement for standards of ethical practice. Indeed, these are fundamental issues that need to be clarified for any field of study. Following his definition of social studies, Jack Nelson, the widely respected social scientist, noted that "our perspectives, political and educational, are colored by our definitions. Further, our concepts of quality and significance, whether in theory, scholarship, or practice, are based on definitional considerations; some things are valued more than others, depending on definition" (Nelson, 2001, p. 16). In fact, whether falling under the umbrella of natural science, humanities or social science, individual disciplines have their canons of practice, standards of scholarship, and associated paraphernalia, ranging from catalogs to conferences to textbooks (Gardner, 2009).

Similar to other interdisciplinary fields, neuroeducation needs to be defined in terms of its own discipline-specific terminology, theoretical and philosophical foundations, goals, topics, issues, and research methodology that distinguish it from other disciplines (Patten & Campbell, 2011). It would be fair to say that Tokuhama-Espinosa (2008) has already begun to address some of such issues. In her influential study, Tokuhama-Espinosa used grounded theory development to determine the parameters of the emerging field of neuroeducation based on a meta-analysis of the literature which was followed by a Delphi survey of 20 international experts. Her study culminated in a new model of the academic discipline of "Mind, Brain, and Education science," which explains the tenets, principles and instructional guidelines supported by the meta-analysis of the literature and the Delphi. Although Tokuhama-Espinosa's study clarified some important issues in the field, many issues and avenues of research are still to be further investigated. In particular, more research is needed to explore the broader nature and disciplinary boundaries of the field. Such research is important, especially that previous studies reported the prevailing enthusiasm in educational community for the bridging of neuroscience and education (Hook & Farah, 2013; Pickering & Howard-Jones, 2007; Serpati & Loughan, 2012). Although these studies represent the widespread interest among educators in the relevance of neuroscience research to educational practice, they also have shown that some educators extremely use a broad definition of neuroscience, which extended into research that would more properly be called cognitive psychology or educational psychology (Hook & Farah, 2013). Furthermore, a recent study showed that on average, teachers believed nearly half of the neuromyths, particularly myths related to commercialized educational programs (see Dekker, Lee, Howard-Jones, & Jolles, 2012). This demonstrates the need to enhance teacher professionalism and training programs to reduce such misunderstandings in the future. It is therefore concluded that an understanding of the state of neuroeducation must be an important consideration when designing

effective professional development programs for teachers and the next generation of neuroeducators.

Thus, this study aimed to define the disciplinary boundaries of neuroeducation, particularly with the focus on opportunities and challenges facing this growing field. This study has the following potential benefits. In the first place, it will facilitate a common language and terminology among educators and neuroscientists and with the broader scientific community. Second, it will encourage the development of new theoretical models, methodologies and tools necessary to address the many challenges facing the field. Finally and perhaps more importantly, it will equip educational practitioners and policymakers with a practical framework to integrate courses on neuroeducation into their current educational studies and teacher education programs.

Methodology

As mentioned before, the purpose of this study is to define the boundaries of neuroeducation as a field of study. To this end, qualitative content analysis (conventional approach) was employed to address the fundamental questions about the state and scope of the growing field of neuroeducation. Conventional content analysis is generally used with the study design that aims to derive key concepts and themes directly and inductively from study participants without imposing preconceived categories or theoretical perspectives (Hsieh & Shannon, 2005).

Participants were selected through snowball sampling technique. Snowballing, also known as chain referral sampling, is a type of purposive sampling that "involves getting research participants to direct the researcher to other potential participants" (Scott & Morrison, 2006, p. 221). Snowball sampling in this study was used when representation from diverse communities was needed, and because it was impossible for the researchers to include a representative of each community (Sadler, Lee, Lim, & Fullerton, 2010). In the beginning, four experts were purposefully identified as the primary participants based on their

strong experiences and noteworthy publications in the field. These experts were the directors of graduate programs for Neuroeducation (Mind, Brain, and Education) who have had both theoretical and practical contribution in advancing the field. While answering the questions, they were also asked to refer other people potentially fit for the study requirements and then, the survey was followed up with these new people. This method of referrals continued until each newly introduced expert has already been identified.

In this way, 27 of 42 experts accepted the invitation to participate in the study. Three participants were excluded, because they did not answer the main research questions. Eventually 24 experts completed the study and were included in the data analysis. The demographic characteristics of these research participants are shown in Table 1.

Data were collected through an email survey over a span of about 9 months between March 2011 and December 2011. To collect the data, the study employed an open-ended questionnaire that allowed participants a considerable amount of time to think about answers before responding and greater freedom of expression on the controversial aspects of the field. The questionnaire was modified and validated by a panel of five educational professionals. The first part of the questionnaire included four items about demographics (highest degree, rank, discipline and institution). The second part of the questionnaire asked respondents about the following aspects of neuroeducation: (a) its scientific and philosophical foundations, (b) its most important goals, (c) the main themes or topics studied in this field, (d) the specific research methods and procedures applied in research, and (e) the most important issues (difficulties) it is now facing. Participants also had the opportunity to add comments describing their experiences and clarifying their responses to open-ended questions. The third part asked participants to refer other people potentially fit for the study requirements. The questionnaire was sent to the experts with a cover letter explaining the nature and objectives of the study. They were also informed that their responses would be confidential.

Table 1: Demographic Characteristics of Research Participants

Participant	Discipline	Rank
1	Education	Associate Professor
2	Neurology	Professor
3	Education	Professor
4	Psychology	Professor
5	Cognitive Neuroscience	Professor
6	Psychology	Assistant Professor
7	Education	Associate Professor
8	Education	Professor
9	Psychology	Professor
10	Psychology	Professor
11	Education	Assistant Professor
12	Cognitive Neuroscience	Professor
13	Psychology	Professor
14	Cognitive Neuroscience	Associate Professor
15	Education	Assistant Professor
16	Psychology	Associate Professor
17	Education	Associate Professor
18	Education	Professor
19	Psychology	Professor
20	Education	Professor
21	Biology	Professor
22	Education	Professor
23	Education	Professor
24	Psychology	Associate Professor

The procedure of conventional qualitative content analysis approach (Hsieh & Shannon, 2005) was employed for analyzing and categorizing the collected data. The analysis began with reading each record several times to gain familiarity with the text as a whole. Then it was to examine the data in detail to develop initial codes. Once all records were coded and broken down into discrete codes, the next step was to apply these codes to the whole set of data and group them into a set of key concepts. The emerged concepts were then labeled with a set of themes. For example, responses such as "all the processes related to learning and teaching," "it is difficult to exclude any topics, since education is so much more than learning to read and write" and "all processes relevant to education can be studied within the field" were placed under the category of "the scope." It is important to note that some of the survey

participants did not respond to every item, so the number of responding participants for each item differed.

It is the process through which pieces of information were grounded in the actual data and generated from the participants' unique perspectives. Peer debriefing (Guba, 1981) were employed to test out the process of analysis and conclusions with colleagues outside the study context. Authentic citations also have been included to increase the trustworthiness of the research and to point out to readers from where or from what kinds of original data categories are formulated (Patton, 1990).

Results

Data analysis was conducted to extract codes, concepts and themes by qualitative content analysis. Subsequently, seven main themes were extracted and labeled as: disciplinary pillars, philosophical basis, the goals, the scope, research methodology, the challenges, and the priorities. Each theme will be described separately in the following sections.

Disciplinary Pillars

The participants (n = 24) collectively defined neuroeducation as a broad interdisciplinary and multidimensional domain concerning matters pertaining to mind, brain and education; it is grounded in a variety of interrelated fields including (but not limited to) education, neuroscience, psychology, and cognitive science. For example, two participants stated:

> We are speaking about a broad multidisciplinary and multidimensional domain. It is characterized by the fact that neuroscience, educational science and behavioral science give basic input into the domain.

> The scientific foundations are primarily in the fields of education, psychology and cognitive neuroscience … of course other fields such as linguistics, and philosophies also contribute.

For better understanding of learning and derivation of valid educational implications and principles in practice, seventeen participants emphasized on the necessity of convergence between all contributing disciplines. Drawing on theories, knowledge and methods from a range of disciplines, they stressed that neuroeducation is a multidisciplinary field that moves beyond basic and applied research. For example, one participant insisted that:

> The field is grounded in empirical science and the scientific understanding of human cognitive and social functioning. The principal idea is that these sciences can be brought to bear on problems in education.

Fourteen participants more explicitly stated that each of these disciplines and the knowledge they generate should be treated as equal, as indicated by the statements below from two participants:

> It is also possible that educators can inform brain science by suggesting educational issues that could be illuminated by brain study.

> As important as it is to find ways in which the neurosciences can inform education, this relationship should not remain asymmetrical: it is of equal importance to find ways in which the social and humanistic aspects of education can inform the neurosciences.

While there was a general consensus among experts regarding the nature of the field and the necessity of convergence between all contributing disciplines, their responses regarding the name of the field showed relatively few but serious disagreement. Indeed, four participating experts complained about the name we used to describe the field and insisted to change it to "Mind, Brain and Education," while some others pointed out:

> First, let me say that another term that is used here in the US for this field of inquiry is *Educational Neuroscience*. Those of us who use this term believe it more accurately describes the nature of this endeavor.

This study also indicated that whether and how education can be informed and enhanced by an understanding of neuroscience is still an

open question. For instance, one of the invited experts who didn't respond to the research instrument replied critically:

> The so-called field of *neuroeducation* is based on serious misconceptions about what neuroscience is and what it can contribute to education. Neuroscience might make contributions in defining the problems and needs of special populations, but has nothing to contribute to solving instructional problems in the classroom. The best outcome for educational practice would be for neuroeducation to disappear and devote scarce resources to cognitive and developmental studies that are relevant to teaching and learning.

However, all participants who responded to the research instrument did not share this view. Two experts called attention to this directly in these ways:

> Whether education can be informed and enhanced by an understanding of neuroscience is still an open question. (We might end up reinventing the wheel or even rejecting the study of the brain, as relevant to education). But I would not myself be devoting time to this field unless I believe that it would ultimately prove useful to educators.

> The brain is central to learning. Everything we do changes the brain. Education is one of the most powerful tools devised to change the brain. Neuroscientists study the brain. Hence neuroscientists should contribute to the study of education.

Philosophical Basis

Only eleven participants answered the question about the philosophical basis of neuroeducation. According to them, the philosophical basis for this field rests in the modern versions of "pragmatic philosophy," as the following statement illustrates:

> Looking back at thinkers like John Dewey can help us place our research to address pragmatic questions and to teach children how to see the world like scientists and use their training in pragmatic ways.

Some participants implicitly described the philosophical underpinnings of neuroeducational research from an "embodied perspective of mind," as illustrated by the statements below from three participants:

> Biological processes are relevant to mental functioning, and that it is possible to hypothesizing the relation between mind and body.
>
> The mind-body problem undergirds this movement which has important consequences either in science or in education.
>
> Note that this requires an understanding of the brain that goes beyond cognition to include emotion and motivation essential for framing problems, analyzing situations and seeking solutions.

Thus, it could be mentioned that the interdisciplinary research in the field of neuroeducation will encourage the development of novel theoretical frameworks of understanding the interrelations among mind, brain and education. However, it still faces formidable methodological and philosophical challenges, as one participant called attention to this directly in this way:

> Providing a coherent account of the nature and relations between the physical and mental worlds has proven to be notoriously difficult. Hence, beyond a "whatever works" pragmatism, as important as such criteria are for educational policy makers, there remains a bona fide problematic in establishing philosophical foundations for any field seriously attempting to bring intellectual coherence to integrating the neurosciences and education.

The Goals

According to the survey participants (n = 24), the two sets of theoretical and practical goals are the primary goals for the field to follow.

The theoretical goal of the field is to integrate theories, models, methods and results of research in neuroscience, cognitive science and psychology with studies in education to provide a more coherent picture

of learning, development and education. This can be concluded from the following statements:

> Neuroeducation seeks to apply an understanding of the networks of attentional, cognitive, emotional and motivational networks of the human brain (achieved via links of neural networks to psychology and development) to enhance the contributions of education to human growth and development.
>
> To analyze and characterize the relative contribution of biological, psychological, psychosocial and cultural factors in their impact on the development of the individual (child, youth, adult, teacher, parent).

The main practical goal of neuroeducation is to create more effective teaching methods, curricula and educational policies based on the knowledge produced from the synergic interactions between neuroscience, cognitive science, psychology, and education. For example, two participants reflected:

> One important goal of the field is to use in the classroom, in a principled manner, what we know about learning and development from scientific research.
>
> The practical goal of the field is to develop procedures and interventions to aid teachers, parents and schools (and our society) and to improve development of our children in a broad sense.

Taken together, neuroeducation seeks to provide an integrated perspective of learning and development that will not only contribute to advance the scientific knowledge about the nature of learning and development but also to inform the improvement of education policy and practice.

The Scope

Based on the responses from experts participating in the present survey (n = 24), the broad theme which could be studied by neuroeducation is study of the nature of learning, development and education and how to

create more effective curricula, teaching methods, and educational policies. For example, two participants stated:

> I do not perceive a limit on the topics or themes that are or could be studied under the auspices of MBE [Mind, Brain and Education]. Any topic or theme involving learning, teaching, or development would seem to be compatible with an MBE approach.
>
> It is difficult to exclude any topics, since education is so much more than learning to read and write …

More specifically, we can say neuroeducation is concerned with an understanding of:

- the neuro-social-cognitive origins of developmental disorders and learning disabilities and the effects of interventions targeted to these problems (n = 20);
- the neuro-social-cognitive bases of learning of specific abilities such as language, reading, writing, math, science, art and numeracy (n = 19);
- the nature of representing the learning, memory, perception, intelligence, reasoning, emotion and development in the brains and minds of students (n = 18);
- the process of developmental changes and their affects on social, physiological, cognitive and emotional processes (n = 18);
- the neuro-social-cognitive bases of individual differences in learning and development and educational implications (n = 14);
- the challenges arising from emerging neuro-ethical issues (neuroscience of ethics and the ethics of neuroscience) in the field (n = 11).

Research Methodology

According to the experts participating in the present study (n = 20), a variety of research methods (laboratory, quantitative, qualitative, and mixed approaches) currently used by the contributing fields could be applied in neuroeducational research. Thus, researchers in the field

will need to learn a combination of methods and procedures that are currently being used as well as developing new ones that might emerge with their scholarly progress. For example:

> I believe that any of the research methods from the contributing fields … both qualitative and quantitative methods have roles to play … can be applied within the scope of MBE research.

> Neuroeducational research should include a variety of methods that are currently used within neuroimaging, psychology and education. This includes a broad range of methods in all contributing fields.

Although these methods are not specific to the proposed field, according to one participant:

> The specificity lies in combining both categories of methods, e.g. relate [relating] measures of brain activity with (behavioral) measures of school performance.

Seven experts mentioned some limitations of neuroimaging technologies and emphasized that although these techniques offer exciting insights to neuroeducators, they complement rather than replace educational and social research methods. For example, two experts stated:

> Neuroimaging data are usually collected in very controlled and isolated laboratory environments and it will be crucial to connect these to more ecologically valid measures of classroom learning. For example, learning in the classroom involves interactions with other learners and this should be linked to the data collected in the laboratory settings.

> There [It] is necessary to go beyond correlational data (identification of neural processes occurring during learning activities; correspondences between brain areas and mental functions-operations processes) in order to identify possible causal relations.

The Challenges

According to a majority of participants (n = 22), the greatest challenge facing neuroeducation might be categorized in two important and

interrelated issues. The first was related to the prevalence of a number of oversimplified or misinterpreted assertions which have come to be labeled "neuromyths." A majority of participants (n = 18) believed that neuroeducation has the urgent goal to disengage from these "neuromyths" and the "misconnected" or "misinterpreted" claims that are so common today in schools. One expert expressed her concern in this manner:

> Taming of the shrew … meaning taming the eager educators who are desperate to translate brain research into classroom practices. That unbridled exuberance is why the educational field is wrought with overgeneralizations, misconnections and lingering myths about the brain and learning.

The second main concern of participants (n = 16) was related to the diversity in the definition of neuroeducational concepts and the lack of a common language among researchers in the field. For example, two experts stated:

> Major difficulty is the lack of a common language. Many problems in the communication between disciplines in neuroeducation are in my view the consequence of semantic problems … This makes it difficult for teachers and other practitioners to get to sound information.

> It is necessary to develop a common language for educators and neuroscientists and identify common ground to increase mutual trust.

Some participants (n = 13) explained the origins of such difficulties and attributed this to the low levels of scientific literacy among education researchers, as the following statement illustrates:

> Too many teacher training institutions are not even considering such a move, either because they are not convinced that there is a connection between neuroscience and pedagogy, or because they have no one on the faculty competent to teach such a course.

The Priorities

All participants in the study (n = 24) answered to the questions related to this theme. Twenty-two of them agreed on the need to develop curricula

and establish institutions that focus on training of students who will be leaders in the future of neuroeducation. They thus recommended persuading schools of education to include courses on neuroeducation in their educational science and teacher preparation programs:

> There is a need to train a new generation of researchers who are specifically trained in both neuroscience and education [and] who are familiar with the design constraints of neuroimaging research but at the same time understand the complexity of the learning environment and the subtleties of teaching.

As the second priority, twenty participants suggested close collaboration and communication between experts of contributing fields. They insisted that true collaborative work, possibly modeled on action research or design of experiments, involving scientists, educational researchers and teachers needs to be encouraged. As one expert mentioned:

> Another important issue is collaboration and conversation — it is not enough to have scientists and researchers and university scholars at the table talking about what needs to be studied, but we must have equal input from teachers, school administrators, and practitioners as part of the dialogue that is central to the field.

The need to expose the "neuromyths" was the third priority that sixteen participants mentioned. They defined neuromyths as false claims arising from overgeneralizations and misconceptions about the brain and learning as well as inappropriately advertised commercial products. In the words of one expert:

> Neuroeducation has the urgent goal to disengage from the neuromyths and the medicalization trend that is so common today in schools, what I call the "neurologist" bias.

Additionally, six participants advocated developing laboratory schools in which researchers and practitioners could formulate research questions and methods to investigate the problems coming out of educational policy and practice. According to one of these participants:

> … also new "research schools" should follow the successful model of research hospitals, where clinical investigation is done in situ. The same will happen with neuroeducational research in research schools.

Discussion

The primary purpose of this study was to define the scope and boundaries of neuroeducation as a field of study. The results of this study might be of interest to educators, teachers, psychologists, neuroscientists, and specifically to faculty and program directors who need to be aware of the realm and scope of the field. Findings from the current study not only agree with previous research but also expand and add to it, contributing to a more nuanced understanding of the scope and boundaries of the interdisciplinary field of neuroeducation. This is of particular importance in light of previous findings reported in Tokuhama-Espinosa (2008) regarding the parameters of the emerging field of neuroeducation. However, there are some points of inconsistency which need more consideration. While Tokuhama-Espinosa's study culminated in a new model of the independent academic discipline (so called "Mind, Brain, and Education science"), the result of our study showed that one of the most controversial concepts among experts is their concern about the term used to describe this emerging field. In the relevant literature, some experts in the field prefer the term Mind, Brain and Education, which they see as being more pedagogically focused (Schwartz & Gerlach, 2011). Some others see "neuroeducation" as more akin to an education science and thus prefer the term (Campbell, 2011; Howard-Jones, 2011). They believe that this better reflects a field with education at its core, uniquely characterized by its own methods and techniques, and constructing its knowledge based on experiential, social and biological evidence (Howard-Jones, 2008, 2011).

Following Campbell (2011), we believe that the term "neuroeducation" encapsulates anything that involves some kind of rigorous synthesis concerning matters pertaining to mind, brain and education quite well. In this view, "educational neuroscience" can be

considered "as a new area of *educational* research, and one that naturally draws on the neurosciences (especially cognitive neuroscience, including psychophysiology), and yet one that falls within the broader emerging *field* of neuroeducation" (Campbell, 2011, p. 8). Neuroeducation in this sense can be described as growing energy behind linking education, psychology, cognitive science and neuroscience in an effort to improve learning theory and educational practice.

This study also indicates that while there is no reputable debate over the significance of neuroscience for education, there is a little controversy over the possibility of linking neuroscience to educational practice. Bruer (1997, 2006) is one of those who started his criticism on making any direct link between neuroscience and education from more than one decade ago. Bruer argued that it is too early to think about the applications of brain science for educational practice and the bridge between neuroscience and education is too far. He proposed "cognitive psychology" as a potential link which can bridges the gap between them.

Indeed, there is no reputable debate over the significance of cognitive psychology for education, but we cannot neglect the broad usefulness of brain science and a vast amount of brain research of direct relevance to education practice and policy (Blakemore & Frith, 2001; 2005). In the words of Goswami (2008), "cognitive neuroscience is important for education because it enables a principled understanding of the mechanisms of learning and of the basic components of human performance" (p. 396).

The other major issue mentioned repeatedly and by more participants was the lack of a common language among researchers in the field. It is clear that the lack of a common understanding on the fundamental terms not only increases the risk of misunderstanding and overinterpretation of information in translation (Devonshire & Dommett, 2010; Howard-Jones, 2011), but also undermines the efforts of practitioners and researchers to solve the complexity of educational issues. Therefore, it is generally accepted that developing a common language as the basis of systematic interactions between researchers

from different disciplines is a challenging and ultimately necessary part of interdisciplinary research.

Besides the diversity in definition and the lack of a common language, considering the greatest challenge facing neuroeducation, the participants in this study emphasized the need of training a new generation of researchers and educators who will be able to generate new knowledge and critically evaluate concepts, assumptions, underlying theories and limitations in the field. The fact is that, today teachers and students of educational sciences are not trained to become adequately familiar with the potential contribution of neuroscience to educational thought and practice. For this reason, they lack insights into neuroscientific theories and their methodological approaches. On the other hand, neuroscientists are largely unaware of the current pedagogical approaches used in schools and, therefore, lack an actual overview of what is being taught in school, how this is taught, and what expectations are being set by curricula. Therefore, it is important to devise strategies to improve the professional development of both neuroscientists and educators working in the field (Ansari, Coch, & De Smedt, 2011; Ansari, De Smedt, et al., 2012).

The participants in our study also strongly advocated "interdisciplinary collaboration" as the key to ensure a more prosperous future for neuroeducational research. The interdisciplinary nature of neuroeducational studies implies conjoining a variety of perspectives and insights from relevant disciplines into a unified or coherent framework to solve complex problems that their solutions are beyond the scope of a single perspective or discipline. This specific structure of the field augments the need to build an infrastructure that supports sustainable collaboration between researchers and teachers and creates a strong research foundation for education (Hinton & Fischer, 2008).

Finally, it should be mentioned that the participants in this study collectively emphasized the need to expose false claims and inappropriately advertised commercial products as well as neuromyths and psychological myths. Indeed a recent study validates the participants' concerns about the proliferation of neuromyths in the field of education

(Dekker et al., 2012). The results of this study show that teachers who are highly interested in brain research are susceptible to neuromyths. It might partially be due to the persuasive and fascinating nature of brain research wherein explanations of psychological phenomena seem to generate more public interest when they contain neuroscientific information, even when neuroscience added nothing in support of the arguments presented (McCabe & Castel, 2008; Weisberg, Keil, Goodstein, Rawson, & Gray, 2008). These data lend support to the notion that part of the fascination, and the credibility, of brain imaging research lies in the persuasive power of the actual brain images themselves (McCabe & Castel, 2008).

However this does not mean that there is nothing new in brain research for educational theory and practice. While this is still the case that research in neuroscience has been educationally misinterpreted and/or overgeneralized in some cases, it is fair to say that research in the neurosciences can and will be a valuable informative source to educational theory and practice in a number of different areas. The majority of research in this area has centered on specific learning difficulties where education of a large number of children is affected by these difficulties such as dyslexia (Eden & Moats, 2002), dyscalculia (Rousselle & Noël, 2007), and ADHD (Tallal et al., 1996). There are also a number of studies that have dedicated to specific abilities such as language (McLaughlin, Osterhout, & Kim, 2004), reading (Dehaene, 2009), and mathematics (Lee & Ng, 2011). It is clear that the broader issues such as general principles and strategies which "are more usable for teachers" (Serpati & Loughan, 2012) also need to be considered. However, in recent years there has been an increasing awareness and acceptance of the need for research in this area. Most notably, Goswami (2008), author of several studies involving "mind, brain and education," has summarized the potential role and the use of neuroscience research in education into a set of six principles of learning demonstrated by empirical studies that can safely be incorporated into education and teaching.

Conclusion

Based on the results of this study, neuroeducation can be defined as a broad multidisciplinary and multidimensional domain concerning matters pertaining to mind, brain and education. It aims to introduce and investigate scientific and pedagogic bases of learning and education using a variety of research methods that are currently used within all the contributing fields. The greatest challenge facing neuroeducation is the prevalence of neuromyths arising from overgeneralizations and misconceptions about the brain and learning as well as from inappropriately advertised commercial products. The second main concern is related to the diversity in the definition of neuroeducational concepts and the lack of a common language among researchers in the field. What is needed more urgently, however, is to train a new generation of professionals who will be able to generate new knowledge and critically evaluate concepts, assumptions, underlying theories and limitations in the field.

The snapshot presented in this article is promising but defining the state and boundaries of neuroeducation requires further investigation. This study could be conducted again with a larger group of experts, giving an opportunity to determine if the outcomes of the current study represent the scope and boundaries of the field. Also, based on the responses from experts in various fields, future research could be investigated whether and how neuroeducation can be distinguished from other related fields such as educational psychology, educational neuroscience, and cognitive neuroscience.

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