Neuro-education
The Myths and Realities

Kuheli Mondal *
K. Chellamani**

Abstract

Neuro-education being a relatively new discipline is faced with many obstacles, which are termed as 'neuromyths' in the teaching-learning practice. The present paper speaks about the prevalence of neuromyths in the minds of teachers and educationists. It mainly deals with the myths, which act as a hindrance in the effective functioning of the education system, and how these are said to be discarded by different researchers to be just named as neuromyths and not reality. Hence, it can be concluded that neuromyths are superfluous, which create misconceptions.

Introduction

The evolving field 'neuro-education' referred to as 'mind brain education' or 'educational neuroscience' has become one of the key talking points in the present teaching-learning scenario. Neuro-education is an emerging scientific field that includes cognitive neuroscience, developmental cognitive neuroscience, educational psychology, educational technology, educational theory and other related disciplines to explore the interactions between biological processes and education. It is an interdisciplinary field that intends to create improved teaching methods and curricula by combining neuroscience, psychology and education. Neuro-education believes that as neuroscience is essential for the progress of science, it will also give education a firmer

* *Research Scholar,* Pondicherry University, School of Education, R.V. Nagar, Puducherry–605014.
** *Associate Professor,* Pondicherry University, School of Education, R.V. Nagar, Puducherry–605014.

empirical basis and help in bringing out appropriate pedagogical reforms. Nouri (2013) defines neuro-education as a "growing interdisciplinary field based on synergetic connection between neuroscience, cognitive science, psychology and education in an effort to improve our theoretical and practical understanding of learning and education". Neuro-education investigates some of the basic processes involved in learning to become literate and numerate, but beyond this, it also explores learning to learn, cognitive control and flexibility, motivation, as well as, social and emotional experience.

Neuro-education helps in creating improved teaching methods and curricula. It is moving closer to prime time as researchers gain more sophisticated understanding of how young minds develop and learn. It helps to explore how children learn and what practices promote and sustain learning problems. It also allows how brain works and where learning takes place by offering a variety of techniques that may teach teachers to improve children's learning capacity. Neuro-education is also referred to as the application of findings of the language of cognitive neuroscience to educational questions and problems.

It is a welcome move that teachers in educational institutions are becoming aware of the application of neuro-education. Even the educational system includes neuro-education in its curricula. It is reverberated in NCF–2005 and NCTE–2009. Though a group of teachers have started applying neuro-education in their pedagogical platform, the loud spoken 'neuromyths' stand as a barrier in accomplishing the focus. It leads to building a gulf between neuroscience and education. Neuromyths were found to be prevalent among trainee-teachers as well (Howard Jones, et al. 2009). The educational scientists have already started working on the 'neuromyths'.

Neuromyths

Neuromyths are generally defined as false ideas, beliefs, interpretations or extrapolations that have permeated the opinions of people, though they have been invalidated by neuroscience. The common misconceptions, misunderstandings, misreadings, which deliberately warp scientifically established facts is coined as 'neuromyths' by the Organisation for Economic Cooperation and Development (OECD) (2002). The delusions which are acting as a barrier in changing and improving education can be termed as 'neuromyths'. The popular media is responsible for creating such misconceptions (Wallace, 1993; Beck, 2010). The OECD's Brain and Learning Project (2002) emphasised on the concept of 'neuromyths' that create a number of misconceptions among educationists and professionals, leading to adverse effects on educational practices. The neuromyths, which act as hindrance for improving the teaching methods and curricula in the educational

system, are many. The neuromyths mentioned by the OECD (2002) and others are:

Neuromyth 1: People Use Only 10 per cent of the Brain

Wanjek (2002) says the idea that "we use only 10 per cent of the brain" is one of the most popular myths in neuroscience. But with the development of newer and more sophisticated tools by neuroscientists to look at brain function, they found that the cortex is far from 'uncommitted'. Marcus Raichle, a neuroscientist at the Washington University in St. Louis and a member of the Dana Alliance for Brain Initiatives (DABI), was one of the first scientists to find that our brain works full capacity even during rest. Since then, neuroscientists have accepted that the brain has a so-called 'default mode', a sophisticated network of areas that remains active even while resting. According to Beyerstein (2004), researchers have conducted millions of studies related to the brain and no one has ever found an unused portion of the brain. In 2003, Nyhus and Sobel remarked, "It is unfortunate that teachers are constantly subjected to such pervasive nonsense about the brain, so it is worth pausing to investigate the various sources of the '10 per cent myth' (Beyerstein, 1999 and OECD, 2007). Science has shown that although people can live with severe trauma, this does not confirm the existence of 'useless areas' and that all areas in the brain have a known function. It is interesting to note that once Albert Einstein underlined the existing neuromyth and it attracted the attention of educational scientists.

Neuromyth 2: Hemispheric Dominance

The idea of hemispheric dominance came from the study 'split-brain' undertaken by Roger Sperry, Joseph Bogen and Michael Gazzaniga (1965). Ninety-one per cent of the teachers believe that the difference between the left hemisphere and right hemisphere creates individual differences among learners. The neuromyth 'left-brain versus right-brain' probably has its basis in studies of hemisphere specialisation (e.g., the left hemisphere subtends language processes and the right hemisphere is implicated in spatial awareness). The hemispheric differences do not exist but the brain function should be considered as a whole (Geake, 2004). Neuro-imaging studies have also clarified this issue by showing that both the hemispheres work together and are always involved in all cognitive tasks (Goswami, 2004). Kurt W. Fischer (2009) in his article, 'Mind, Brain and Education: Building a Scientific Groundwork for Learning and Teaching', talks about two boys named Nico and Brooke. Nico had to remove his 'right hemisphere' to prevent the recurring of severe epileptic seizures when he was three years old. According to neurologists, people without 'right hemisphere' will have poor visual-spatial skills

and those without 'left hemisphere' will have poor intonation in speech. Brooke at the age of 11 years had to remove his 'left hemisphere' due to severe epilepsy. The results revealed that despite Nico did not have the 'right hemisphere', he was able to perform some skills better with the help of his family members. He was able to perform certain visual-spatial skills, such as physical activities and drawing. Brooke, even after getting operated upon, was unable to speak. After a certain period, he became skilled at both speech and reading. In his article, Kurt W. Fischer (2009) said despite their loss of hemisphere, they functioned well in school and family, and also became almost normal in their educational skills. So, according to researchers, neither hemisphere is solely responsible for one type of personality.

Neuromyth 3: VAK Learning Styles (Visual, Auditory and Kinaesthetic)

Despite its lack of evidence, the educational community has been flooded with information concerning a multi-sensory model called VAK learning styles (Dunn, Dunn and Price, 1984). According to this model, visual learners learn better through pictorial information, so showing diagrams and colour images to them will allow stronger memory traces due to crossed modular learning; auditory learners acquire knowledge by storing sounds; and kinaesthetic learners are more successful if they do things practically by means of body movement. Strictly following a VAK regime appears to bring dilemmas to the teacher, for example, what should be done with 'V' and 'K' learners in a music lesson? (Geake, 2008). Clearly, it is a simplistic model and requires further research as there is no data showing an educational advantage of teaching in the preferred learning style. As pointed out by Howard-Jones (2008), neuroscience or any other science has, so far, not found support for the educational value of categorising learners by their sensory modality or any other type of learning style.

Neuromyth 4: Myths about Multilingualism

Neuromyth 4 (i): It is impossible or difficult to achieve competency in a foreign language after a certain age

It is often heard that it is difficult to learn a new language after attaining a certain age. Certain researches have also shown that there is a particular time referred to as 'critical periods' in one's life when one can learn skills and abilities, such as second language more effortlessly and completely. If these experiences happen to be absent or occur later in the course of human development, it will be impossible for a child to ever acquire those skills and abilities (Blakemore and Frith, 2005; OECD 2007; Worden, Hinton and Fischer, 2011). It is never too late to learn a foreign language. Goswami (2008) implies that if a particular ability is the best forever, the 'biological window' for that ability

is missed. Moreover, no evidence supports 'biological critical periods' for acquiring non-native languages (Bruer, 1999; Worden, Hinton and Fischer, 2011). They say neuromyths rest on a static conception of the brain, which they know to be false. The fact is that the brain can adapt to any environment and is capable of learning throughout the lifespan as it is plastic and that educational rehabilitation in adulthood is possible and worth investment (Blackmore and Frith, 2005). The brain's plasticity is of two types. They are — 'experience-expectant' and 'experience-dependent'. the OECD (2002, 2007) says experience-expectant learning takes place when the brain encounters the relevant experience, ideally at an optimal stage of development. These periods are also known as 'sensitive periods' or 'windows of opportunity' because they are the optimum movements for individuals to learn specific skills, such as oral language. They take place with natural development but experiences are required to make the learning more effective. 'Experience-dependent' is just the opposite, which takes place at any moment in an individual's life.

Neuromyth 4 (ii): Exposing children to foreign language interrupts knowledge of the first language

Another misconception is introducing a foreign or second language when a child has learnt the first language as it interrupts his/her language development and creates confusion. So, it is better to speak the native language until high school (Frey and Fischer, 2013; Petitto, 2009; OECD, 2007). The false inference is that the native language had to be grasped 'correctly' before learning another language (OECD, 2007). Though children are found to have problems in learning a second language in school, it is found that some educational systems expose them to foreign language too early. This helps them to avoid difficulty in learning a foreign language. De Jong, et al., 2009; Petitto, 2009. OECD (2007), in its research, found that human beings can have strong command in more than one language at a time, and hence, it is stored in areas far from the area reserved for languages. Hence, children, who are exposed to the two languages at an early stage, do not get weaker in the first language, but are able to grasp the fundamentals of both the languages (Petitto, 2009). The OECD (2007) says when the second language is acquired early, multilingual education does not lead to a delay in development. Hence, the myth is counteracted by studies showing that children who have mastery in two languages can understand the structure of each language in a better way and can apply them more consciously.

Neuromyth 4 (iii): It is impossible to learn a second language while sleeping

The history of research speaks that sleep is one of the primary sources of learning throughout one's lifespan.

Research on the role of sleep in memory functions, especially to memory consolidation (Peigneux, Laureys, Delbeuck and Maquet, 2001) often cited as evidence in support of the idea that foreign language learners are able to learn English during sleep. The OECD (2007) implies that the act of learning always begins with an unconscious process and it is more efficient during sleep than while being awake. Though there is evidence that sleep plays a significant role in the development of the functioning of the brain and memory, some individuals are capable of problem-solving while they are a sleep, but new researchers, Arzi, et al. (2012), argue that sleeping participants can form a link between a particular tone and a pleasant and an unpleasant smell. They added that it is also possible to acquire a simple association while being asleep, but learning more complex skills, like new language, cannot be acquired while sleeping as one needs to consciously memorise numerous new words and their meanings, develop a learning strategy and continuously restructure the newly acquired information in a fashion coherent with the pre-existing knowledge base (Peigneux, Laureys, Delbeuck and Maquet, 2001).

Neuromyth 5: High Consumption of Water Enhances Learning

No direct evidence or link has been found that high consumption of water will help enhance learning. Though 'brain-based' learning programmes have promoted drinking plenty of water as it helps improve learning. Howard-Jones (2009) ensures that children drink at least six to eight glasses of water. The fact that it helps prevent the brain from shrinking is not supported by neuroscience. Though dehydration restricts proper cognitive function of the brain, the myth speaks that encouraging children to drink extra water will lead to better learning. Howard-Jones (2010) says that drinking water is beneficial for the body and keeps it hydrated, but going beyond that would mean entering the ground of extrapolation. Miyamoto, et al. (2012), Boetzkes (2010) and Manz (2007) said that taking too much fluid leads to negative consequences, like water intoxication and hyponatremia. So, the myth that high consumption of water enhances learning has not been proven by neuroscientists to be true.

Neuromyth 6: Men and Boys have Different Brains from Women and Girls

Lise Eliot (2011), a neuroscientist at the Chicago Medical School, says some modest disparities have been found, such as men tend to have a larger amygdala, a region associated with emotion. These types of differences are small and highly influenced by the environment. Daniel Amen (2013) says 'male brains' are about 10 per cent larger than 'female brains'. The terms 'male brain' and 'female brain' were coined to refer

to differences in cognitive style rather than biological differences (Baron-Cohen, 2003). He even argued that men were better 'systemisers' (good at understanding mechanical systems) and women were better 'empathisers' (good at communicating and understanding others). However, he did not argue that male and female brains were radically different, but used the terms male and female brain as psychological shorthand for (overlapping) cognitive profiles. Elizabeth Spelke (2005), in her study, found that male and female, on the whole, possess an equal aptitude in both math and science. Despite such evidence, gender differences existed. In 2007, Diane Halperm, Hyde and others in their research found that women tend to score higher on verbal abilities, while men tend to have a slight edge when it came to visuo-spatial skills. In 2008, a study conducted by Hyde and colleagues found that there was no gender difference in math skills from grades II to XI. In 2009, Hyde and Janet Mertz said the gender gap has been closed overtime and in the study both the groups scored the highest level in mathematics. The evidence speaks that both boys and girls are capable of doing anything.

Neuromyth 7: 'Enriched Environments' Enhance the Brain Capacity for Learning

This neuromyth has its origin in the studies of rats brought up in 'enriched' or 'deprived' environments (Diamond, et al., 1987). In his study, rats brought up in an enriched environment were found to have greater synaptic density in their brains. Hence, the theories of education state that a child should be exposed to enriched environments in order to enhance his/her learning potential (Whitebread, 2002). But soon after, the OECD (2002) proved this neuromyth to be false, making it clear that there was no evidence in humans linking synaptic densities and improved learning, and there was no evidence relating synaptic densities in early life with those later in life. The theory was even criticised and it was said that the rat was exposed to an artificially 'deprived environment' so it showed greater synaptic density. The neuromyth was further supported by a study where Romanian orphans were brought up in an impoverished environment, which suffered from ill-effects, showed possibility of rehabilitation in many cases (O' Connor, et al., 1999).

Neuromyth 8: Critical Time Period

The idea that there are critical time periods for brain development derives from the study of visual deprivation in kittens cited earlier (Cragg, 1975A). The critical time period suggests that if the timeframe for learning a particular information is missed, the learning opportunity is lost forever. Goswami (2004) ensures, "Neuroplasticity allows learning to occur at anytime during a person's lifespan and is a strong evidence against the existence of strict critical learning periods in an individual's life." Bruer (1999) said 'critical

periods' help in understanding the processes of synaptogenesis and pruning in the developing brain. In its extreme form, this neuromyth becomes the 'myth of the first three years' which states that the brain will learn the maximum in these three years, else the opportunity for the development of the brain is lost forever. Neuroscientists shield away from the term 'critical periods' and have identified certain types of learning subject to 'sensitive periods', i.e., times when the brain appears to be particularly primed for certain types of input and is ready to adapt itself to meet such demands, but which are not a case of 'all or nothing' (OECD 2002). Hence, it proves that any human beings can be an expert in areas, such as phonology and syntax of language, even after his/her early teenage years.

Conclusion

Neuromyths are misconceptions, which are prevailing among teachers, as well as, teacher-trainees. The implementation of these myths should be prevented from classrooms as they result in diminishing the teacher's confidence in a successful collaboration between the fields of neuroscience and education (Sylvan and Christodoulou, 2010; Pasquinelli, 2012). To eradicate the neuromyths that proliferate within schools, proper education to teachers should be given. Hence, to avoid the misconception in future, there should be proper communication among neuroscientists and practitioners to bring about an enhancement in neuroscience literacy of teachers. Lelienfeld, et al. (2012) says that incorporating neuroscience courses into initial teacher training should include the skills needed to evaluate scientific research. The gap between neuroscience and education is almost removed as scientists have already alerted the society to the neuromyths that are dominant in education. If researchers and practitioners collaboratively conduct research, it will help in bringing educational reforms and removing the neuromyths from the minds of teachers and teacher-trainees. Therefore, it is important to support a translational process and provide opportunities to teachers and neuroscientists to collaborate.

References

Amen, Daniel. 2013. *Unleash the Power of the Female Brain: Supercharging Yours for Better Health, Energy, Mood, Focus and Sex*. Mind Works Press, California.

Arzi, A., et al. 2012. Humans Can Learn New Information during Sleep. *Nature Neuroscience*. Vol. 15. No. 10, pp.1460–1465.

Baron-Cohen, S. 2003. *The Essential Difference: Men, Women and the Extreme Male Brain*. Penguin/Allen Lane, London.

Beck, D.M. 2010. The Appeal of the Brain in the Popular Press. Perspectives. *Psychological. Science*. Vol. 5, pp. 762–766. doi: 10.1177/1745691610388779

Beyerstein, B.L. 1999. Whence Cometh the Myth that We Only Use Ten Per Cent of our Brains? In S. Della Sala (ed.), *Mind Myths: Exploring Popular Assumptions about the Mind and Brain*. (pp. 314–35). John Wiley and Sons, New York.

____. 2004. Ask the Experts: Do We Really Use Only 10% of Our Brains? *Scientific American.* Vol. 290. No. 6, p.86.

Blakemore, S.J. and U. Frith. 2005. *The Learning Brain: Lessons for Education*. Blackwell, Oxford.

Boetzkes, S., K. Van Hoeck, W. Verbrugghe, J. Ramet, M. Wojciechowski and P.G. Jorens. 2010. Two Unusual Pediatric Cases of Dilutional Hyponatremia. *Pediatric Emergency Care.* Vol. 26. No.7, pp. 503–5.

Bruer, J.T. 1999. *The Myth of the First Three Years: A New Understanding of Early Brain Development and Lifelong Learning.* The Free Press, New York.

Cragg, B.G. 1975A. The Development of Synapses in Kitten Visual Cortex During Visual Deprivation. *Experimental Neurology*. Vol. 46, pp. 445–451.

____. 1975B. The Development of Synapses in the Visual System of the Cat. *Journal of Comparative Neurology*. Vol. 160, pp. 147–166.

De Jong, T., et al. 2009. *Explorations in Learning and the Brain: On the Potential of Cognitive Neuroscience for Educational Science*. Springer, New York.

Diamond, M.C., E.R. Greer, A. York, D. Lewis, T. Barton and J. Lin. 1987. Rat Cortical Morphology Following Crowded-enriched Living Conditions. *Experimental Neurology*. Vol. 96. No. 2, pp. 241–247.

Dunn, R., K. Dunn and G.E. Price. 1984. Learning Style Inventory. Lawrence, KS: Price Systems. *Education.* Vol. 6, pp. 89–96.

Eliot, L. 2011. *Sex Roles*. Published online on August 18, 2011. doi: 10.1007/s11199-011-0037-y.

Fischer, Kurt E. 2009. Mind, Brain and Education: Building a Scientific Groundwork for Learning and Teaching. *International Mind, Brain and Education Society*. Vol. 3. No. 1, pp. 3–16.

Frey, N. and D. Fisher. 2013. Reading and the Young Brain. In L.H. Wasserman and D. Zambo (Eds), *Early Childhood and Neuroscience: Links to Development and Learning* (pp. 43–54). Springer, New York.

Gazzaniga, M.S., J.E. Bogen and R.W. Sperry. 1965. Observations on Visual Perception after Disconnection of the Cerebral Hemispheres in Man. *Brain.* Vol. 88, pp. 221–236.

Geake, J. 2004. How Children's Brains Think: Not Left or Right but Both Together. *Education.* 3–13, 32(3), 65–72.

____. 2008. Neuromythologies in Education. *Educational Research*. Vol. 50. No. 2, pp. 123–33.

Goswami, U. 2004. Neuroscience and Education. *British Journal of Educational Psychology*. Vol. 74, No. 1, pp. 1–14.

____. 2008. Neuroscience, Education and Special Education. *British Journal of Special Education.* Vol. 31, No. 4, pp. 175–183.

____. 2008. Principles of Learning, Implications for Teaching: A Cognitive Neuroscience Perspective. *Journal of Philosophy of Education.* Vol. 42. No. 3–4, pp. 381–399.

Halpern, D.F., C.P. Benbow, D.C. Geary, R.C. Gur, J.S. Hyde and M.A. Gernsbacher. 2007. The Science of Sex Differences in Science and Mathematics. *Psychological Science in the Public Interest.* Vol. 8, No. 1, pp. 1–51.

Howard-Jones, P.A. 2010. *Introducing Neuroeducational Research.* Routledge, Abingdon,

____. 2008. Education and Neuroscience. *Educational Research.* Vol. 50, No.2, pp. 119–22.

____. 2009. *Scepticism is not Enough.* Cortex. Vol. 45. No. 4, pp. 550–51.

Hyde, J.S. and J.E. Mertz. 2009. *Gender, Culture and Mathematics Performance. Proceedings of the National Academy of Sciences.* Vol. 106. No. 22, pp. 8801–8807.

Lilienfeld, S.O., R. Ammirati and M. David. 2012. Distinguishing Science from Pseudoscience in School Psychology: Science and Scientific Thinking as Safeguards against Human Error. *Journal of School Psychology.* Vol. 50. No. 7, pp. 36. doi: 1016/j.jsp.2011.09.006

Manz, F. 2007. Hydration in Children. *Journal of the American College of Nutrition.* Vol. 26. No. 5, pp. 562S–9S.

Miyamoto, K., J. Ichikawa, M. Okuya, T. Tsuboi, J. Hirao and O. Arisaka. 2012. Too Little Water or Too Much: Hyponatremia due to Excess Fluid Intake. *Acta Paediatrica.* Vol. 101. No.9, pp. 390–1.

Nouri, A. 2013. Practical Strategies for Enhancing Interdisciplinary Collaboration in Neuroeducational Studies. *International Journal of Cognitive Research in Science, Engineering and Education.* (IJCRSEE). Vol. 1. No. 2, pp. 94–100.

Nyhus, E.M. and N. Sobel. 2003. *The 10% Myth.* Poster presented at the Society for Neuroscience Conference, New Orleans.

O'Connor, C., G. Rees and H. Joffe. 2012. Neuroscience in the Public Sphere. *Neuron.* Vol. 74. No. 2, pp. 220–226.

Organization for Economic Cooperation and Development. 2002. *Understanding the Brain: Towards a New Learning Science.* OECD, Paris.

____. 2007. *Understanding the Brain: The Birth of a Learning Science.* OECD, Paris.

Pasquinelli, E. 2012. Neuromyths: Why Do They Exist and Persist? *Mind Brain and Education.* Vol. 6, pp. 89–96.

Peigneux, P. Laureys, S.X. Delbeuck and P. Maquet. 2001. Sleeping Brain, Learning Brain: The Role of Sleep for Memory Systems. *Neuroreport.* Vol. 12. No. 18, pp. A111–A124.

Petitto, L.A. 2009. New Discoveries from the Bilingual Brain and Mind Across the Life Span: Implications for Education. *Mind, Brain and Education.* Vol. 3. No. 4, pp. 185–197.

Pickering, S.J. and P.A. Howard-Jones. 2007. Educators' Views of the Role of Neuroscience, in Education: A Study of UK and International Perspectives. *Mind, Brain and Education.* Vol. 1. No. 3, pp. 110–13.

Raichle, M. 2014. *What Happens to Your Brain When Your Mind is at Rest?* Retrieved online from https://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=133010

Spelke, Elizabeth S. 2005. Sex Differences in Intrinsic Aptitude for Mathematics and Science: A Critical Review. *American Psychologist.* Vol. 60. No. 9, pp. 950–958.

Sylvan, L.J. and J.A. Christodoulou. 2010. Understanding the Role of Neuroscience in Brain-based Products: A Guide for Educators and Consumers. *Mind Brain and Education*. Vol. 4, pp.1–7.

Wallace, M. 1993. Discourse of Derision: The Role of the Mass Media within the Education Policy Process. *Journal of Education Policy*. Vol. 8, pp.321–337. doi: 1080/0268093930080402

Wanjek, C. 2002. 10 Per Cent Misconception, 90 Per Cent Misdirection: The Brain at Work. In C. Wanjek, (Ed.) *Bad Medicine: Misconceptions and Misuses Revealed, from Distance Healing to Vitamin O.* Wiley, New York.

Whitebread, D. 2002. *The Implications for Early Years Education of Current Research in Cognitive Neuroscience.* Paper presented at British Educational Research Association Annual Conference, University of Exeter. Also available from http://www.leeds.ac.uk/educol/documents/00002545.doc

Worden, J.M., C. Hinton and K.W. Fischer. 2011. What Does the Brain have to do with Learning? *Kappan.* Vol. 92. No. 8, pp. 8–13.