Neuromyths

Misunderstandings about the brain (or "neuromyths") are often associated with ineffective or poor teaching practices, so it is helpful for teachers to be aware of the most popular ones and why they cannot be supported by science.

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Theme/s:

Neuromyths / Effective teaching

This report arises from Science of Learning Fellowships funded by the International Brain Research Organization (IBRO) in partnership with the International Bureau of Education (IBE) of the United Nations Educational, Scientific and Cultural Organization (UNESCO). The IBRO/IBE-UNESCO Science of Learning Fellowship aims to support and translate key neuroscience research on learning and the brain to educators, policy makers, and governments.

Executive summary

- Many neuromyths are popular across the world.
- Neuroscience is rarely included in teacher training and development, and this allows neuromyths to flourish.
- Misunderstandings about the brain (including popular "neuromyths") are often associated with ineffective or poor teaching practices.
- Since teachers base their decisions about their teaching on their understanding of learning, a scientific understanding of the learning brain—and its development—can have practical benefits and be helpful in avoiding neuromyths.

Introduction

A "neuromyth" is a popular idea about the brain that is not based on scientific understanding and may even contradict what is known. For several decades, scientists and educational experts have expressed their concern about the spread of neuromyths in schools and colleges. Not only can neuromyths reflect and promote a poor understanding of science, but many are also related to poor practice in the classroom.

Neuroscience is of great public interest and teachers are generally enthusiastic to know more about how the brain learns. Teachers are responsible for their students' learning and the brain is central to learning, so this enthusiasm appears justified. However, neuroscience is rarely included in the training of teachers in any country. The combination of enthusiasm and lack of specialist knowledge can be unfortunate. It means teachers are generally ill-prepared to reflect critically on ideas and educational programmes that claim to be based on brain science. This may explain the high global prevalence of neuromyths amongst teachers (see Table 1)[1]. All the ideas expressed in this table are essentially false but very common. Some of the most popular neuromyths are explored below.

Learning styles

Some regions become more active than others when we are doing different tasks (e.g., activity in different regions varies according to whether we are looking, hearing, or touching). Since all brains are different, this functionality of different brain regions is sometimes used to support learning style theory. For example, some have suggested categorising learners as "visual," "auditory," or "kinaesthetic" (VAK) or "left-brained" or "right-brained." The brain is so highly interconnected that even seeing the word "bell" can activate the auditory cortex—providing little basis in neuroscience for a VAK approach to learning styles. At the end of their extensive review, it was concluded[2] that there were no clear implications for pedagogy arising from any existing models of learning styles. Psychological research using controlled experiments has concluded that teaching to students VAK learning styles is "wasted effort"[3]. Despite this, the idea that it is educationally helpful to categorise students and teach to their learning styles remains popular and has spread to higher education. In a recent review of the literature, 89% of recent educational papers implicitly or directly endorsed the use of learning styles in higher education—despite lack of scientific or educational evidence for their effectiveness[4].

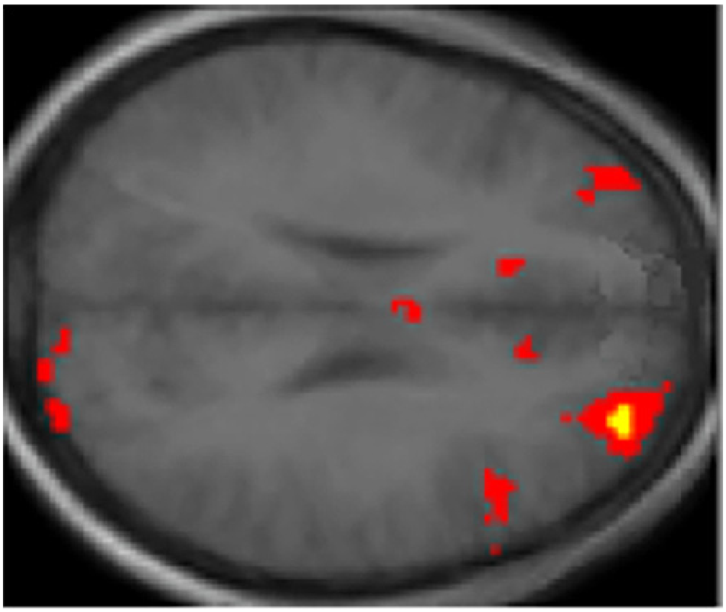

Figure 1. In this horizontal slice of a brain, it is not true that regions of the brain outside of the "hot spots" are not active at all. They are just less active than inside the hot spots. All the brain is active all the time.

Brain studies showing static pictures of well-defined islands of activity can be easily misinterpreted (see Figure 1). They appear to show just a few parts of the brain as being active. In reality, however, the activity in these "hot spots" has only exceeded a threshold defined by the experimenter.

No part of the brain is ever normally inactive in the sense that no blood flow is occurring (so you would be very ill if only 10% of your brain was active). Furthermore, performance in most everyday tasks, including learning, requires many regions in both hemispheres to work together in a very sophisticated parallel fashion. This is helped by an information superhighway that joins left and right hemisphere—called the corpus callosum (see Figure 2):

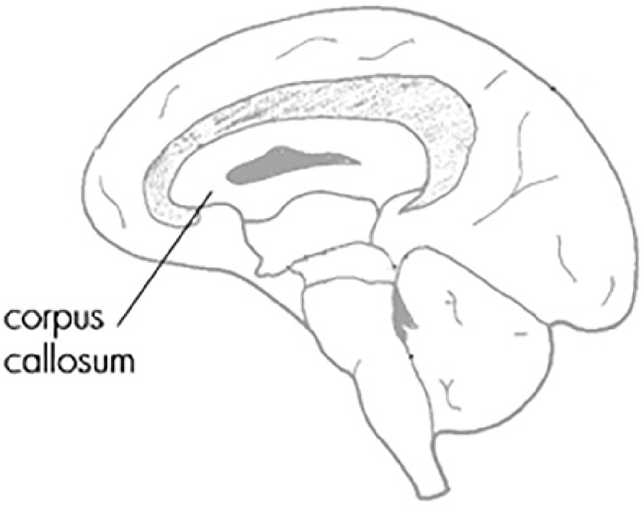

Figure 2. Here is a section through the two cortical hemispheres. It reveals the corpus callosum—an "information superhighway" that connects the two halves of the brain, allowing them to work together. We use both sides of the brain for even the simplest task.

In reality, brain activity at any moment is occurring, to a greater or lesser extent, throughout the brain. The static brain images fail to capture the rapidly changing nature of real brain activity. If the technology was better, scientists would show shimmering changes of activity all over the brain, fluctuating on time scales of milliseconds. The idea we use the left side of our brain in one task and the other side of our brain for other tasks is another myth, and the division of people into "left-brained" and "right-brained" takes this misunderstanding one stage further.

Emotional bias

Many neuromyths reflect an emotional bias. Our anxieties and/or wishful thinking shape them. For example, in the UK, there have been several media articles reporting on the value of drinking water as a means to improve grades[5]. It is true that dehydration can quickly reduce our mental abilities. However, in the absence of exercise or unusual heat, reports of dehydration amongst healthy children who have access to a quality water supply are very rare. There is scarce evidence of improved grades from the drinking of water, but the idea of such a cheap and easy means to improve exam results is appealing to our wishful thinking, and this helps promote the myth.

Around half of those teachers surveyed in Table 1 considered that eating sugary snacks detracted from children's ability to attend. This echoes anxieties that are already common in some countries about children's diets. However, the research linking sugar and attention is mixed at best[6] with some studies even showing benefits to attention. A review of 16 studies concluded sugar does not affect the behavior or cognitive performance of children at all[7]. Of course, this does not detract from the health hazards of sugar, especially with respect to dental decay.

Myths usually arise from a distortion of fact

Many misleading myths have developed around a misinterpreted scientific fact that *does* have potential importance for education. For example, dehydration can lead to poor learning, but drinking water when not thirsty is unlikely to raise grades and can even reduce mental ability[8]. Teaching all students using all their senses (visual, auditory, touch, etc.) can be very effective, but teaching to learning styles is not. Similarly, exercise is very good for the brain and good for learning[9]. It is one of the few ways, and perhaps the most easily implemented, to improve students' mental abilities, including those that involve attention and memory—which are essential to effective learning in school. However, approaches that seek to integrate perceptual and motor skills do not appear very effective at improving learning. They have been promoted as a means to support literacy and despite disappointing results in numerous studies in the 1970s and 1980s[10-15], these ideas continue in circulation. Research tells us that the aerobic content of exercise may be crucial to its positive effects on learning, but coordination exercises tend to be low in aerobic content. This emphasises how understanding the science of why something works can help inform its effective implementation in the classroom. Short aerobic exercise breaks during class have been shown to boost the attention of students[16].

Ideas about brain development can also influence teaching

Perhaps less obvious—but just as potentially damaging—are those myths that surround brain development. A common idea is that when differences in ability become associated with brain differences (such as reported by studies of dyslexia and dyscalculia), this somehow means that children with these disorders cannot be helped by education[17]. This has implications for students, not least because the achievement of students diagnosed with a learning disorder can relate to their teacher's implicit attitude to the disorder[18].

Recent studies provide clear evidence against notions of biologically determined and fixed qualitative differences between individuals diagnosed with such disorders. For example, an imaging study of developmental dyscalculia involved a computer-based mathematical intervention (See Figure 3A) in which children responded with their answers by landing a spaceship on a number line[19]. After the intervention, children with and without dyscalculia improved their arithmetic ability and also showed reduced activation when doing a number line task in a range of mainly frontal regions (Figure 3B shows both groups combined). Both behavioural and neural changes were greater for the dyscalculia group. Similar studies demonstrating positive changes in both brain activity and behaviour have been shown for dyslexia[20-23]. Such research emphasises the plasticity of the brain and the benefits of education for all students, helping to avoid notions of biologically determined and fixed differences between students. They also, of course, help point the way towards more effective approaches in the classroom.

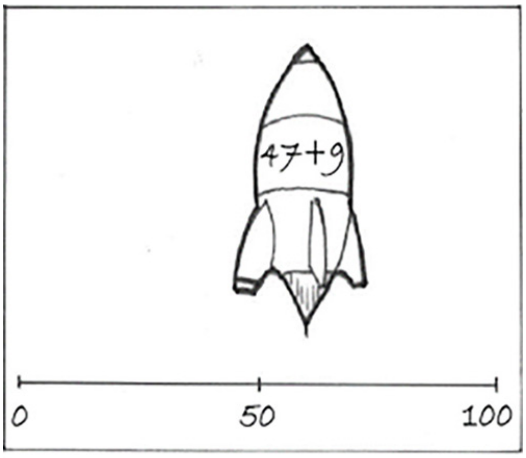

Figure 3. Effects of an educational intervention on the brains of children diagnosed with dyscalculia.
(A) In this brain imaging study of developmental dyscalculia, children responded by landing a spaceship on the correct number on a number line.
(B) Children with and without dyscalculia improved their arithmetic ability and also showed reduced activation in a range of mainly frontal regions (shown in white)—suggesting they were solving problems more efficiently. Having a learning disorder does not prevent your brain function and learning from being improved by education.

Bridging the gap

The cultural gap between neuroscience and education has also helped neuromyths multiply and spread. Despite both these fields having a keen interest in how we learn, their differences in language and concepts have constrained dialogue between them, providing a vacuum in which neuromyths can grow. There is a need for neuroscientific insights to be transferred more carefully to education in a timely, scientifically valid, and educationally meaningful way. Such transfer could help dissipate misunderstandings and inspire more scientifically valid approaches to learning. Creating messages and interventions informed by neuroscience requires a joint effort amongst experts in education, neuroscience, psychology and other disciplines. A new field is now emerging that aims to achieve this, often referred to as "Brain, Mind and Education," "Science of Learning" or "Educational Neuroscience." Research centres combining neuroscience and education are springing up around the world, often associated with popular postgraduate courses. In the future, these may play a central role in training "hybrid" professionals versed in both neuroscience and education.

In the meantime, whenever you hear something about education that claims to be based on brain science, ask where it was published—was it in a reputable research journal? And who made the claim—was he/she a scientist?

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Table 1. Percentage of teachers who believe in some typical neuromyths.

Myth	United Kingdom (N=137)	Netherlands (N=105)	Turkey (N=278)	Greece (N=174)	China (N=238)
We mostly only use 10% of our brain.	48	46	50	43	59
Individuals learn better when they receive information in their preferred learning style (e.g., visual, auditory, kinesthetic).	93	96	97	96	97
Short bouts of co-ordination exercises can improve integration of left and right hemispheric brain function.	88	82	72	60	84
Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.	91	86	79	74	71
Children are less attentive after sugary drinks and snacks.	57	55	44	46	62
Learning problems associated with developmental differences in brain function cannot be remediated by education.	16	19	22	33	50