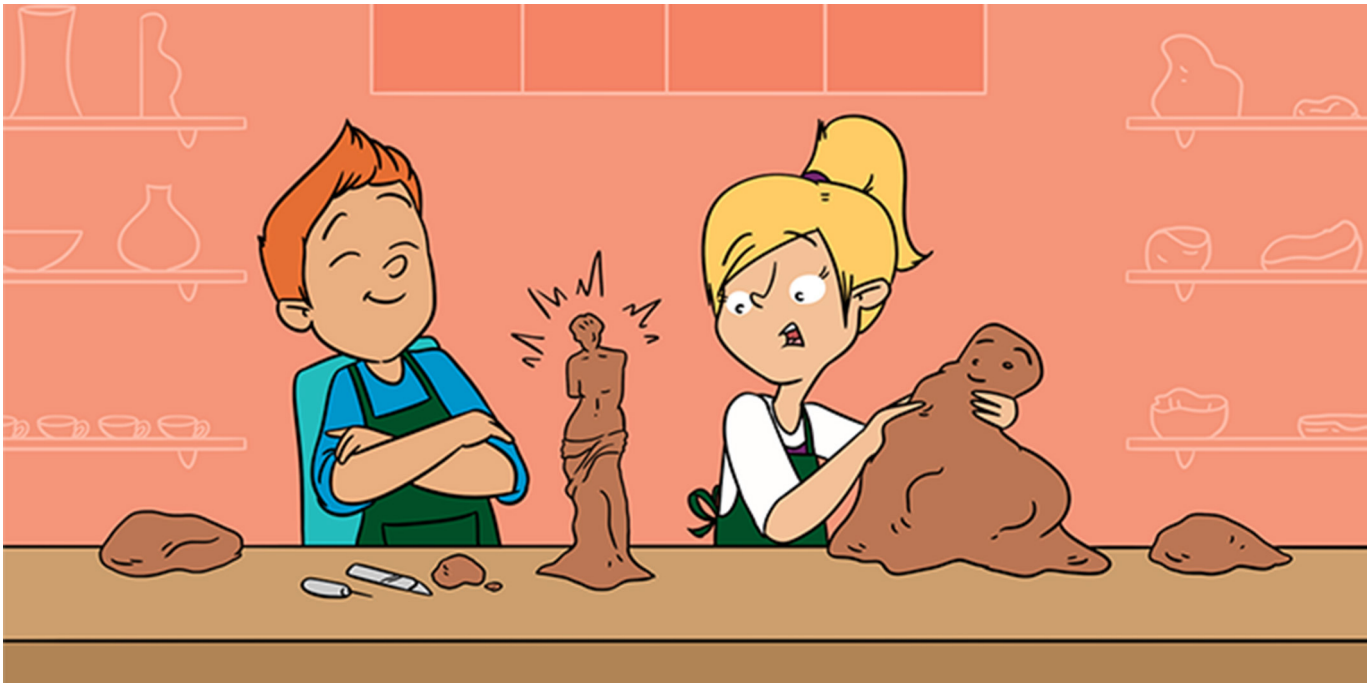
frontiers FOR YOUNG MINDS

NEUROSCIENCE
Published: 21 April 2020
doi: 10.3389/frym.2020.00049



NEURO-MYTHS IN THE CLASSROOM

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YOUNG REVIEWERS:

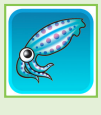
ANYA
AGE: 7

DR. H. BAVINCK SCHOOL
AGES: 8–12

LIAM
AGE: 8

MONICA
AGE: 6

OLIVER
AGE: 10



PALOMA
AGE: 8

Have you ever heard that we only use 10% of our brains? It is a nice thought that we could tap into hidden brain power—but could most of our brains really be doing nothing all day? No! Every bit of your brain is busy 24 hours a day. There are lots of these so-called neuro-myths floating around: ideas about the brain that sound true, but are not. There is usually a good reason why a neuro-myth got started: maybe there is an element of truth to it, or maybe people would just like it to be true. In this article we explore three widely believed neuro-myths about the growing brain, and explain why it is important for you to know what is true and what is not. We will explore whether you can change how clever you are, whether girls and boys think differently from each other, and whether some children are "left brained" and some are "right brained."

WHAT IS A NEURO-MYTH?

A myth is something that a lot of people think is true, but actually is not (for example, that King Arthur was a real king in England) and "neuro" tells us that we are talking about the brain. So, a neuro-myth is a statement about the brain that is often thought to be true, but is not. There are lots of neuro-myths, like that we only use 10% of our brains, or that our brains are not active while we sleep. You may well have come across these ideas yourself, and whether you realize it or not, they could be making a difference to the way you think about your own brain and the way you learn in school. Importantly, neuro-myths are also things that parents and teachers might believe and that can affect how they think about the growing mind. Neuro-myths can influence how teachers teach and how parents, you know, parent. In this article, we will spend a little time exploring three neuro-myths, then think about why it matters that you know how to spot a myth when you hear one.

MYTH #1: INTELLIGENCE IS FIXED

The idea here is that how well you can do on things like school exams or tests of **intelligence** depends on your **genetics**. Genetics means something that runs in families—things like eye color and height usually depend strongly on genetics. If your intelligence were fixed by genetics, then how well you do on school exams would depend on how well your parents do on tests of intelligence, or how well they did on school exams. It is clear where this idea came from, because children can indeed be very similar to their parents. Actually, we can measure how similar children and their grown-ups are. If you take a group of twins, some identical and some non-identical, and choose a behavior—say, juggling—you can work out how much differences in that behavior are influenced by genetics and how much the differences are due to the environment in which the children were raised. This is because identical twins share 100% of their genetic make-up, while non-identical twins only share 50%, yet both sorts of twins share very similar environments (they live in the same house, they have the same number of juggling classes, etc.). If juggling ability is more similar between identical twins than non-identical twins, this tells you that the identical twins' greater genetic similarity is producing more juggling similarity—so this behavior must be influenced by genetics. We call this genetic influence "heritability". Zero heritability means differences are totally due to the environment, while 100% heritability means all the differences in behavior come from differences in genes.

Using the twin technique, we can see how much genetics has to do with one person doing better than another on a school test. It turns out that a little over half (60–65%) of the difference between children in how they perform at school is due to genetics (Oliver et al. [1] show

INTELLIGENCE

Intelligence is a word often used to mean how clever someone is. For example, how well people do on tests to measure things like problem solving. But ask a group of scientists what intelligence is and they'll probably all have a different answer!

GENETICS

Something that is passed on from parents to their children in DNA, so the color of your hair is determined by genetics, but the length of your hair is not.

this for science and maths). Of course, genetics is not the whole story, far from it. After all, no one would know much about anything if they were not taught it!

There are plenty of things that can influence how well you do in the classroom that have nothing to do with your parents: things like believing that your performance can change with learning, or having a great teacher. Every teacher knows that they can make a real, positive difference for a child. One study showed this elegantly: they found that reading ability was more influenced by genetics in classes with better teachers [2]. Here is why this is elegant: if you have a rubbish teacher, this holds everyone back, no matter how good their reading genes are. If you have a perfect teacher, the differences in reading ability are more down to each person's different genetic potential. Let us think of children as plants. Plants should end up being all different heights, like their different parent plants. However, if the little plants do not get enough water, then it does not matter how tall their parent plants are, they would not grow to their full potential. Only when it has enough water (a great teacher) can a plant be as tall as its genetics allow (do as well as it can in school). Work like the study on reading shows us that, while there is truth to the idea that intelligence is passed on from your parents, it is not true that it is fixed. The way your intelligence is revealed depends on you and the world around you.

MYTH #2: GIRLS AND BOYS THINK DIFFERENTLY

ANALYZE

To decide what a set of information can tell you.

DATA

A set of information.

The idea here is that girls are born to be better at some classroom activities and boys are born to be better at others. Generally, girls are thought to excel at more creative things, like English, while boys are thought to be better at technical things, like maths. Many scientific studies have been published that show group differences between males and females; for example, males are better at turning images of objects around in their minds. Not everyone believes that males and females are so different though. One scientist **analyzed data** from a bunch of studies including around seven million people in total, looking at gender differences across a range of activities, from talking to throwing [3]. She found that over three quarters of the studies showed gender[1] differences to be small or almost absent. This was true even in areas where people thought there were big differences, like maths ability.

The other important thing is that studies of group differences look at just that: groups. If you take a group of boys, some of them will be great at maths, most will be ok at maths, and some will be bad at maths. The same is true of girls. Even if, as a group, the boys do slightly better on a particular test, that tells you nothing at all about any specific individual (as you can see in Figure 1). The two groups will overlap considerably. Any individual boy will probably do better than lots of girls, and any individual girl will probably do better than lots of boys.

[1] We use "gender" to mean biological differences between males and females, rather than how people see themselves.

Figure 1

This is an example graph showing how a group of girls and a group of boys did on a pretend test. See how even though the girls do slightly better as a group (the "girls" curve is slightly to the right of the "boys", showing they got slightly higher scores), mostly the two groups overlap.

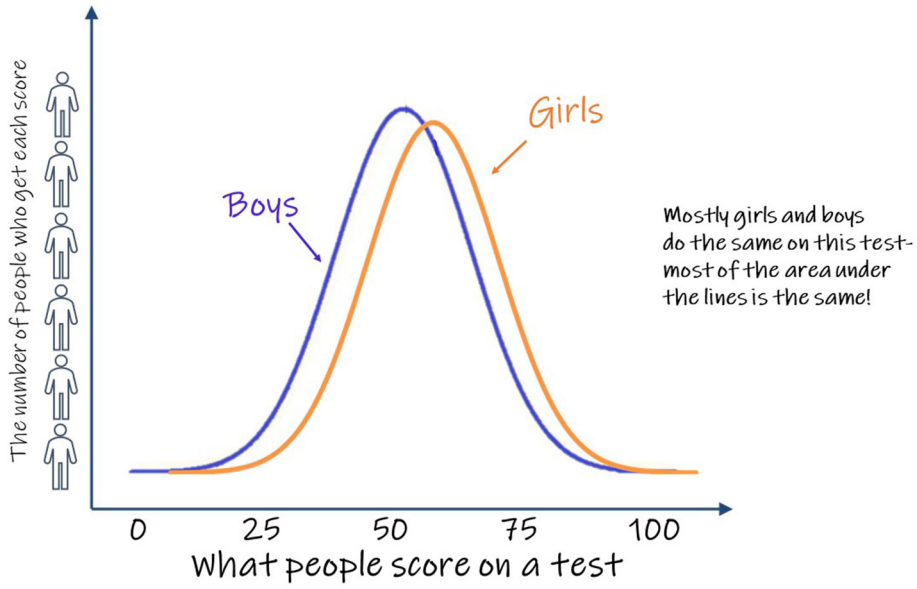


Figure 1

So, while there may be some differences between the way girls and boys think, those differences are small, and group differences really do not tell you anything about any individual, anyway.

MYTH #3: SOME CHILDREN ARE "LEFT-BRAINED" AND SOME ARE "RIGHT-BRAINED"

There are really two ideas here: (1) the brain is divided into a logical, wordy left half and a creative, emotional right half; and (2) people have one side that is more active than the other, so they are better at either left-brained or right-brained activities.

HEMISPHERE

One half of something round—the brain has two hemispheres (left and right), so does the earth (north and south).

SPECIALIZATION

If you specialize in something you do that one thing really well, so someone might specialize in playing the cello. In the article we talk about areas of the brain specializing in doing one thing, like reading words or moving your hand.

As we have seen with the other neuro-myths, there is some truth lurking around here. Looking at the brain, one of the most striking things is that there are two very distinct halves (called **hemispheres**) that, to a large extent, are mirror images of each other (as illustrated in Figure 2). It is also true that different areas of the brain specialize in different jobs, like moving your hands or making you scared of spiders. Sometimes that **specialization** can be seen completely (or mostly) on one side of the brain: this is called "lateralization". The classic example is that language (talking and listening to others talk), relies on the left half of the brain in most people. However, even language is not exclusively left-brained: the right brain is important for many aspects of language. For example, the right hemisphere is crucial for understanding why jokes are funny once the left hemisphere has understood the sentence [4]. The two halves of the brain almost always work together like this.

Figure 2

This is a drawing of the two halves of the brain.

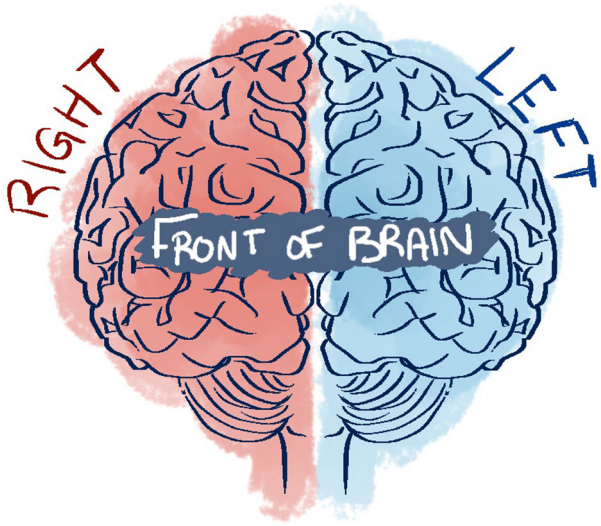


Figure 2

Although we do often use different sides of the brain for different things, this does not mean that people are right-brained or left-brained, as such. A huge study of over 1,000 individuals showed that, overall, people do not have one half of the brain that is more active than the other half [5]. Rather, where activity happens in the brain depends on what you are doing. It also depends on how good you are at doing it. For example, musicians have more brain matter in some parts of the left brain compared with non-musicians [6]; but these differences are seen in specific, small areas of the brain, not generally in one hemisphere or the other. So, although tasks might be more right-brained or left-brained, people are not.

WHY DO NEURO-MYTHS MATTER?

Neuro-myths matter because they affect people's thoughts and behavior: they can change how we see ourselves and how we see each other. Let us take the example of gender again. At age 8 to 9, there is no difference in how well girls and boys do at maths, yet girls (and their parents) rate their maths ability to be lower than boys [7]. This suggests that what people believe (in this case, that girls are not as strong at maths) may have a real impact on how children see themselves, which may in turn affect their actual performance. In one study, when a group of college students was given a maths test, men did better than women when they were told that the test usually shows gender differences, but when they were told it was a gender-fair test, women did just as well as men [8]. This is important because, by the end of education, differences that were once small become massive: 94% of maths professors in the UK are men [9]. This is a good example of why we should be careful about neuro-myths—what you believe about your brain and the brains of those around you may just come true. So, start believing you can do maths!

AUTHOR CONTRIBUTIONS

Written by VK and edited by MT.

ACKNOWLEDGMENTS

We would like to wholeheartedly thank those who assisted in the translation of the articles in this Collection to make them more accessible to kids outside English-speaking countries, and for the Jacobs Foundation for providing the funds necessary to translate the articles. For this article, we would especially like to thank Nienke van Atteveldt and Sabine Peters for the Dutch translation.

REFERENCES

1. Oliver, B., Harlaar, N., Hayiou-Thomas, M. E., Kovas, Y., Walker, S. O., Petrill, S. A., et al. 2004. A twin study of teacher-reported mathematics performance and low performance in 7-year-olds. *J. Educ. Psychol.* 96:504–17. doi: 10.1037/0022-0663.96.3.504
2. Taylor, J., Roehrig, A. D., Soden-Hensler, B., Connor, C. M., and Schatschneider, C. 2010. Teacher quality moderates the genetic effects on early reading. *Science* 328:512–4. doi: 10.1126/Science.1186149
3. Shibley-Hyde, J. 2005. The gender similarities hypothesis. *Am. Psychol.* 60:581–92. doi: 10.1037/0003-066X.60.6.581
4. Marinkovic, K., Baldwin, S., Courtney, M. G., Witzel, T., Dale, A. M., and Halgren, E. 2011. Right hemisphere has the last laugh: neural dynamics of joke appreciation. *Cogn. Affect. Behav. Neurosci.* 11:113–30. doi: 10.3758/s13415-010-0017-7
5. Nielsen, J. A., Zielinski, B. A., Ferguson M. A., Lainhart, J. E., and Anderson, J. S. 2013. An evaluation of the left-brain vs. right-brain hypothesis with resting state functional connectivity magnetic resonance imaging. *PLoS ONE* 8:e71275. doi: 10.1371/journal.pone.0071275
6. Gaser, C., and Schlaug, G. 2003. Brain structures differ between musicians and non-musicians. *J. Neurosci.* 23:9240–5. doi: 10.1523/JNEUROSCI.23-27-09240.2003
7. Herbert, J., and Stipek, D. 2005. The emergence of gender differences in children's perceptions of their academic competence. *J. Appl. Dev. Psychol.* 26:276–95. doi: 10.1016/j.appdev.2005.02.007
8. Spencer, S. J., Steele, C. M., and Quinn, D. M. 1999. Stereotype threat and women's math performance. *J. Exp. Soc. Psychol.* 35:4–28.
9. London Mathematical Society. 2013. *Advancing Women in Mathematics: Good Practice in UK University Departments*. London: London Mathematical Society.

SUBMITTED: 29 September 2019; **ACCEPTED:** 26 March 2020;
PUBLISHED ONLINE: 21 April 2020.

EDITED BY: Nienke Van Atteveldt, Vrije Universiteit Amsterdam, Netherlands

CITATION: Knowland VCP and Thomas MSC (2020) Neuro-Myths in the Classroom. Front. Young Minds 8:49. doi: 10.3389/frym.2020.00049

CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

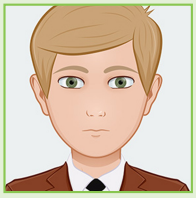
YOUNG REVIEWERS

ANYA, AGE: 7
I like to be active and do many sports with a lot of enthusiasm and as well as I can. My favorites are swimming and gymnastics. I also like to hear new stories through books, storytelling, and movies, and I like to create my own when I play. But I also like mathematics which is my favorite subject at school. I like singing and everything musical, and I make my own muffins for breakfast whenever I can.

DR. H. BAVINCKSCHOOL, AGES: 8–12
We are Spectrum classes 5–6 and 7–8 of the Bavinckschool in Haarlem, the Netherlands. This is a group of 40 kids (19 in group 5–6 and 21 in group 7–8) who are eager to learn a bit more than the regular school program. They had a lot of fun reviewing for FYM, and went through the articles with great focus and enthusiasm, and made a critical evaluation. They really enjoyed contributing to science and helping out!

LIAM, AGE: 8
I am in third grade and love stuffies and my mom. I am an artist and I love to ski. When I grow up, I want to travel all over the world and in space.

MONICA, AGE: 6
I like to draw pictures... because I want to express what is on my mind. I enjoy going to new cities and countries. I am extremely creative, and I love cooking. I also like to read books and learn things by children all over the world. I like sports like swimming and skating.



OLIVER, AGE: 10
I am in fifth grade and love robotics, math, and science. I just started to learn to play the trumpet. I cannot wait for ski season to start. When I grow up, I want to be an astronaut and travel to Mars!

PALOMA, AGE: 8

Hi my name is Paloma, my favorite things are school and traveling because I like learning new things. Science is my favorite subject because it is really interesting and I have a great teacher. I also really enjoy reading graphic novels because they are fun! I am also really worried about pollution and water conservation and I hope to 1 day find solutions to these problems.

AUTHORS

VICTORIA C. P. KNOWLAND

Vic is a researcher at the University of York. Her job is to try and understand how sleep in childhood might be important for learning language. She is interested in how and why children's language skills are different to each other, for example why some children might know more words than others. She is also interested in how to support children who find communication a challenge. Together with Michael, Vic has written a series of short articles about neuromyths that are relevant to learning in the classroom. *victoria.knowland@york.ac.uk

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