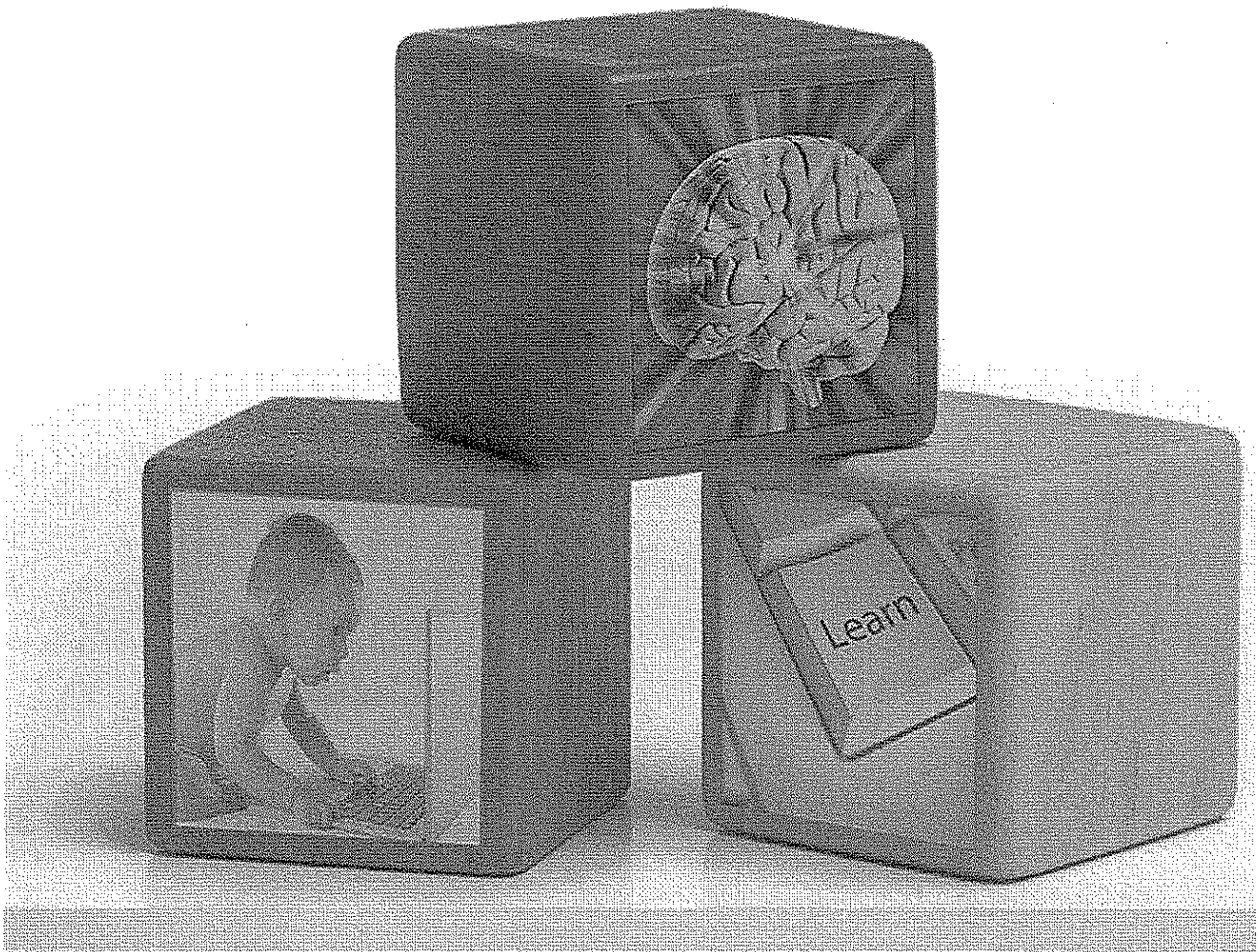
URBAN MYTHS

ABOUT

LEARNING AND EDUCATION



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Introduction

We go to school to learn, but what exactly do we know about learning and how do we make use of what we know in daily practice? In this first series of myths we will look at a number of popular (in other words, stubborn and very persistent) thoughts about how we learn – or don't. Two different aspects come to light in this discussion. The first relates to "theories" surrounding learning. An example of this is all that has been written about learning styles, work forms, and knowledge versus problem solving. We will discuss questions such as: Are there different styles of learning? Are there different work forms that allow us to learn more or less? We will also look at what we need to learn: now that we can look everything up on the Internet, is all that knowledge really necessary? Is solving problems the best way to learn to solve problems? These different aspects will be discussed specifically in the first dozen myths or so.

The second relates to paradigms that people (researchers and teachers, but also politicians, administrators, advisers, etc.) use to justify their actions. The three most prevalent paradigms are the behaviorist paradigm, the cognitivist (also often called the instructivist) paradigm and the constructivist (and its offshoots social-constructivist and constructionist) paradigm. We take the time to discuss this here, before going to the myths. There are three reasons why we oppose this approach.

The first reason is because this way of thinking tends to separate and compartmentalize people into camps where one is for or against and as such stimulates dogmas and academic wars. This is the last thing that education needs. The second reason is that, strangely enough, at least two of the three schools of thinking are so closely related to each other that differentiation is absurd. If we look at cognitivism and constructivism closely we see the following:

- Constructivism is a philosophy of the world which states that we all construct our own reality based on our own knowledge and experiences. A cognitivist – if such a thing actually existed – would say that each individual constructs her or his own schema based on prior knowledge and new learning experiences.
- Early constructivists couched their educational theories in terms of terminology and theorists such as situated cognition (Brown, Collins, & Duguid), cognitive apprenticeship (Collins) and cognitive flexibility (Spiro, Coulson, Feltovich, & Anderson).
- The "gurus" of constructivism such as Jean Piaget (i.e., assimilation and accommodation = accretion, tuning and restructuring) and Vygotsky (e.g., cognitive development results from an internalization of language)

Finally, thinking that one paradigm is sufficient for effective, efficient and enjoyable learning is as absurd as thinking that there is one best way of cooking. A top chef makes use of a wide variety of techniques (e.g., baking, frying, freezing), tools (e.g., paring knife, steam oven, blender) and ingredients (e.g., vegetables, meats, herbs, spices) to create meals that fit both the eater and the occasion. An educational designer or teacher should, in our opinion, work as and be considered to be a top educational chef and should not be limited by artificial limits on her or his art and science.

In what you are about to read, those readers who are of bad faith (i.e., those who think that the word instruction is a curse) might find a reason or two that seems to argue against change or in favor of boring lessons, without taking due account of the differences between pupils. Nothing could be further from the truth. As stated, a good teacher works with a carefully considered mix of different work forms, based on a number of different elements. In part, this can be a matter of personal preference, but it is also important to take account of the initial starting point of the pupils. We will show that styles of learning do not exist, but this is not to say that pupils do not differ in terms of interests. We will also question the appropriateness of particular work forms, but this is not to say that they are not excellent in other situations and for other purposes. A real education professional knows that there is no such thing as a "one-size-fits-all" approach, not for learners and not for groups of learners.

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MYTH 1

People Have Different Styles of Learning

People are all different and so we all learn differently. This is a truism that is hard to deny. Because of this, for many teachers it feels intuitively right to say that there are people who prefer to learn visually, while others prefer to learn auditively, and yet others kinesthetically. We all know the type of pupil who needs to have heard everything (i.e., auditive style), who works in stark contrast to the pupil who remembers things by linking them to a movement (i.e., kinesthetic style). Then there are those who prefer verbal methods, who again contrast strongly with those who prefer to think in images.

PROBLEMS?

Is there a problem here, then? The answer to this question is: Yes! And the problem is twofold. First, there is a great difference between the way that someone says he or she prefers to learn and that which actually leads to better learning. Let's go back to food. Nobody (we hope) would dispute, deny or confuse what someone prefers to eat and what is good for them to eat. If that were the case, then there would not be such a prevalence of overweight, obesity and morbid obesity and all of the health problems associated with this in the developed world. Most people prefer foods that are rich (i.e., fatty), sweet and/or salty, and in our society these things are readily available and relatively inexpensive. But fat, salt and sugar are not the best things for us to eat, and the same is true for learning.

In 1982, Clark found in a meta-analysis of studies using learner preference for selecting particular instructional methods that learner preference was typically uncorrelated or negatively correlated with learning and learning outcomes. That is, learners who reported preferring a particular instructional technique typically did not derive any instructional benefit from experiencing it. Frequently, as Clark later explained, so-called *mathemathantic* (from the Greek *mathema*, learning, and *thanatos*, death) effects are found; that is, teaching kills learning when instructional methods match a preferred but unproductive learning style. Giving children candy and soft drinks because they prefer them is an example of bad nutritional practice, just as catering to preferred but often unproductive "learning styles" is an example of bad educational practice.

The second problem deals with the concept of learning styles itself, as Kirschner and van Merriënboer noted. Most so-called learning styles are based on types; they classify people into distinct groups. The assumption that people cluster into distinct groups, however, receives very little support from objective studies (e.g., Druckman & Porter). There are at least three problems with this pigeonholing of learners: Most people do not fit one particular style (i.e., most differences, and especially differences in cognition, between people are gradual rather than nominal); the information used to assign people to styles is often inadequate (i.e., self-report measures are most often used, but the adequacy of such self-reports for assessing learning styles is questionable at best (e.g., Veenman, Prins, & Verheij); and there are so many different styles that it becomes cumbersome to link particular learners to particular styles (Coffield, Moseley, Hall, & Ecclestone described 71 different learning styles, which if dichotomous would produce 2^{71} combinations of learning styles – more combinations of styles than people on Earth).

And if we set all of the difficulties aside, the question would be how to tailor instruction to particular learning styles. This is where the learning styles hypothesis (Pashler, McDaniel, Rohrer, & Bjork) comes into play. For a true learning style, that is where there is a crossover interaction where type A learners learn better with instructional method A, whereas type B learners learn better with instructional method B. Here is an example: van Merriënboer compared a generation method for teaching programming which stresses writing programming code (i.e., impulsive learning style) with a completion method which stresses studying and completing a given code (i.e., reflective learning style). While reflective learners tended to profit more from completion than impulsive learners, completion was superior to generation for both types of learners. Thus, while studies might show interactions between supposed learning styles and specific instructional methods, they have no real practical educational implications since only crossover interactions provide acceptable evidence for learning styles.

A well-known and often used approach is to classify people as thinkers, doers, dreamers and deciders. This last system of categorization is known as the Kolb inventory, the basis of what is called *experiential learning*. Unfortunately, attempts to validate experiential learning and learning styles have not really been successful. In 1994, for example, in a meta-analysis of 101 quantitative studies using Kolb's Learning Style Inventory, Iliff reported low correlations (<0.5) and weak (0.2) to medium (0.5) effect sizes. The conclusion was, thus, that the sizes of these statistics do not meet standards of predictive validity to support using the inventory or experiential methods for teaching or training. Similarly, Ruble and Stout concluded that the Inventory has low test–retest reliability and that there is little or no correlation between factors that should correlate with the classification of learning styles. There are plenty of other such inventories, each invalid in its own different way, which form the basis on which schools, parents, teachers and companies continue to think that if we adapt our education to the style of learning that people use or say that they prefer to use, then they will learn better.

This is a particularly stubborn myth. Rohrer and Pashler summarize it as follows: "The contrast between the enormous popularity of the learning style approach in education and the lack of any credible scientific proof to support its use is both remarkable and disturbing" (p. 117). The question here is: Why?

First off, we like to identify ourselves and others and put ourselves and others into categories or groups. Kurt Vonnegut, in his 1963 book *Cat's cradle*, referred to this as a *granfalloon*; an association or society based on a shared but ultimately fabricated premise. Such categories are used by us to help bring order to our often chaotic environment and give us quick, though often unreliable, ways to understand each other.

Second, this pigeonholing appeals to us because it propagates the idea that each learner should be considered to be "unique", and that the differences between learners should be recognized and attended to. It is a comforting thought that by teaching to different learning styles, "all people have the potential to learn effectively and easily if only instruction is tailored to their individual learning styles" (Pashler et al., p. 107).

Third, and possibly a cynical reason, is that using the concept of learning styles allows both learners and parents to attribute any failure to learn not to themselves but rather to the mismatch of the industrial-age educational system with the specific qualities of the learner. The often heard claim sounds something like, "How can you expect me/my child to learn and score well when I am/(s)he is a holistic learner, visual learner, etc., but the lessons are atomistic, verbal, etc.?" In other words, it is a good way to blame a failure to learn on the teacher's, school's or pedagogy's failure to adopt and make use of teaching methods that do not match an individual's often self-diagnosed learning style.

Finally, according to Tanner, the wide acceptance of learning styles is because they look a lot like the concept of metacognition (i.e., how we think about our own thinking). In her research, Tanner prompted students to self-reflect on how they studied for an examination (and whether they succeeded or failed in their learning) as a way to help them to monitor their own learning and, eventually, learn more effectively for their next exam. She found that having students describe which strategies worked for them and which did not improved their learning for the next exam. Unfortunately, while integrating metacognitive activities into the classroom is supported by a wealth of research, using learning styles is not.

Furthermore, learning style theories are based on the premise that the way something is ordered or the way you think about something determines how quickly and easily you can learn that something. But Daniel Willingham has shown that this is not how the human brain works. Try to imagine the ears of a German Shepherd. There is a good chance that you are now thinking of the image of a dog. But if we now ask you to imagine the voice of your best friend, then there is an equally good chance that this time you will not see an image of your friend, but will hear his or her voice inside your head. And if we ask you to imagine something involving movement, then at your age you will probably no problem envisaging how to tie your shoelaces. In other words, we each think in different ways about different things all the time. But there are more serious lessons to be learned. Imagine that you have a visual learner and an auditory learner. You first read out a list of words and then you show a series of images. You would probably think that the auditory learner would remember the spoken words better than the visual images, and vice versa for the visual learner. But this is not the case. This does not mean that some people are not slightly better at remembering things in images, which may be useful if they need to remember, say, buildings or maps, but only a small minority will have any real problem with these things. Even auditory learners can work with maps without serious difficulties.

If you ask someone to memorize something, it is not really a question of what they see or hear; it is a question of meaning. And is this not what we primarily learn at school: meanings? If this were not so, a visual learner in a mathematics lesson would only remember the symbols and would not know what $(a + b)^2 = a^2 + 2ab + b^2$ really means.

So, should you adjust your lessons to the learning style of your pupils? There is almost no scientific evidence for the different learning style categorizations and no proof for their added value in the classroom. But does this mean that all learners are the same and should be treated and taught the same way? No! What it means is that learning styles is not a theory of instruction and should not be treated as such. Different learners react to different things in different ways and a good teacher, like a good chef, knows how to optimize this by playing to the learner's strong points and compensating for the weak ones.

As Pashler and colleagues stated, what actually is supported is "a thriving industry devoted to publishing learning-styles tests and guidebooks" and "professional development workshops for teachers and educators" (p. 105). Thousands of articles and books have been written on learning styles and their application in education. Furthermore, as Kirschner and van Merriënboer note, there is an incredibly lucrative commercial industry for (1) selling measurement instruments meant to help teachers diagnose their students' learning styles and (2) holding workshops and conferences meant to provide information and training to teachers on how to align their teaching to the learning styles of their students.

Learning in Movement

A number of research projects have been conducted that show the positive link between movement and learning. Physical activity has been found to generate positive structural changes in the brain, such as development of nerves (neurogenesis), formation and differentiation of blood vessels (angiogenesis), and improved connectivity (Thomas, Dennis, Bandettini, & Johansen-Berg). These positive effects of physical activity on the brain are thought to consequently improve academic achievement. Many studies, for example, have indicated that children who spend more time in physical activities have better academic achievement than those who are less physically active (Fedewa & Ahn). These results appear to apply to all children, not just to those who have preference for a kinesthetic learning style. For example, developmental psychologist John Best carried out an experiment to investigate the influence of "exergames" on the brain (Figure 3). He asked 33 children to take part in games that differed in their levels of physical activity and cognitive engagement (the intellectual challenge of the game). He examined the effect of these games on the executive functions – the higher control functions – of the participants' brains. The results showed that the level of cognitive engagement had no effect, but that the level of physical activity did. Children were able to solve problems more quickly after playing a physical game than a cognitive game. He concluded that children "learn"

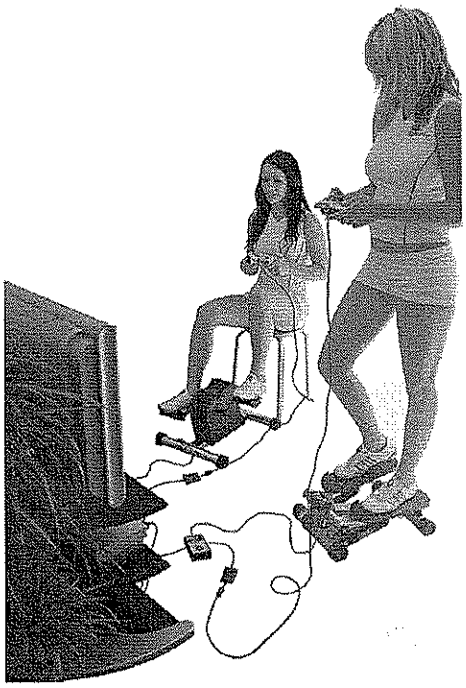

Figure 3 Movement and learning. *This image, which was originally posted to Flickr.com, was uploaded to Commons using Flickr upload bot on 09:24, 20 July 2008 (UTC) by Wowowwiki (talk). On that date it was licensed under the Creative Commons Attribution-Share Alike 2.0 Generic license. Original location: http://www.flickr.com/photos/13139702@N05/2038082937*

more (in the sense of using the higher part of their brain more effectively) from exergaming than from, say, watching an educational video. He explained this in terms of physiological excitement, which ensures that more attention is devoted by the brain to the coordination of the motor functions.

This is not only the case in children. Gao and Mandryk, for example, found acute cognitive benefits of even a casual exergame (10 minutes of light exercise) over the watching the same game bit not exercising on cognitive tests requiring focus and concentration. Maillot, Perrot, and Hartley found that exergaming significantly improved cognitive measures of executive control and processing speed functions in older adults. In our aging society this is an important finding!

We will see later in the book that you need to be very careful when making references to brain activity in this manner. Even so, the Best study is interesting. It not only demonstrates the positive effect of gaming, but also emphasizes how vitally important physical exercise is for children. It not only counteracts overweight and obesity, but can also improve people's learning.

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:-\ Though appealing, no solid evidence exists showing that there is any benefit to adapting and designing education and instruction to these so-called styles. It may even be the case that in doing so, administrators, teachers, parents and even learners are negatively influencing the learning process and the products of education and instruction.

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CHAPTER 3

Neuromyths

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Teachers who are more interested in neuroscience in the classroom are more inclined to believe neuromyths.

(Dekker, Lee, Howard-Jones, & Jolles, 2012).

Introduction

In 2007, Susan Pickering and Paul Howard-Jones investigated teachers' views on the role of neuroscience in education. Their findings showed that almost 90% of teaching staff think that neurological insights are important for education, and that teachers are enthusiastic about the idea of incorporating insights from neuroscience in their daily practice. At the same

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time, most scientific publications also warn that neuroscience is a relatively new discipline and that there is a huge gap between what neurologists investigate and what educationalists do with the results of those investigations. Pickering and Howard-Jones' study also revealed that teachers' concept of neuroscience varied widely.

However, this does not prevent countless people in the education profession from telling you everything they know about the relation between the brain and education, which often leads to inconsistencies and inaccuracies. This, of course, is how myths are born. In practice, at the moment it is only the insights of cognitive psychology that can be effectively used in education, but even here care needs to be taken.

Neurology has the potential to add value to education, but in general there are only two real conclusions we can make at present:

- For the time being, we do not really understand all that much about the brain.
- More importantly, it is difficult to generalize what we do know into a set of concrete precepts of behavior, never mind devise methods for influencing that behavior.

One problem is that once we see the word "brain", we immediately become more inclined to believe what is said. In an interesting experiment by David McCabe and Alan Castel, a number of explanations for psychological phenomena were given to two groups of test subjects. One group consisted of neurological experts; the other group consisted of non-specialists. There were four possible answers for each phenomenon:

- a correct explanation
- an incorrect explanation
- a correct explanation supplemented with neurological details that had nothing to do with the phenomenon in question
- an incorrect explanation supplemented with neurological details that had nothing to do with the phenomenon in question.

In both groups, thankfully, the test subjects were usually in agreement with the correct explanation. More remarkable, however, was the fact that among the group of non-specialists the minority who chose the wrong explanation consistently preferred the wrong answer with the unnecessary neurological details to the wrong answer without any details whatsoever.

And this effect increases if you add an image of a brain scan into the equation.

So, what about teachers? Do they believe in neurological myths or not? Research undertaken by Sanne Dekker and colleagues and published in the online journal *Frontiers in Psychology* focused specifically on educators who had indicated an interest in the relationship between neuroscience and education. You would expect this group to be well informed about the difference between "reliable" scientific findings and pseudoscientific "opinions". The survey put forward a list of 32 propositions to 242 people working in the education profession (137 English, 105 Dutch). Fifteen of the 32 propositions, spread randomly throughout the list, were incorrect; in other words, they were neuromyths. Some of these myths will be explored in the pages ahead, such as the contention that "we only use 10% of our brain". The correct statements were things like "boys have bigger brains than girls" and "the left and right halves of the brain always work together". How many of the neuromyths were incorrectly identified as being true? An amazing 49%, half of them. Even more remarkably, the teachers who had a better knowledge of the working of the brain believed more of the myths! In a review article, Howard-Jones compared three additional regions to this data and the prevalence of neuromyths was also high in Turkey, Greece, and China.

These conclusions are disturbing. The teachers who are most interested in applying neuroscience in the classroom are also those who are most inclined to believe in neurological myths. For this reason, we will now look at some of the most stubborn of these myths.

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MYTH 1

We Are Good Multitaskers

Teachers often ask themselves whether or not pupils who try do everything all at the same time are actually able to devote the required degree of attention to each element. Many publications and media sources claim that young people nowadays not only are able to multitask, but also are experts at multitasking. By multitasking, we mean the ability to carry out two or more things that require thinking (i.e., processing of information) simultaneously.

We are tempted to believe that we can multitask because at some level, intuitively, it seems to make sense: it looks as if we are indeed able to perform multiple actions at the same time. For example, driving a car involves performing a number of actions simultaneously: shifting gears, turning the steering wheel, looking into the mirrors, and so on. Experienced drivers appear to be able to perform all these actions while maintaining a conversation with friends in the car. Or can they? As it turns out, the ability to multitask is far more complex than it appears on the surface. An important question is whether humans actually do perform actions simultaneously, or if they really switch between tasks by diverting their attention from one task to another; that is, task-switching.

It turns out that only under special circumstances, where people have so much experience in performing a task that it has become fully automated, can we carry out multiple processes. However, since these processes have become automated, they don't require thought or information processing. Walking and talking at the same time is something most people are able to do, but even then accidents are possible, especially when the conversation is engrossing. When this is the case – especially if the environment is a novel one – we may not register what is in our environment (i.e., we see it but don't process it) and thus trip over a curb, walk into a lamppost, miss the corner where we should have turned off, and so forth. What is clear is that people are not capable of thinking two different thoughts at the same time. In that case, they task-switch, which means that they divide their attention and switch their attention to different cognitive tasks. Because of the often short switches it may appear simultaneous, but it is not. The fact that the brain has strict constraints about the number of cognitive processes it can process is known as the "cognitive bottleneck". A team of researchers led by Michael Tombu has shown the existence of the cognitive bottleneck at the neural-cluster level. These findings imply that executing different cognitive tasks at the same time is much more difficult than we might expect.

For example, have you ever tried to type an e-mail while you are talking to someone on the telephone? It's not easy, is it? Actually, this is a very difficult task. It seems as if each of the tasks that we try to perform distracts us from the other task that we try to do at the same time, even though neither is "rocket science". The result is poor performance on both tasks. While typing, you miss what the other person has said since you were thinking about what you were writing. You heard the person say something but did not process it. It turns out that almost nobody can multitask successfully, whether they are female, generation Y, Z or whatever, or both!

One of the authors of this book has argued in the past that research has proven time and again that the simultaneous execution of tasks inevitably leads to a loss of concentration, the need for longer periods of study and poorer performance. For mastering the content of short texts, "multitaskers" (learners who read and texted "at the same time") needed almost twice as much time and made almost twice as many mistakes as "serial taskers". With reference to learning, we can point specifically to studies carried out at the University of California, Los Angeles, where it was shown that even if you do learn something during multitasking, it is more difficult for you to use what you have learnt later on, because it is much more difficult for your memory to recall. A study by Sanbonmatsu, Strayer, Medeiros-Ward, and Watson at the University of Utah corroborates these claims. Sanbonmatsu and his colleagues looked at the difference between the multitasking activity that people reported about themselves and their actual ability to multitask. The results were very interesting: the self-reported multitasking behavior was negatively correlated with multitasking ability. People who perceive themselves as multitaskers engage more than others in multitasking behavior, but their performance is much worse than they seem to expect.

What the study by Sanbonmatsu and colleagues strongly suggests is that most multitasking may not really be multitasking after all. In reality, multitasking implies continually changing between different tasks. Our brain is well able to do so, but the rapid switching between tasks costs (mental) energy. The end result is that you actually work less efficiently. The so-called "myth of multitasking", as Rosen calls it, is popular because performing more than one task at the same time *appears* to give people emotional gratification. We feel that we accomplish more, which gives a positive feeling. Thus, multitasking is self-reinforcing, as Wang and Tchernev describe it. The pleasure of multitasking overcomes negative cognitive effects in the minds of the "multitaskers".

Still, all this may be a problem of the past, right? It might be that new media teach children how to become better at multitasking. Sadly, the answer to this seems to be negative. This can be illustrated by research that was performed by a team from the Visual Cognition Laboratory at Duke University. Donohue's team investigated whether someone who regularly plays computer games is better at focusing on different tasks at the same time. It turns out that they are not. The test group of gamers was no better at driving and phoning than the control group of non-gamers. Sixty students were asked to play a racing game, while answering questions at the same time (to simulate a telephone conversation). The gamers were much better at the game – as you would expect – but their scores fell significantly once they were required to answer the questions. A large analysis by Wasylyshyn and Verhaeghen of the relation between people's age and their ability to switch between different tasks showed a similar result. When general cognitive decline was taken into account, older people did not perform worse than younger people when being asked to regularly switch between two different tasks.

So, Is Nobody Really Capable of Multitasking?

In all truth, there does seem to be evidence for the existence of a group of people who have the ability to multitask effectively. A research study carried out by Jason Watson and David Strayer in 2010 concluded that their survey population of 200 test subjects contained five "supertaskers", people who were able to do different things at the same time without any noticeable loss of quality. However, it is suspected that these people – as has been already mentioned – are able to switch from one task to another very quickly, rather than actually doing both tasks at the same time. So if you are one of the 2.5% of people who can e-mail and telephone simultaneously, congratulations! You now know that you belong to a very small and privileged minority.

Source

Watson, J. M., & Strayer, D. L. (2010). Supertaskers: Profiles in extraordinary multitasking ability. *Psychonomic Bulletin & Review, 17*, 479–485.

:-\ We often do different things at the same time, but is that really positive? The simultaneous execution of tasks leads to a loss of concentration, the need for longer study periods and poorer performance. Very few people can multitask effectively.

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MYTH 2

We Only Use 10% of Our Brains

When looking at the end-of-term results of their class, some teachers may take comfort from the thought that their pupils are using only 10% of their brains. If only this were true! For one thing, it would mean that we could engage in much more dangerous action, because the chance of resulting brain damage would be much less. On the other hand, it would be a disaster if brain damage occurred in precisely the "10% region". But these ideas are absurd, as we will show.

In *Scientific American*, Robynne Boyd has argued that this myth dates back to the American psychologist and philosopher William James, who, in his book *The energies of men*, suggested that human beings make use of only a limited part of their physical and mental potential. This "unexploited potential" idea developed into the familiar 10% myth. Others have linked this assertion with Albert Einstein, who is supposed to have used it to indicate his own level of intelligence. This is incorrect, in that no reliable source for this quotation seems to exist (still, neuroscientist John Geake argues that Einstein did mention the 10% statement in a 1920s radio show). The myth seems to have become a part of Western culture. Even Hollywood likes to use it as a plot vehicle, for example in the movie *Limitless*, which revolves around a so-called "smart pill" that allows users to access 100% of their brain abilities. The 2014 movie *Lucy* exploits a similar concept.

Why do we call this claim a myth? Neuroscientist Barry Beyerstein has put forward five arguments to refute it, based on the concepts of brain damage, evolution, brain scans, functional areas and degeneration.

- *Brain damage.* As already mentioned, the effect of damage to the brain would be much less dramatic if we were using only 10% of its full capacity. Unfortunately, the opposite is true: there is almost no part of the brain that can suffer damage without at least some loss of function. In fact, relatively small amounts of damage to relatively small areas of the brain can have devastating consequences. With the right therapy, the victims of brain damage can sometimes compensate for loss of function through the plasticity of the brain, but that is the exception rather than the rule. Also, the notion that parts of the brain do not serve any particular purpose can have devastating consequences, as shown by the popularity of frontal lobotomy, a surgical procedure in which most of a person's frontal cortex is removed. Although this does successfully reduce pathological behavior, it has major behavioral side-effects; and to think that António Egas Moniz won the Nobel Prize for Medicine in 1949 for inventing this procedure!

- *Evolution*. Our brains use a lot of energy, in terms of both nutrition and oxygen. Even though the brain makes up only about 2% of our body weight, its energy consumption is about 20% of all available oxygen in the blood. Imagine that the "we only use 10% of our brains" idea is true. This would mean that creatures with a small brain would have an evolutionary advantage. In these circumstances, it is open to question whether we would ever have survived so long with such a large brain. In fact, evolution would probably have ensured that our brain was never allowed to get so big. As Beyerstein concludes: "In the millions of studies of the brain, no one has ever found an unused portion [of the brain]".
- *Brain scans*. New technologies such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) allow us to see the activity of the brain in detail. These scans make it clear that there is neural activity throughout the whole brain, even when we are sleeping. Conversely, in cases of serious brain damage there are large areas in the brain where there is no longer any activity at all. This is why we often use the term "brain dead", not to be confused with vegetative state. Brain dead refers to the worst degree of functional brain damage that that is compatible with physical survival following coma.
- *Functional areas*. The human body contains quite a few "leftovers": body parts that evolved in the past, but that we do not need any more for daily life, for example our wisdom teeth. Our bodies even have a remnant of a tail (the coccyx). The question can be asked whether the brain also contains parts that are evolutionarily "outdated". Many years of research have taught us that this does not seem to be the case. The brain is made up of different areas with different functions, which all work together. There is no known part of the brain that does not have a specific function.
- *Degeneration*. Imagine that our brains contain lots of brain cells that we never use. These would gradually die off, since this is what automatically happens to cells that have no useful function; they degenerate and die. In this case, the largest part of the human brain would already

have disappeared before we died. But we know that this is not the case under normal circumstances.

In fact, the brain is very flexible in the way it allows cells to die. This is a process called "synaptic pruning", and it forms the foundation for brain development. Without pruning, our brains would never really develop. Years of research have shown that the brain is constantly has developing and that brain function is much more "plastic" than has been assumed. For example, a study by Scholz, Klein, Behrens, and Johansen-Berg revealed that juggling changes the brain in different ways. Both gray and white matter in the brain appear to grow and shrink under the influence of practice. Another famous study that showed this effect was conducted by Maguire and his colleagues, who studied the brains of London taxi drivers. It turns out that the brain areas responsible for maintaining an accurate representation of the complex street layout of London have grown enormously in experienced taxi drivers. Both pruning and plasticity of the brain indicate that an exact measure such as "10%" is far removed from reality.

In view of all these different arguments, how is it possible that the 10% myth continues to be believed by so many people? A few reasons have been touched upon above. In addition to those, it may be the result of all the images of brain scans that have appeared in the media in recent times. These often show limited areas of bright color to denote peaks of brain activity (actually of blood flow) – but this does not mean that the rest is not working at all! Pictures of brain activity are heavily processed and are subjected to different statistical analyses to make clear in which part of the brain there is more activity than in other parts, at any given time. The result is a distorted representation. In short, it is all a matter of lies, damned lies, and brain statistics.

We began this section by stating that the myth may find its origin in William James's idea that people do not tap their full potential, and that a huge amount of it remains unused. Certainly, this is not an unattractive idea. It implies that we all still have room for growth in our lives. One way to achieve such growth is through better use of our brain. This idea is particularly appealing in education, where it is important to focus not just on limitations but also on possibilities for improvement. The brain's plasticity is perfectly suited to this approach. But both growth and improvement are still possible even if we use more than the 10% of our brains stated in the myth. And we do use more, much more – 90% more!

> It may seem that some people are using only 10% of their brain, but this is not the case – we use all of it, all of the time.

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MYTH 3

The Left Half of the Brain Is Analytical, the Right Half Is Creative

To succeed in life, it is important to be creative. Creativity refers not to some specific ability, but to a more generic aptitude for intelligent problem solving and a knack for looking at problems from a new, fresh perspective. Of course, the brain is heavily involved in creativity, and it can be argued that one important aspect of creativity is the interaction between the brain's two hemispheres. The hemispheres are connected by a large bundle of neural fibers, the corpus callosum. The fact that the two halves of the brain are heavily connected to each other and are in constant communication has not stopped marketing and education gurus from encouraging us to use the right half of our brains more, since this is our innovative, creative, holistic, feminine, Eastern, "yang" side. These same gurus also tell us that we live in a world dominated by the rational, systematic, masculine, Western, "yin" left half of the brain. As Michael Corballis has noted, this asymmetry between the two halves of the brain is considered by many to be unique to humans, although this is not the case. Perhaps you have done a test on the Internet, which showed a turning dancer. The direction in which you see the dancer turn is commonly interpreted as revealing which half of your brain is more dominant. The real explanation for the direction you perceive (and the way it usually changes after staring at the picture for a while) has absolutely nothing to do with the left and right hemispheres and some sort of "dominance". The dancer is an example of a so-called bistable perception or an ambiguous figure: it can be perceived in two ways, with no way being dominant over the other. As Parker and Krug explain, the brain simply picks one perception, and will after a while switch to the other perception.

Lisa Collier Cool described how the concept of different and independent halves of the brain originated during the nineteenth century. Doctors discovered that if one side of the brain was damaged, certain functions would disappear. Modern brain scans have now revealed that the two sides are more closely connected than originally thought, but the basic idea developed in the nineteenth century – that the left side of the brain directs the right side of the body and vice versa (something that was hypothesized by Hippocrates) – is broadly true.

The idea that the left side of the brain is "rational" and the right side "creative" is more recent. It first appeared in a number of popular books in the second half of the twentieth century. From there, it slowly gained a hold in education. Professor Usha Goswami refers to the idea as one of the most troubling of the different neuromyths, because it results in a complete misunderstanding among the public about the relation between neuroscience and education.

What is the current thinking on this matter? As we said, if someone needs to approach a problem creatively, they use their whole brain. It is true that the two halves are different, and that the majority of people do use the left half for most aspects of language, while using the right side for more specialized spatial skills. But still, even for specialized functions such as language, it is clear that the opposite half still plays an important contributory role. The consensus in the neuroscience community seems to be that the study of connectivity in the brain is more interesting than localization of specific functions. Major steps still need to be made in this direction. Steven Bressler and Vinod Menon showed how it is possible to describe brain functioning on a large scale. Central to their notion is dynamic interaction between different areas in the brain. A large study by a group of researchers led by Jared Nielsen also found that although there are localized areas in the brain, it makes no sense to talk about a "left-brained" or "right-brained" network when the whole brain is taken into account. Interestingly, Nielsen and his colleagues also found no difference in brain lateralization between men and women. The analyses that we describe here are forays in an unknown direction, but the future looks promising. Eventually, new discoveries about integrated brain functioning may lead to a rethinking of the way in which cognitive processes occur in the brain.

There is also evidence from research that shows how both halves of the brain are involved in creative processing. In 2004, an experiment by Singh and O'Boyle tested the claim that the two halves of the brain in creative people are used unequally. In their experiment they projected letters at high speed on to the retinas of a group of young people. If participants in the experiment saw the same letter twice, they had to quickly press a button. We already know that through brain lateralization the letters projected on to the left eye end up as images in the right half of the brain and vice versa. This is what makes it a difficult test, involving the coordinated use of both halves of the brain. What transpired? The young people who pressed the button quickest often turned out to be the most creative as well, thereby showing that the combined working of both halves of the brain can be linked to creativity.

What are the biggest dangers associated with this myth? Some have used the idea as a metaphor to indict a world that has become dominated by reason, and reason alone. But this is the same kind of thinking that pigeonholes people in just one of two boxes: rational or emotional. And we have already seen earlier in the book that this kind of restrictive thinking can be a bad idea. Also, the left-brain and right-brain distinction is another example of so-called "neuromarketing", the business involved in highly lucrative selling and endorsing of products that the makers say or claim are specifically geared to the "whole brain" or the "creative brain". An experiment by Annukka Lindell and Evan Kidd revealed the effectiveness of neuromarketing: consumers preferred a training program that was called "Right Brain" over a training that was simply called "Right Start". Again, the use of the word "brain" gives people a feeling of a strong scientific basis. If it's in the brain, it must be true!

For this reason and for the reasons above, we would not recommend the training packages that are now available to specifically develop the right side of your brain.

:-\ Although thinking and creativity require a good connection between both halves of your brain, there is no reason to assume a "left-brained" and "right-brained" style of thinking.

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MYTH 4

You Can Train Your Brain with Brain Gym and Brain Games

Brain training is hot. Training your brain, which means training your problem-solving skills, your hand–eye coordination, your memory or any other combination of cognitive abilities seems to have replaced dieting as a "must-do" fad. All kinds of wonderful new tools have been developed for this purpose in recent years, such as Brain Gym® or Brain Games, with Nintendo's Brain Age™ perhaps being the best known of all. The reason is simple: brain training has grown into a major business. Worldwide revenues in 2012 exceeded more than $1 billion, and they may well surpass $6 billion by 2020. The popularity of training programs for the brain raises questions about their effectiveness. Does regular practice with brain games improve cognitive functioning, and can these changes have a permanent effect? A number of scientific studies have tried to find out, but the results have been unequivocally disappointing.

For example, in 2010 the British television program *Bang goes the theory* tested brain games that claimed to improve the memory and reasoning skills of its users. In total, 11,430 people participated in this experiment. The trial involved 8692 participants aged between 18 and 60 years who were asked to play one of the games three times a week for six weeks, with a minimum game time of 10 minutes a day. In addition, there was a control group of a further 2738 people. These people were asked not to play a game but instead to surf the Internet for the same amount of time, to try and find the answers to a number of general questions. At the end of the trial period, the same IQ test was administered to all participants. The results of this test were clear: there was no difference between the performance of the game group and that of the Internet group. In fact, the Internet surfing group scored higher than the game group on some elements of the test. Although the experiment was conducted for television (and was criticized for this reason), it had a sound scientific base. Adrian Owen of the Cognition and Brain Sciences Unit at Cambridge University and his colleagues published their findings in the respected journal *Nature*. Their report concludes with a crystal-clear verdict: "We believe that these results confirm that six weeks of regular brain training confers no greater benefit than simply answering general knowledge questions using the Internet".

So far, so bad, but how about the popular Nintendo games? Stuart Ritchie from the University of Edinburgh and his colleagues conducted research on Brain Gym, and also reviewed the evidence relating to brain training on Nintendo consoles. Their conclusion is that this training is not effective. The same lack of effect was found with respect to Brain Gym, a series of physical movement exercises designed to improve your brain. Ritchie found that other, more traditional brain enhancers – such as drinking lots of water (which prevents the brain from drying out) or using cod-liver oil (rich in omega-3) – could also be dismissed. Apparently, it's not easy to affect the brain through simple means.

A report commissioned by the UK government and carried out by the Education Endowment Foundation reviewed educational interventions informed by neuroscience (Howard-Jones, 2014). The report points out that there is some evidence for the effectiveness of a few specific interventions, but that any differences that are found in research usually disappear as soon as more rigorous analytical methods are applied to the data. This is the case, for example, with Cogmed Working Memory Training (© CWMT; www.cogmed.com). Cogmed was developed with the goal of being able to improve working memory in children with attention-deficit/hyperactivity disorder (ADHD). A working memory deficit has been found to be one of the main characteristics of ADHD. In a thorough study, Anil Chacko from the City University of New York and colleagues administered either a CWMT active or a CWMT passive (control) treatment to 85 children with ADHD. They found only limited results: working memory did improve a little for children in the CWMT active condition, but this improvement could only be found when specific memory tests were administered. No discernible improvement in normal functioning could be found. Chacko concludes that Cogmed should not be considered effective for treating children with ADHD.

What Cogmed does show is that there are methods that can improve the working of our memory, but they are often devised for the learning of very specific types of content. For example, you can try mnemonic tricks, repetitive sequences of the same stimulus or making mind maps, which are designed to give a particular meaning to the things you want to remember. A mind map, as the name suggests, requires you to mentally map out a concept clearly and concisely, but without the need to think in too much detail about a specific formulation. You do this by using a graphic schedule (often known as an information tree), starting from a central subject that you can then link to related concepts and other subsidiary matters.

Still, it is important to note that training effects have been shown to be limited. In a 2013 study by Tyler Harrison and colleagues, participants followed a specific training regime to improve the size of their working memory. The study showed how people's working memory capacity did improve: they were able to use their memory more effectively on tasks that were similar to the training tasks. However, the ability to better use your memory does not seem to spread to more general cognitive improvements. Harrison et al. looked at fluid intelligence, which involves problem solving and logical thinking. Improving working memory capacity did not have any effect on the fluid intelligence scores of the people who participated in the training.

All the research seems to point in one direction: training can help people in learning to apply strategies that improve working memory capacity. The word "brain" is misleading since any training necessarily involves the brain. There is as yet no evidence at all that brain training that is aimed at improving general cognitive abilities such as fluid intelligence will in any way be effective: just don't expect to become smarter from playing video games.

In October 2014, 73 psychologists, cognitive scientists and neuroscientists from around the world signed an open letter stating that companies marketing "brain games" that are meant to slow or reverse age-related memory decline and enhance other cognitive functions are exploiting customers by making "exaggerated and misleading claims" that are not based on sound scientific evidence.

To end this section on a positive note, there are some things that are known to be healthy for your brain. These are: using it regularly, taking exercise and eating a balanced diet. Did you expect anything else?

Or You Could Start Chewing ...

Curiously enough, it appears that bubblegum also has a positive (very) short-term effect on the brain. Craig Johnston of the Baylor College of Medicine found that chewing gum helps to reduce stress and improve concentration, and thus helps academic performance. Opinion on this matter is still divided, though, not least because Johnston's research was sponsored by chewing gum business William Wrigley Jr. Even if it is true, it is not clear whether its beneficial effect is caused by the chewing motion or by an injection of sugar into the system.

As a result, we wouldn't yet recommend you to tell your pupils to chew their way through their exams!

Source

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Train Your Working Memory Against Depression

While there is hardly any evidence to support the brain improvement claims of the various computer-based commercial packages, Swedish researchers are developing programs that can help to optimize working memory in children with ADHD. Similarly, in The Netherlands, Elke Geraerts and her colleagues at the University of Rotterdam have been working on a series of computer exercises to improve the working memory, specifically as an aid to combat depression.

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:-\ Buy a game console for your pleasure – because that is all it is good for. For the time being, there is no evidence that this and other brain gym methods do anything to improve the performance of your brain.

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MYTH 5

Men Have a Different Kind of Brain than Women

Obviously, men are different from women; at least, physical differences are observable. People also have all sorts of ideas about gender differences in thinking. Some of these ideas are clearly stereotypes, but for others things are less clear. The question boils down to this: Is there such a thing as the male brain and the female brain? And if there is, should we take account of differences between male and female brains in the classroom?

We know that male and female brains do differ from each other in terms of form and function. On average, the male brain is larger than the female brain. This fact led the famous neurologist Pierre-Paul Broca to assume that men must be more intelligent than women (a claim that was socially acceptable during Broca's days in the nineteenth century). Also, the language area in the female brain is, in general, more active than the same area in the male brain. Still, it is far from clear what these observable differences actually mean in practice. We have already seen that boys and girls perform differently in different subjects (even to the point that girls were shown to be better in all subjects in a metastudy of school results over the past 100 years), such as mathematics, but we concluded that this was more the result of cultural factors than biological ones. In other words, the observed differences between performance between boys and girls seem to be unrelated to brain differences.

To date, no empirical proof has been offered to show that boys and girls learn in a different way from each other. Nor has it been scientifically proven that women are better at multitasking or that their brains are designed to behave more empathically. It is certainly true that women score better than men in empathy tests ... except in the tests where the men are told that they usually do better than women! A study by researchers from Cambridge University looked at many aspects of the brains of men and women with the aim of improving neuropsychiatric diagnosis and eventual treatment. This large meta-analysis compared data reported in 167 articles (selected from an initial giant stack of 5600 relevant articles). Apart from the obvious differences, such as brain size, differences were found in the amygdala (a brain area involved in memory and emotion) and the hippocampus (an area involved in processing memories). The researchers note that they cannot predict how differences in brain structures influence actual behavior. Even though differences in brain physiology provide a welcome source for ideas about behavioral gender differences, these are not substantiated by facts.

This brings us back to the danger of thinking in terms of boxes. The British psychologist Cordelia Fine warns us to be on our guard against "neurosexism". By placing too much emphasis on possible but unsubstantiated differences between the brains of men and women, there is a risk that we will create new and prejudicial sexual stereotypes. Although the concept of neurosexism and the book by Fine were heavily criticized by some neuroscientists, there is certainly a growing consensus that there exists a tendency to overstress gender-based differences. We tend to look for and focus on small differences between two groups, whereas we underestimate or even ignore the much larger differences within groups. If we look at the things our brains are most actively engaged in, we find no relevant differences between the way men and women observe the world, the way they learn new things, the way they store memories or how they communicate with each other.

A study by Janet Hyde has shed new light on this last aspect, although her conclusions may so some extent by colored by her basic premises. This is a general issue in research on gender differences; it is often very difficult to distinguish between opinions and facts. In her research Hyde did not search for differences, but instead for similarities between men and women. Of course, she was able to observe many similarities. Consequently, she was able to dispel a few classic ideas about men and women, by establishing that:

- Women do not really talk more than men.
- Women only reveal marginally more personal details about themselves than men.
- Men and women are equally capable of interrupting; this is largely a question of social status – if the woman has the lead, she will be more inclined to butt in.

As we have already stated, in practice there are more differences within the sexes than between the sexes. But this fact implies that the claim that single-sex education will be more effective than mixed education is wrong. We will look at this subject again later in the book.

:-\ Yes, the brains of boys and girls are in some ways different, but there are more similarities than differences. You should not use these differences as an argument.

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MYTH 6

We Can Learn While We Are Asleep

It may be every student's dream: to be able to learn while you're asleep! The idea that it could be possible to learn new information during sleep (also known as hypnopedia) is not new. Sleep-learning has always been a popular topic in fiction. Also, there is a business element involved: in the past cassette tapes were sold with the intention that they would be put on "repeat" while sleeping, while nowadays digital files are sold through the Internet with the same intention. Experiments to see whether sleep-learning is really possible were already being carried out during the Second World War. It was hoped that secret agents would be able to more quickly learn the dialects of the regions into which they were to be parachuted if they continued learning foreign languages while they were sleeping.

Russian research has suggested that the idea is a valid one, but their scientific methods were not wholly reliable. In particular, it was not clear why it seemed to work with one person, but not with another. Moreover, the Russians failed to check to what extent the test subjects did or did not sleep throughout the night. This may help to explain why scientists in the West have never been able to come up with comparable results.

Research has established that after an operation, people were able to remember things that were said during their operation, while they were anaesthetized. But this is not the same as learning in your sleep, because the state of being under anesthesia is not comparable with the sleep state. It lacks the depth of sleep and second, it is more like a chemically induced and reversible coma, in which relatively little brain activity is registered.

So, unless you recorded yourself speaking the text or you never actually sleep, we are afraid that the recording you play on your smartphone throughout the night won't help you much when exam time comes around.

Yet, perhaps there is a little bit of hope. A study by researchers from the Weizmann Institute of Science in Israel has shown that there is a way in which you *can* learn during your sleep. It is similar to the way the Russian neurologist Ivan Pavlov conditioned his dogs to salivate. In other words, we are not talking about learning content, but more a kind of classical conditioning. The dogs learned to associate receiving food with the sound of a bell. Over time, they began to salivate in anticipation every time they heard the bell. It now appears that this same mechanism can be applied to people, not with sound – which would probably wake the person up – but with smell. While asleep, test subjects heard a tone, following which an aroma was released. A pleasant aroma followed one tone and a less than pleasant aroma followed a different tone. What happened? The following day – while awake – test subjects reacted to both tones as though the "learnt" aroma was about to be released. This means that while they were sleeping, their brain did learn to associate a tone with a smell.

Of course, this is not really learning but rather, at most, very low-order learning at the same level as simple operant conditioning. Further research is needed to explore whether it is possible to extend this to real learning. In the meantime, we recommend not letting those recordings disturb your beauty sleep just yet.

Sleep and School: Why not Begin at 11 o'Clock?

Research by Russell Foster, a professor of neuroscience at Oxford University, has suggested that the students' memories function better during tests conducted at 2 pm than at the "ungodly" hour of 9 am. For this reason, he argues in favor of starting school at the more reasonable hour of 11 o'clock.

The most important reason for this, according to Foster, is that young people sleep too little. Why do they sleep so little? Because teenage life is overfull (e.g., homework, friends, Internet, television, parents, parties, sports) and they drink too many caffeine-rich drinks. Moreover, during this period of their lives their sleeping rhythms change. The research was formally conducted in an English school, but the results only made the British media, and to date have not been published in any scientific journal.

Source

Rosen, D. (2009). Sleeping angels. Should high school start at 11am? *Psychology Today*, Retrieved June 14, 2014, from <http://www.psychologytoday.com/blog/sleeping-angels/200903/should-high-school-start-11-am>.

:-\ People can be conditioned in their sleep; for example, to associate particular smells with particular tones. But can we actually learn content in our sleep? Dream on!

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MYTH 7

Babies Become Cleverer if They Listen to Classical Music

In 1993, an influential article was published in the scientific journal *Nature.* The researchers, from the University of California, claimed that after listening for just 10 minutes to a Mozart piano sonata (K448), a group of university students were able to perform a series of spatial reasoning tests – as part of the standard Stanford–Binet Intelligence Scale – noticeably better than a control group which was played a tape of "ordinary" relaxing music, whatever that is. The improved spatial reasoning was sometimes interpreted as a claim that listening to Mozart could temporarily raise your general IQ by 8 or 9 points! This finding has gained wide popularity and has become known as the "Mozart effect". The inevitable Mozart CDs for babies soon followed. Even now, there are multiple web stores selling MP3 recordings geared at "stimulating your baby's brain". In 1998, the governor of Georgia even set aside $105,000 of the state budget to provide every child born in the state of Georgia (approximately 100,000 per year) with a tape or CD of classical music. The governor was quoted in *The New York Times* as stating: "No one questions that listening to music at a very early age affects the spatial, temporal reasoning that underlies math and engineering and even chess".

It is clear that this research had a high score for reliability on the checklist at the back of this book, but (once again) the conclusions reported in the media went far beyond what the researchers had actually said. For one thing, the improvement in reasoning in the group that listened to Mozart was only noted immediately after the playing of the Mozart sonata. Also, the effect seemed to last only for a very brief time. It was never claimed to be a lasting effect.

The Mozart effect has been a welcome research topic, and multiple studies have tried to replicate the effect, sometimes with (limited) success. Versna Ivanov and John Geake (Geake is mentioned elsewhere in this book as a "myth buster") found some evidence for the Mozart effect, although listening to music by Johann Sebastian Bach proved to be just as effective. One obvious question is whether it is necessary to play music by Mozart to improve one's cognitive skills. Maybe music that we personally enjoy can be just as, or even more effective than Mozart. In that case, classical music should not have any specific advantage over other types of music: it's just a matter of personal preference. Studies like the one by Ivanov and Geake provide evidence that backs up this claim. Donna Lerch and Thomas Anderson analyzed and compared many of the Mozart effect studies. They came to the following general conclusion:

> *The music of Wolfgang Amadeus Mozart is both physically and aesthetically accessible to the general public. A number of studies have indicated that listening to Mozart's work may temporarily increase cognitive skills. Other studies have found no statistically significant "Mozart effect". It is unfortunate that the media and commercial ventures have taken the initial modest, unverified study and conjured up a pseudo-science which gave rise to, and which continues to promote, a full-blown industry.*

One of the companies that discovered to their own cost and shame that they should never have become involved with such products is Disney. The "Baby Einstein (TM)" CDs were a profitable and successful business venture for Disney. In 2007, however, a study by Zimmerman, Christakis, and Meltzoff caused a large stir among the public when they reported that their research showed that the products in the Baby Einstein series could actually lead in some cases to a worsening rather than an improvement of language ability. This study was hotly contested and a number of matters still remain unclear. A reanalysis of the data from Zimmerman et al.'s 2007 experiment by Ferguson and Donnellan led them to conclude that it is not possible to make strong inferences from the data from the 2007 experiment, but Zimmerman strongly disagrees. The matter remains contested; even so, after many complaints, in 2009 Disney organized repayment for disgruntled parents, admitting that its products had been incorrectly marketed as "educational".

So, does a bit of music have no positive effect on the brain at all? Actually, there may be one long-lasting effect that is of interest. However, it does not involve merely listening to music, but practicing and playing a musical instrument yourself. Research has shown that older adults benefit from music training early in life. Even when people have not played a musical instrument for decades, their neural processing of sounds is improved over people who had no music practice early in life. These "trained" older people experience fewer difficulties understanding speech, even in crowded environments. This leads us to conclude that smart parents do not force their children to listen to Mozart, but encourage them to create their own music instead.

:-\ Classical music will not make your children any smarter.

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MYTH 8

We Think Most Clearly When We Are Under Pressure

It has become a staple of many popular action movies. About two-thirds into the movie, the hero gets into serious trouble. All hope seems lost. It is right at that moment of maximum pressure that the hero has his or her finest hour, and saves the day. This idea is also part of our culture: when we are forced to think under pressure, we come up with better solutions more quickly. It has become a cliché – but is it actually true?

At first hearing, it doesn't sound illogical. As soon as our adrenaline begins to flow, we are capable of much more than in a normal situation (you've heard of the woman who lifted up the car that her child was under). What happens in stress situations is that our bodies show a physiological fight-or-flight response. As part of this, our brains become supercharged with powerful hormones. The fight-or-flight response facilitates a quick reaction to emergency situations. Also, a bit of pressure makes us more alert and helps us to create new memories. Still, everything in moderation. If stressful situations happen too often, they can have a negative effect on the brain. Some researchers argue that too much stress can even cause permanent brain damage. For example, researchers from the Yale University School of Medicine have shown that learned helplessness in rats, which is a typical stressful condition, leads to damage in the hippocampus, the area in the brain that controls memory formation. The same seems to be true for humans. In particular, our memory can suffer if it is subjected to too much stress, so that we have more trouble remembering and recalling things. A large review study at the Center for Studies on Human Stress at McGill University showed that the relation between the level of stress and cognitive performance as measured, for example, in hippocampal volume follows an inverted-U shape. That is, there is an optimum level of performance that depends on the amount of stress: both too little and too much stress degrades performance.

Other studies have shown that the related emotion of fear can also have a negative effect on how children perform at school and can actually limit their ability to learn. For example, considerable research has been carried out into so-called "maths anxiety". An analysis of the Programme for International Student Assessment (PISA) results for 2003 showed that the countries with above-average performance in mathematics were also the countries with the lowest incidence of maths anxiety. The question is: Which causes which? Is it the case that if you're good at math this leads to less anxiety? Or is it that if you have less anxiety, you perform better? Or is there possibly a third factor that influences both?

Mullainathan and Shafir describe how we seem to have a limited amount of what they call mental "bandwidth" and that we use a bit of that bandwidth each time we address a problem (e.g., fear or stress because of poverty or time restraints). This used bandwidth then cannot be used for learning.

:-\ You do not think "better" under pressure and you learn less well if you are frightened.

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Does It Help to Have a Correct Knowledge of How the Brain Works?

Right, so what have we learned so far? Most of us cannot multitask, we use all of our brain (both the left and the right halves), we prefer to have our sleep undisturbed and babies prefer this too (no Mozart, thank you), and we do not necessarily perform better under pressure. The fact that many people, including many teachers, still believe in some or all of these myths is a cause for real concern. We have shown that knowledge about the brain is taken seriously (and usually rightfully so), and will in all probability have a direct impact on teaching practice. So if this knowledge is faulty, the impact on educational practice cannot be anything else than negative. We therefore need to ensure the use of correct knowledge so that it can have a positive – rather than a negative – effect.

It is likely that part of the potential of every pupil in class is unused at the moment. This is a matter of concern, and appropriate action may be taken, as long as it is clear that it has nothing to do with the pupil's brain.

Over the years, numerous studies in the field of educational psychology have shown that learning requires active effort on the part of the learner in order to be effective. It is better to be honest with your pupils – and their parents – on this score, rather than offer false hopes that learning will happen by itself, almost like magic. Learning is hard, and it can be argued that it is important for learning to be hard to be more effective. As Lev Vygotsky stated at the beginning of the twentieth century, real learning takes place in a learner's zone of proximal development: that narrow region where learning is challenging but not *too* hard. However, putting pupils under pressure – as is sometimes the case with speed tests – can also have a clear negative effect, particularly for pupils who are more sensitive to being placed in a stressful situation.

Teachers who treat boys and girls differently are in danger of creating a self-fulfilling prophesy: they may encourage pupils to behave in accordance with the stereotypes that have been set for them; a process sometimes referred to as the "stereotype threat", an effect that has been researched with sometimes positive and sometimes negative results.

The idea that there is some kind of general training method that can help us to improve the working of our brain and the way we think is an old one. We have shown that these general methods are mostly ineffective. The implication for education is that we should not become fixated on disciplines that we believe can help our pupils to think better. In the past, these were thought to be classical languages such as Latin and Greek; nowadays you see many schools devoting extra attention to chess. Even computer programming has been touted as a method to improve logical problem solving. Both are certainly useful and entertaining pastimes, just as Latin and Greek are fascinating subjects, but the idea that they will somehow hone your "analytical skills" should be taken with a very large pinch of salt.

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