Neuromyths: Why Do They Exist and Persist?

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ABSTRACT—Neuroeducation—a recent approach to educational policy—claims that a bridge should be established between education and mind-brain sciences, with the double aim of devising educational methods that work and of understanding why they work. The success of this encounter depends, among other conditions, on getting the science *right*; otherwise, neuroeducation and science-informed policies risk doing more harm than good. On several occasions, the cognitive and brain sciences have been misunderstood, and misused: neuromyths—the misconceptions about the mind and brain functioning—have blossomed, thus raising both theoretical and pragmatic concerns. This article addresses the origin, persistence, and potential side-effects of neuromyths in education. The hypothesis is put forward that the persistence of neuromyths is sustained by specific cultural conditions, such as the circulation of pieces of information about the brain and the appetite for brain news, but has its roots in deeper cognitive intuitions.

> There are many hypotheses in science which are wrong. That's perfectly all right; they're the aperture to finding out what's right. Science is a self-correcting process. To be accepted, new ideas must survive the most rigorous standards of evidence and scrutiny. (Carl Sagan, *Cosmos*, Fourth Episode).

The orienting of research toward the development of real-world applications—and the orienting of real-world policy making toward science and evidence—is the flavor of the month in education: between 2009 and 2010, and coherently with its editor-in-chief's claim that "policy-making needs science" (Alberts, 2010), the prestigious journal *Science* has dedicated three special issues to science-informed education. Just before that, in 2007, were born the *Mind, Brain, and Education* conference, collaboration, and journal; and during the 2000 decade, while the international organization OCDE was achieving two programs on education and the brain, with relative publications, the ESRC and the Royal Society were producing reports on neuroeducation for the UK. Education, cognitive science, and neuroscience have thus become active arenas for the encounter of science and society. The success of this encounter depends, among other conditions, on the fact that policymakers get the science *right*; otherwise, neuroeducation and science-informed policies can do more harm than good (Bruer, 1997). It is a fact that on several occasions the cognitive and brain sciences have been misunderstood and misused. In 1998, the state of Florida passed a bill for day-care centers to play classical music to children. The same year, the Georgia governor asked for $105,000 for the production and distribution of classical music to newborns. He did so because he had read that listening to Mozart's music can boost IQ scores. Too good to be true. The good news had been amplified by several newspapers, but it had its origin in scientific research developed in a psychology department. Rauscher, Shaw, and Ky (1993) had measured the effects of listening to Mozart's music on adults' spatial capacities, compared them to listening to relaxing music and to silence, and found an increase of 8 to 9 points on an IQ scale for the "Mozart condition." Unfortunately, other laboratories have not been able to replicate the results, and the "Mozart effect" has been debunked (Chabris, 1999; Pietschnig, Voracek, & Formann, 2010; Steele et al., 1999). Despite the absence of evidence, in 2004 80% of 496 people interviewed in California and Arizona were familiar with the Mozart effect and products based on the Mozart effect© (a Don Campbell's trade mark) are sold in millions of copies (Bangerter & Heath, 2004). It is worth adding that the article originally published by Rauscher and colleagues does not even mention potential effects on children or long-term modifications.

This article proposes a reflection on the diffusion of misconceptions—like the Mozart effect—that negatively affect the scientific approach to education. As these misconceptions are related to knowledge about the mind

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and brain, in the domain of education they are known as "neuromyths" (Geake, 2008; Goswami, 2008; Howard-Jones, 2009; OECD, 2002; Waterhouse, 2006).[1] This article discusses the origin of neuromyths and offers a theoretical framework for explaining their persistence in the face of opposing knowledge; in the framework of an examination of the ethical risks for science-informed education, some possible actions for countering their effects are put forth.

GENESIS AND PERSISTENCE OF NEUROMYTHS

Neuromyths can be generated by a variety of processes. Some neuromyths are *distortions of scientific facts*, that is, they stem from undue simplifications of scientific results. For example, research on hemispheric specialization and dominance has given rise to the myth that people are rather right- or left-brained, and that the balance between the two is a desirable effect, somehow not to be taken for granted; special forms of training are then proposed in order to bring the brain to an equilibrium (Geake, 2008; Goswami, 2008). Neuromyths can also be the *offspring of scientific hypotheses* that have been held true for a while, and then abandoned because of the emergence of new evidence—as in the case of the Mozart effect. Thirdly, myths can grow from the *misinterpretations of experimental results*. It is the case for the myth of the first 3 years, stating that learning depends (only) on synaptic growth and that no other period is as good as the first 3 years of life for learning (in general), because this is the limited window of time during which synaptic growth occurs. The myth fails to take into account the different rates of maturation of the human brain, and life-long learning based on functional rather than anatomic plasticity (Bruer, 1993, 1997). In other cases—for example, the myth that only a fraction, namely 10%, of our brain is currently used—it is harder to trace the relationship of the myth with (distorted, outdated, or misinterpreted) scientific results. The myth of the 10% might stem from considerations about the untapped potential of the human psyche (including unproven parapsychological assertions) or take inspiration from neuroanatomical considerations about glia-neuron rate, or white matter-grey matter (Della Sala, 2007; Lilienfeld, Linn, Ruscio, & Beyerstein, 2010). What is sure is that the myth of the 10% relates to the more general shift from the mentalist vocabulary to the *neuroscientific jargon* that characterizes neuromyths as special misconceptions about the mind in relationship with the science of the brain. *Neuro*myths would not exist unless neurosciences had breached the perimeter of the scientific community and reached the laypeople by the means of popular media. Withal, neuromyths seem to find a favorable ground in *neurophilia*: the appetite for brain news, as it is discussed below.

Another characteristic of neuromyths consists in the fact that they tend to survive the circulation of correct information, and to be inflated by sensationalist press releases. Consequential to the academic and public debunking of the Mozart effect, enthusiasm for the power of classical music upon *adult* intelligence has declined in the popular press, yet claims concerning its effectiveness on the *baby mind* have become more common (Chabris & Simons, 2009). The "meme" of the Mozart effect has spread to the point that the Japanese market now offers bananas grown with the help of Mozart music (the Mozart bananas) and sake brewed on the notes of classical music (Krieger, 2010). Neuromyths thus seem to enjoy the same resilience to change that affects illusions (Pasquinelli, 2012), naïve beliefs about the physical and biological world (Vosniadou, 2008), ideas that "stick" independently from their truth (Heath & Heath, 2007), and urban legends (Brunvald, 1981).[2] While illusions are robust characteristics of the human mind, however, neuromyths are submitted to cultural conditions—that is, to the circulation of information and eventually of misinformation. The hypothesis can thus be put forward that the persistence of neuromyths is sustained by specific cultural conditions, such as the circulation of pieces of information about the brain and the appetite for brain news, but has its roots in cognitive illusions and biases. The aim of the following sections is to discuss this hypothesis and to devise strategies for countering the negative side-effects of scientific communication's shortcomings, neurophilia, and cognitive illusions.

COMMUNICATION SHORTCOMINGS

Titles like '*Your Brain in Love*' (Fischer, 2004) or '*Sarcasm Areas Discovered*' (BBC News, 2005) abound in newspapers and web sites. Still, the media coverage of brain news is often suboptimal, and three main flaws can be identified that are susceptible of feeding neuromyths: the tendency to offer irrelevant information, sensationalism, and the omission of relevant information.

The author of a news report on car crashes can cite the fact that "Brain studies have shown that the frontal lobes are not fully developed until young people reach the age of 25 years, the same time when age disappears as a risk factor for crashes, even after driving experience is taken into account" (Massey, 2007). Yet, knowledge about the rate of maturation of the frontal lobes does not add much to the crucial information that teenagers are bad drivers and that this condition is more or less solved around the age of 25: the identification of risk factors for crashes constitutes sufficient evidence for supporting the call that the minimum driving age should be set at 18 years rather than at 17. Providing pieces of information about brain studies is, in this case, irrelevant. Weisberg (2008) raises the same point in relations to media coverage of brain localizations: because taking place in the brain is the only possibility for mental processes, the claim that a certain mental process takes place in the brain is hardly informative for the layperson. Adding irrelevant or placebic information is not without consequence, however. Langer, Blank, and Chanowitz (1978) have shown that uttering: "Excuse me, may I use the Xerox machine because I want to make copies?", rather than the equivalent but shorter: "Excuse me, may I use the Xerox machine?" will help cutting in line at copying machines. When placebic information is stated in the jargon of neuroscience (e.g., by relating it to the activation of brain areas) circular explanations are mistakenly taken for good ones. Scientific literacy does not seem enough for preventing this kind of bias for longer and scientifically stated explanations: while neuroscience experts correctly identify the information about brain activation as irrelevant and nonexplanatory, students barely acquainted with neuroscience are as affected as naïve ones (Weisberg, Keil, Goodstein, Rawson, & Gray, 2008). Likewise, the judgment of perceived soundness of a neuro scientific argument can be influenced by the presence of topographical maps of the brain , while displaying bar graphs is as effective as the absence of images (McCabe & Castel, 2008). The biasing effect of images might be explained in terms of the effortless and apparently direct access to the world provided by vision: because neuroimages appear as compelling as eyewitness, they are persuasive (Roskies, 2007, 2008); because they are more easily tractable than graphs, they produce a misleading sense of fluency or understanding (Trout, 2008), analogous to the one prompted by reductionist explanations and the reference to causal mechanisms (Trout, 2002, 2008). As longer explanations, neuroscientific jargon, and brain images seem to have a persuasive power—no matter how relevant they are—they might affect the capacity of judging, case by case, the real *added value* of neuroscience discoveries in informing educational decisions (Willingham, 2008).

The risk of overestimating the applicative relevance of research feats is especially present when sensational but fresh results are made public before confirmation. It is common for results that apparently deviate from current knowledge to be successively falsified or at least adjusted (a phenomenon known as "regression to the mean"); nevertheless, the popular press tends to jump on them before they are stabilized by further research. Sensationalism is especially regrettable in consideration of the possibility that, once stored in memory, outdated information will continue to be used for further judgments, just like in the following experiment. Two groups of subjects receive news reports about a fire in a warehouse; the first report announces that rescuers have come across inflammable materials. The second report corrects this information (in fact no inflammable materials were stored in the place), but only for the experimental group. When asked to suggest a hypothesis about the cause of the fire, the experimental group and the control group were equally susceptible of using the wrong information about the presence of inflammable materials; the attitude seemed to be especially strong in the absence of an alternative causal account (Seifert, 2002). Considerations about the persistence of corrected information make a case for judiciousness in the divulgence of sensational but fresh experimental results. Besides, beating the drums for fresh results that are susceptible of declining (e.g., the Mozart effect) cheats the layperson into believing that myths are indistinguishable from facts, and that scientific facts are as changeable as any other opinion (Ioannidis, 2005; Lehrer, 2010, 2011).

At the same time, the media coverage of brain news is likely to omit relevant information about how results are obtained and brain images produced. Instead of *photographs* of the brain in action, functional neuroimaging techniques (fMRI, PET, MEG) produce expert images that represent indirect evidence—obtained through measurements of blood flow—of statistically significant signals of neural activation (Dumit, 2004). The "aspect" of the final image varies with the kind of statistical analysis conduced, the threshold of significance and the kind of baseline condition adopted, as well as with the sensitivity of the machine. The ignorance of basic facts about the making-of of brain images can mislead the layperson into believing that an image of the brain is sufficient to prove the existence of a mental state—an attitude described as "neurorealism" (Racine, Waidman, Rosenberg, & Illes, 2006). Besides, because only few spots appear in color or are highlighted in brain topographies, it can reinforce the myth that only a part of the brain is active when we speak, read or count, that is, the myth that we would use only 10% (or in any case a percentage) of our brain.

NEUROPHILIA

In the course of the last two decades, mind and brain sciences (especially the latter) have attracted the interest of the general public, as well as of policy makers and educators. The appetite for neuroscience—termed "neurophilia"—has conspicuously grown during and after the "decade of the brain" (Abi-Rached, 2008). Neurophilia reveals itself in the growing presence of brain images and neuroscience results reports in the newspapers (Racine, Bar Ilan, & Illes, 2006), in the proliferation of neuro-labels for new research fields (Legrenzi, Umiltà, & Anderson, 2011), in the blossoming of projects, reports and studies on the social, economical, political, and educational implications of neuroscience (e.g., *Brain Waves*: Royal Society, 2011a, 2011b). In the recent field of neuroeducation two approaches can be distinguished. One approach claims that the studies in education, the mind and brain should hatch a new interdisciplinary field of research, and devise new ways for translating knowledge and evidence into the design of instructional methods that work (Fischer et al., 2007; Fischer, Goswami, & Geake, 2010). Another approach sees neuroscience as a body of knowledge that can be searched in order to find guidelines and/or easy fixes for education (Dennison & Dennison, 2010; Dunn & Dunn, 1978; Jensen, 1995). The risk exists of generating undue simplifications that encourage the proliferation of neuromyths. It is regrettable that we dispose of limited evidence about the diffusion of neuromyths among educators. However, the proliferation of pseudoscientific, soi-disant “brain-based” instructional methods testifies that neurophilia has gained purchase in education in a way that can be baffling, and that an effort is required to separate the wheat from the chaff (Howard-Jones, Pickering, & Diack, 2007; Howard-Jones, Franey, Mashmoushi, & Liao, 2009). To take but one example, Brain Gym is a commercial instructional method based on the idea that when different parts of the brain do not work in coordination learning can be impaired.[3] Despite the fact that Brain Gym’s claims often clash with well-established biological knowledge and that there is no evidence that its exercises are effective, they are globally well received in the domain of education (Hyatt, 2007; Spaulding, Mostert, & Beam, 2010). The same consideration applies to VAK learning styles and other learning methods that classify learners according to their preferred format of learning—that is, visual, acoustic, or kinesthetic paths (Pashler, McDaniel, Rohrer, & Bjork, 2009).[4]

If the acceptance of the neuromyths contained in Brain Gym and VAK learning styles methods cannot be attributed to the efficacy of the respective methods, then why do neuromyths persist, even in the face of well-established, conflicting knowledge? Or, in other words, why do neuromyths persist independently of their falsity and poor applicative value? It is likely that under the urge of application, educators are susceptible of turning toward easy-fixes that are presented in a respectable, scientific jargon and are loosely inspired by neuroscience (Hirsh-Pasek & Bruer, 2007). When joined by the need to operationalize knowledge, neurophilia can thus favor the myth that the translation of brain science into applications is straightforward. This is especially true in face of the almost generalized lack of neuroscience education in the course of educators’ initial and professional training (Dubinsky, 2010). A diet poor in scientific education does not help in discriminating between brain pseudoscience and brain science. This situation is made more difficult by the absence of referential experts toward which educators can turn for advice, and of compelling theories of education that are inspired by mind and brain sciences. For the moment, mind and brain sciences are providing a framework for better understanding learning mechanisms and disabilities, and for ruling out ideas about the mind that are potentially harmful for education (such as the equation between the mind and a blank slate); but they are not yet at the origin of ready-to-use applications that fulfill the needs and aims of education. This is possibly because the world of education and the world of scientific research are still running parallel binaries, with ideas (but more rarely people) jumping on the other’s train. At present, scientists are not operating together with educators at the common production of educational theories and practices inspired by how the mind-brain works and compliant with educational aims. It is likely that in such a framework, the proliferation of neuromyths would be significantly reduced.

COGNITIVE ILLUSIONS AND OTHER BIASES

Suboptimal media coverage of neuroscience results and neurophilia are presumably involved in the perpetuation of neuromyths. The case of educators suggests that poor scientific education and the lack of a substantial interbreeding between scientific research and potential domains of application are further contributors that should be attentively looked out. But they do not tell the entire story. What strikes us about neuromyths, is that they outlive updates, absence of evidence, and inconsistency with well-established knowledge. The hypothesis can thus be proposed that, at least in part, the success of neuromyths banks on features of the human mind that generally serve us well, but can mislead us, for instance when triggered to answer the wrong question (Pinker, 1997).

Certain neuromyths for instance seem to fulfill a “soothing” function. Bangerter & Heath (2004) have shown that the interest in the Mozart effect (inferred from the measure of the number of newspaper articles dedicated to some aspect of the phenomenon) positively correlates with lower teachers’ salaries and low national tests scores per pupil spending (evaluated by comparing the two parameters in the different US states). We can infer that countries that are more in need of good education are easy prey to scientific legends about learning, be it because they are more anxious about children’s education, or because they are less able to separate the wheat from the chaff, or because they are less interested in children’s education (hence the lower salaries for teachers).

Another feature of the human mind that might favor neuro- and other myths is confirmation bias, that is, the tendency to seek or interpret fresh information in a way that confirms previous beliefs (Nickerson, 1998). Confirmation bias has the advantage of helping us solve conflicts within discordant information, by comforting us *in our own opinions*.[5] By way of an example, if confirmation bias plays a role in the success of pseudoscientific learning methods, we can predict that (a) someone who believes in Brain Gym will seek for more literature about related myths than will Brain Gym skeptics; (b) someone who has bought into the Brain Gym method will be more prone to buy into the Mozart effect and other methods for easily fixing learning problems than someone who is skeptical toward Brain Gym; and (c) those who believe in the method will tend to reject counter-evidence, for instance by deeming such evidence partial, unfair, or narrow-minded. This threefold prevision calls for empirical investigation, but survey data exist, for example in the domains of alternative medicine and of paranormal beliefs, that pseudoscientific misconceptions tend to come in clusters (Della Sala, 2007; Goldacre, 2008).[6] In these same domains, people that report their experiences tend to focus on the hits and to omit the misses (selective perception and memory), to see correlations even where there are none (illusory correlation), and to infer causation from correlation (illusory causation).[7] The same features of the human mind might contribute to the subjective misevaluation of the efficacy of methods such as Brain Gym. Other mechanisms, described as availability and familiarity bias—that is, the tendency to rely more on available examples than on statistics when estimating risks and probabilities for future choices—and source amnesia—that is, the forgetting of whether the source of the information is trustworthy—might be involved in the persuasiveness of such methods and related ideas (Schacter, Harbluk, & MacLachlan, 1984; Tversky & Kahnemann, 1974). The teacher who has adopted Brain Gym© methods is ready to deliver an emotionally rich story far more memorable than the negative statistics drawn from meta-analyses. More in general, the hypothesis can be put forward that a number of cognitive biases favor the persistence of neuromyths. Again, empirical investigation is required in order to ascertain which cognitive biases ensure the persuasiveness and longevity of neuromyths.

Finally, it is largely accepted that both adults and children behave as if they had intuitions about laws of physics, biology, and psychology (diSessa, 1993). These intuitions are in many cases misconceptions that interfere with scientific instruction while preceding and influencing the acquisition of knowledge (Bloom & Weisberg, 2007). The term "conceptual change" has been coined in order to describe the hard job of overcoming the ascendancy of such misconceptions. Resilient misconceptions include metacognitive illusions that result in an optimistic vision (overestimation) of our cognitive abilities.[8] The myth of the Mozart effect, or the one according to which we use only 10% of our brain, the promises of easy fixes to learning troubles produced by right brain/left brain disequilibrium, can all be easily connected with the optimistic view, in particular with the optimistic view that our mind-brain has a greater potential that is normally non-expressed. In contrast to other misconceptions—which are non-adaptive but can be the byproduct of otherwise useful mechanisms—optimistic illusions might even have an adaptive value in themselves (MacKay & Dennett, 2009). It has been shown, in fact, that those who hold intelligence to be fluid and dynamic do better at learning than those who hold intelligence to be fixed, independently from the fact that they portray themselves as more or less intelligent at the start (Dweck & Sorich, 1999). Because of their intrinsic adaptive value, optimistic cognitive illusions might be especially hard to fight.

CONCLUSION: ETHICAL ISSUES

Should one fight neuromyths and their dubious commercial exploitations or wait for them to vanish into thin air under the pressure of best practices and good explanations? The analysis of the genesis and resilience of neuromyths presented in this article provides reasons for dismissing the uninvolved attitude.

To begin with, when considering the application of scientific knowledge to education and other applicative domains, practices that are built on neuromyths can harm, albeit indirectly. Even if drinking water, doing some anaerobic exercise, rubbing one's cage, practicing brain training and sudoku, and listening to Mozart from birth are in themselves unobjectionable, these practices are not proved to foster learning, and in fact apparently they do not. Whenever these methods are adopted, time and budget constraints risk keeping other effective methods out of hand. For instance, an elderly person who wishes to keep up with her brain could be absorbed in sudoku and brain training exercises at the expense of aerobic activity. The case is analogous to homeopathy, causing secondary harm by eventually discouraging patients from following evidence-based treatments (Goldacre, 2008). Thus, neuromyths are one of the objects of the recently born field of neuroethics (Farah, 2002).

Furthermore, placebo-methods based on myths interfere with the understanding of the real processes. In the case of education, the effects of teachers' attitude and motivation, the role of receiving more attention, and the weight of expectations upon pupils' performances are not well understood, yet. They might be at play whenever teachers take on themselves the load of adopting a new instructional method. Attributing hypothetical gains to the method, rather than to the context and attitudes, undermines the understanding of the potential educational payoffs of the teacher's effect.

In addition, neuromyths must be dispelled in order to fully exploit scientific knowledge about the mind and brain. No matter how natural, neuromyths still carry a *wrong* view. It is an assumption accepted by the author that evidence and knowledge can help making better real-world decisions in education and beyond, and that the condition of having the science *right* (and a solid evidence rationale) is mandatory for achieving this objective. Besides, unless educators and policy makers are confident that wheat *can* be parted from chaff, the idea will grow that science and pseudoscience are just two sets of opinions. In conclusion, even when neuromyths are not leading to deadly choices, their growth threatens the program of science-informed and evidence-based policymaking.

But what actions can we take? First, knowledge must be pursued, conveniently disseminated, and taught. Neuromyths would have less chance of being perpetuated in a society where the critical appraisal of evidence and a broader scientific literacy are part of a diffused educational project, and of a general world view.

Yet—no matter how laudable the enterprise of promoting the level of scientific education and literacy—several studies lower our optimism: we have seen that the visual representation of information has a compelling effect on our belief system, because it makes the problem more tractable; that we are biased by explanations that mislead us into feeling persuaded and satisfied with placebic explanations; and that we tend to prefer soothing, optimistic accounts that confirm us in our positions. Expertise, but not familiarity, immunizes us from the seductive allure of neuroscience placebo (Weisberg et al., 2008). This conclusion seems to be confirmed by the fact that the more psychology students advance in their studies, the less they are seduced by "psychomyths" (Standing & Huber, 2003). It is possible that expertise allows us to automatically turn toward answers that are more likely to solve the specific situation at stake. Even in the event of a radical rethinking of the educators' profession, with the introduction of scientific education imparted during training, this is not going to turn educators into neuroscientists (an issue not even desirable). At the same time, it seems that explicit education on psychomyths is helpful for reducing their incidence (Kowalski & Taylor, 2009). We can thus propose that (in an analogy with other professionals, such as those in public health's) educators' training includes skills of critical thinking and appraisal of scientific approaches, as well as the exposition of widespread faulty beliefs and intuitions.

For the layperson, however, neuromyths are probably here to stay. What counts, really, is that neuromyths are kept under control when policy decisions are taken or applications devised. How? By having neuroscientists more involved in scientific mediation and more aware of the ethical issues related to the application and misapplication of their knowledge (Racine, Waidman, et al., 2006); and by privileging the dissemination of ideas that have survived the scrutiny of replication and the most rigorous standards of evidence over the broadcasting of fresh results and extraordinary claims. But above all, by establishing an effective interbreed between science and applicative domains (such as education), as an alternative to the import-export of ideas from one domain to the other. From this collaboration, compelling theories and practices can see the light that are at the same time true of science and meaningful for educators.

NOTES

1 Neuromyths belong to the larger family of misconceptions about the human mind (Della Sala, 1999, 2007; Lilienfeld, Linn, Ruscio, & Beyerstein, 2010) and of metacognitive and epistemic illusions (Aamodt & Wang, 2008; Chabris & Simons, 2009). An even larger family includes the reception of pseudoscience claims and bad science (Goldacre, 2008). See the OECD web site at http://www.oecd.org/document/4/0,3343,en_2649_35845581_33829892_1_1_1_1,00.html. Related web sites are: Society for Neuroscience—Neuromyth Busters at http://www.sfn.org/skins/main/pdf/neuromyth_busters/neuromyth_busters.pdf, and the McDonnel Foundation: Neuromill http://www.jsmf.org/neuromill/calmjittery neurons.htm.

2 Urban legends travel through word of mouth and spread from one host to another following a Friend Of A Friend pattern of diffusion, can be inflated by sensationalist press releases, tend to resist to evidence, and to fulfill shared desires, fears, and common beliefs.

3 Specific body exercises are devised that are alleged to integrate brain functions (*whole brain learning*), and in particular the left and right hemispheres (*laterality*, supposed to have positive effects in reading, writing, maths, . . .), the front and back (*focusing*, supposed to be helpful with attention deficit), or top and bottom parts of the brain (*centering*, supposed to produce a most-desirable balance between emotions and rationality). Together with physical exercises, Brain Gym methods include the stimulation of *brain buttons*—special locations of the body the pressure of which helps brain oxygenation—and the hydration of the brain by drinking a good glass of water. Brain Gym principles thus exemplify a number of neuromyths: that different parts of the brain, and notably the hemispheres, are unfortunately separated and need balance; that in normal conditions the brain can be under-oxygenated (and this without any lesion to ensue) or under-hydrated (and still be able to work).

4 Most of these methods state that the format preferred by the learner (typically ascertained through questionnaires) is also more profitable to learning (preference and meshing hypothesis). The idea of the personalization of instructional paths, and of differential cognitive and learning profiles, is not necessarily false. However, the idea of visual, acoustic, and kinesthetic paths to learning is only loosely based on the existence of modules for treating information in the brain, and methods inspired by this approach are simply not proven to work: both the preference and the meshing hypotheses have failed confirmation.

5 Because perceptual conflicts are potentially disruptive for adaptive responses in animals, errors can be committed in the effort to maintain coherence. The avoidance of perceptual conflicts is observed in perceptual illusions (Bruner & Postman, 1949) and in other perceptual adjusting mechanisms (Stein & Meredith, 1993).

6 It is noteworthy that "believers"—as well as "skeptics"—are exposed to biased information, even unintentionally. Performing a search on amazon.com triggers the

"Customers who bought items in your recent history also bought" advice; surfing the Internet with Google makes recommendations pop in the screen that fit with one's search; searching online news makes news we are more interested in pop. This is possible because "filter bubbles"—algorithms—filter information so that Internet users can first receive recommendations—but also search results and news—that are personalized in relation to their preferences and fit with their history. The first consequence is to confirm Internet users in their previous positions and avoid un-looked for information. The further consequence is to extra-shrink the possibility of being exposed to information that could challenge or broaden one's world view (Pariser, 2011).

7 In addition to reinforcing the acceptability of certain neuromyths, the illusion of correlation can also intervene in the shaping of their content. This is the case of the dense correlations that are perceived between functions of the two brain hemispheres, between male and female characteristics, between styles of personality and of reasoning or learning; that is, of the neuromyth that people are either right-brained or left-brained. The desire for quick answers can lead to the image of the unbalance between the two as being responsible for learning, social, emotional difficulties, and to the idea that "balancing exercises" can easily fix the problem. Although the formulation in neuroscientific jargon is as recent as split brain studies, Aristotle relied on opposite couples such as male/female, rationality/emotions, and right/left, and claimed that females grow in the left part of the uterus, males in the right part.

8 Optimistic cognitive illusions of this kind are themselves sustained by several biases, such as hindsight—the tendency to judge past events as more predictable than they really are (I knew it all along)—and overconfidence or the illusion of validity—people tend to place confidence in their judgments, even when their performance does not reflect a corresponding the degree of accuracy (Kahneman & Tversky, 1973; Baddeley & Woodhead, 1983).

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