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Original Article

Neuromyths about movement and the brain: debunking misconceptions

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Abstract:
Neuromyths are misconceptions arising from misinterpreted or biased data, often lacking scientific evidence and presenting unverified claims. Examples include the Mozart effect, Brain Gym, the idea that some people predominantly use one hemisphere of the brain, the belief that women are inherently better at multitasking, the notion that reggaeton benefits brain function, and the theory of multiple intelligences. Despite their initial popularity, these myths lack solid evidence. The main objective of this article is to select the most relevant neuromyths about movement that have had the greatest impact on education and society in order to demonstrate their inconsistencies and lack of scientific rigor, and then to show the most relevant academic literature that disproves them. To do so, we will refer to numerous meta-analyses, as well as quantitative and longitudinal studies. However, research on the relationship between movement and brain function has significantly expanded over the past decade. Validated tests and large sample studies provide strong evidence of the physical and cognitive benefits of movement, as thoroughly documented in numerous systematic reviews and bibliometric analyses. Nevertheless, certain educational and academic circles still promote information about movement and the brain that lacks scientific support and has questionable efficacy. Examples include claims about the relationship between crossed laterality and learning, learning styles, kinesthetic intelligence, and the notion that walking 10,000 steps a day is essential for fitness. Despite their widespread presence in some sectors, these claims have no scientific basis. This article aims to highlight neuromyths related to movement and reference high-impact publications that disprove these myths, demonstrating their inaccuracy.
Key Words: **control motor, higher education, cognitive stimulation, physical exercise, Bapne**

Introduction

Neuromyths are misconceptions about how the brain works that are often based on pseudoscience or misinterpretations of actual research. These false beliefs can come from a variety of sources, such as poorly disseminated information in the media, lack of understanding of the technical language of neuroscience, or limited access to high-impact engines (Newton & Salvi, 2020). The consequences of not combating these misconceptions in the educational setting can be serious. Therefore, it is essential to promote education based on scientific evidence that equips teachers with the necessary tools to discern between what is true and what is not true about the brain. In this regard, the initial training of teachers plays a crucial role. It is essential that during their training they learn not only to read, but also to select and include reliable scientific sources. This will allow them to develop critical and reflective thinking when making pedagogical decisions, based on the most current scientific knowledge and not on misconceptions that could harm their students' learning. These false beliefs can have negative consequences, as they can lead to educational practices that are ineffective or even counterproductive (Betts et al., 2019; De Bruyckere et al., 2015; Dekker et al., 2012; Kirschner, 2017; Newton & Salvi, 2020). In our view there are several reasons why neuromyths spread:

- Misinterpretations of scientific research: sometimes the results of neuroscientific studies are simplified or taken out of context, leading to erroneous conclusions.
- Excessive generalizations: Some research is conducted with specific groups of people or in specific situations, but their results are incorrectly extrapolated to the general population.
- Search for quick fixes: Neuromyths sometimes offer simple and appealing answers to complex questions about learning and human behavior, making them popular with those looking for quick and easy solutions.
- Commercial interests: Some companies or individuals may promote neuromyths to sell brain-related products or services.

The origin of neuromyths is complex and multi-causal, but some key factors can be identified:

Misinterpretation of neuroscientific research.

- Studies simplified or taken out of context: Results of complex scientific research are often simplified or taken out of context in the media or in educational materials, which can lead to misinterpretations.
- Lack of access to reliable information: Not all people have access to reliable and quality neuroscientific information, which makes them more susceptible to fall for neuromyths propagated by unreliable

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sources.

Search for quick and easy solutions:

- Attraction to simplistic explanations: neuromyths often offer simplistic and appealing explanations of how the brain works, which can be tempting for people seeking to understand a complex topic without delving too deeply.
- Promises of cognitive enhancement: Some neuromyths are used to promote products or services that promise to improve cognitive performance, which may appeal to people seeking an advantage in areas such as education or work.

Influence of popular culture:

- Misrepresentations in movies and TV: The brain is often misrepresented in movies, TV series, and other popular culture media, which may contribute to the spread of neuromyths.
- Use of neuroscientific language in marketing: Some companies use neuroscientific terms in their marketing campaigns to give their products or services the appearance of scientific legitimacy, even though there is no evidence to support their claims.

Pre-existing beliefs:

- Confirmation bias: People tend to seek information that confirms their pre-existing beliefs, making them more likely to accept neuromyths that fit their worldview.
- Resistance to change: Changing preexisting beliefs about how the brain works can be a difficult process, which can make people resistant to accepting new information that contradicts their preconceived ideas.

There are many neuromyths that survive in the educational field and even in certain academic sectors such as the Mozart effect, we must first acquire our mother tongue before learning a second language; there are certain things that cannot be learned after childhood; that the hemispheres are independent and therefore determine personality, reggaeton is good for the brain, that people can learn while they sleep, we only use 10 percent of our brain, the bigger the brain the smarter you are, the female brain is multitasking, a single cerebral hemisphere controls language, there are people with left hemispheres and others with right hemispheres, the brain shrinks due to lack of water, sugar reduces attention span and so the list could be almost endless. The purpose of this article is to unify the most representative neuromyths related to movement.

Purpose

The purpose of this article is to show some neuromyths linked to movement that mainly concern learning, academics and sports. So far, after the literature review, no article has been published on neuromyths with an exclusive focus on movement, which is the reason for this text.

Objectives

1. To select the most relevant neuromyths linked to movement and which have the greatest educational repercussions.
2. To justify by means of high impact publications the reason why such information is not credible.
3. To provide alternatives to avoid neuromyths in education.

Neuromyths and movement. From little evidence to the classroom.

The following is a list of the seven neuromyths that have had most relevance at the educational and academic level.

Kinesthetic intelligence

The concept of intelligence has a wide scientific literature with very conflicting positions (Coe et al., 2014; Lucas - Claxton, 2010; Mackintosh, 2011; Sternberg, 2018). There are several theories about intelligence from those contributed by Binet, whose author considered intelligence as a single capacity. Another of the theories to highlight about intelligence is Spearman's bifactor theory which proposes that there is a general intellectual capacity or "G Factor", and that it is common to all the activities we perform. Subsequently, other theoretical models of intelligence were developed, such as those of Cattell, Vernon, Thurstone, Guilford and Sternberg, among others. The theory of multiple intelligences has generated a great deal of debate both pedagogically and academically (Ferrero et al., 2021; Geake, 2008; Howard-Jones, 2014; Jarrett, 2014; Waterhouse, 2006; Gardner, 2020). Even so, the author of MI theory himself, Howard Gardner, after receiving the Prince of Asturias Award in 2011, argued that the concept of multiple intelligences can be reinterpreted as "talent" (Gardner, 2020).

It is important to note that there is no evidence through meta-analysis showing that there is a kinesthetic intelligence, although there is informative literature with such a title (Claxton, 2015). Therefore, it is incorrect to speak of kinesthetic intelligence.

VAK model. Learning styles.

It is true that learning styles have been greatly mythologized and are a matter of debate (Howard-Jones, 2014). Numerous scientific studies have not proven the idea that each person has a different way of learning that is the most viable for the best results (Carpenter et al., 2012; Coffield et al., 2004; Dekker et al., 2012; Pashler et al., 2008; Rohrer & Pashler, 2012).

For this reason, the kinesthetic learning style has no evidence. It is true that several studies have been conducted with the aim of knowing whether adjusting teaching to the learning style improves their learning, but the results have not been positive (Riener & Willimgham, 2010; Newton & Miah, 2017); although many educational programs continue to claim it (Kirschner, 2017; Willingham et al., 2015).

What is the reason why the idea of learning styles endures? According to various authors (Karpicke et al., 2009; Ruiz-Martín, 2023; Stanton et al., 2021) it is due to two aspects coprincipally. First, confusion about the way in which it is most convenient for us to learn, with the way that will give us the best results. The problem lies in the fact that a person has become accustomed to study in a specific way, it does not mean that it is the most correct (Dunlosky et al., 2013; Knouse et al., 2016).

Secondly, it is due to the link with memory. We have two types of memory, explicit and implicit. Regarding implicit or non-declarative memory, we have motor or procedural memory and emotional memory; but the most important thing is that the meaning of the information we receive depends on explicit memory, specifically semantic memory, which is why remembering information does not depend on the physical properties of the stimuli received, according to Willingham (2005).

In conclusion, it is important to note that a person may have a more efficient input channel at certain times, but it must be made clear that he/she needs the rest of the sensory variants to integrate the information that arrives in a fragmented manner. All the information that arrives needs to build a mental representation in order to have meaning, which is why the brain needs to organize it to make it understandable and thus make a learning process. Therefore, as Karpicke (2009) argues, we confuse what we like with what suits us.

Cross laterality and learning.

Laterality is an exciting topic that has attracted the attention of numerous scholars who reflect on the reason why we have more ability in one part of the body than in another. Our brain is made up of two asymmetrical halves that are joined by the corpus callosum. Each hemisphere controls the contralateral nerves, which is why the right hemisphere controls my left side of the body and vice versa.

Laterality is structured in auditory, visual, manual and pedal. Based on these parameters, our laterality can be classified as homogeneous, crossed, ambidextrous and contrariant. There are various theories on the origin of laterality, with the publication of Ocklenburg (2017) being of particular note. These researchers from Ruhr-University Bochum (Germany) argue that laterality is defined in the womb and its origin is linked to the development of the spinal cord. Laterality is rooted in biological functions from before birth, but in the form of a variation of gene activity in the spinal cord. The cause of this asymmetry: it is not influenced by mutations or regular, inherited traits, but by environmental factors that influence the baby growing in the womb. Although it is not yet clear what these environmental (epigenetic) factors might be, but it is possible that they cause alterations in the way enzymes function in the baby's development, which in turn changes the way genes are expressed.

On the other hand, Schijver's study based on a sample of 350,000 subjects (38,043 left-handed and 313,271 right-handed) from the UK biobank looking for rare genetic variants is published in 2024. The researchers show that the TUbb4B gene produces proteins that are different from the usual ones and these modifications are what increase the probability of being left-handed. Therefore, the research suggests that laterality has a genetic component.

Regarding learning disabilities and their link to crossed laterality, numerous investigations through various meta-analyses show that crossed laterality has no link to learning disabilities (Bondi et al., 2020; Brusasca et al., 2011; Nielsen et al., 2013; Weinland et al., 2019). Even so, it is important to point out that contrariant laterality can have a negative impact on the learning process. Contrary laterality is understood as when someone is forced externally to change a limb that he or she uses naturally. For example, left-handed people had their left hand tied behind their back to force them to write with their right hand (Grabowska et al., 2019; Klöppel et al., 2010; Marcori et al., 2019; Palmis et al., 2019; Papadatou-Pastou et al., 2020).

Coordination exercises improve the connection between brain hemispheres.

Social networks flood us with activities related to Brain Gymnastics arguing that certain activities improve attention, memory, intelligence and many other aspects without having studies with experimental group, control group and validated tests to prove it. Due to the ease of its activities and its easy implementation, it has had a global repercussion.

Brain Gym, also known as Brain Gymnastics, is a program developed by Paul and Gail Dennison that proposes a series of physical and mental exercises to improve learning and academic performance (Hyatt, 2007; Spaulding, 2010). However, Brain Gym has been classified as a neuromyth by the scientific community due to a lack of evidence to support its claims (Gleichgerrcht et al., 2015; Grospietsch & Mayer, 2019; McMahon et al., 2019; Pasquinelli, 2012):

- Lack of scientific rigor: research conducted on the efficacy of Brain Gym has not found conclusive results demonstrating its benefits for learning.
- Pseudoscientific explanations: The theoretical basis for Brain Gym is not founded on sound neuroscientific principles.
- Exaggeration of benefits: Brain Gym proponents often attribute exaggerated benefits, such as improved memory, concentration, and intelligence, without corroborating evidence (Howard-Jones, 2014).

The reasons are mainly due to:

- Simplistic appeal: Brain Gym proposals are easy to understand and apply, which makes them attractive to educators and parents looking for quick fixes to improve academic performance (Dekker et al., 2012).
- Placebo effect: It is possible that some students experience a slight improvement in their performance due to the placebo effect, believing in the effectiveness of the program.

- Lack of alternatives: In some cases, Brain Gym may be seen as a more attractive alternative to traditional teaching strategies.

If it is true that as an active pause it can be employed, but never as a resource to improve intelligence, memory, attention due to the lack of scientific evidence (Pastor-Vicedo et al., 2021; Turner & Chaloupka, 2017).

10,000 steps to good health.

There is a myth that we should walk 10,000 steps every day for good health, but it has been proven to be a myth (Friedman, 2014; Lee et al., 2019; Ulmer et al., 2020). The story goes back to 1965, when a Japanese company called Yamasa Tokei released a pedometer called Manpo-Kei. "Manpo-Kei" means "10,000-step meter," and the story goes that the reason for choosing that number was because 10,000 in Japanese (万) resembles a pictogram of a person walking. The idea caught on and, with the rise of pedometers in the following decades, the idea that 10,000 steps was the ideal daily goal for health became popular.

However, subsequent research has found no evidence to support this specific number. In fact, studies such as the one published in 2019 suggest that walking between 7,000 and 8,000 steps per day can already provide important health benefits, such as reducing the risk of all-cause mortality.

The studies showed that:

- The optimal number of daily steps can vary according to age, physical condition, health status, and individual goals.
- It is important to focus on total physical activity, including other types of exercise in addition to walking.
- The bottom line is to move more and be less sedentary.

For this reason, it is not correct to say that we need to take 10,000 steps a day for good health.

Body percussion cures ADHD, Autism, Alzheimer's, Parkinson's...

Body percussion is a very broad resource that can be used in various disciplines such as theater, body expression, learning a foreign language, working on motor skills, or music (Andreu-Cabrera & Romero-Naranjo, 2021, 2024; Romero-Naranjo, 2013, 2020, 2022; Romero-Naranjo & Andreu-Cabrera, 2023a, 2023b, 2023c). Its diffusion in social networks has led it towards a pedagogy of entertainment where people with little preparation following a pre-recorded music mechanize a choreography, with the aim of feeding more the ego and vanity than the actual learning of their students (Arnau-Mollá & Romero-Naranjo, 2022a, 2022b, 2024a, 2024b).

In the first instance, it is extremely noteworthy that there is no meta-analysis to date that shows clear evidence of cognitive improvements in the population. There are only very specific studies that should be taken with caution in the absence of studies with a larger number of subjects.

Therefore, it is very important to clarify that there is no scientific evidence that shows that body percussion, nor the BAPNE method, cures or reduces ADHD, ASD, Alzheimer's, Parkinson's or any other type of disease, syndrome or pathology. Certain media with sensationalist headlines and without academic reading skills have made statements out of place, when in fact we need many more statistical studies with control and experimental groups to have conclusive data (Romero-Naranjo & Romero-Naranjo, 2022).

Any type of exercise is good.

There is a common myth that any type of exercise is positive, but several specialists have demonstrated that this is not the case. It is known that physical exercise is positive for the formation of new neurons in the adult hippocampus, for growth factors in the cerebrospinal fluid as well as within the brain tissue, for mitochondrial function or dendritic arborization of neurons (Suárez et al., 2024).

However, when exercise is excessive and its level of fatigue is too high, its effect is the opposite. To justify such a myth we must talk about the hormetic curve of exercise or the well-known hormetic profile (Gradari et al., 2016). Hormesis is the dual behavioral response of an individual and the hormetic profile, is the ability to respond with a biphasic profile to certain stimuli; in a summarized way it could be said that low exposure to the stimulus produces a certain positive effect but too much exposure produces the opposite effect or no effect at all.

There is a limit, known as the inflection point in the hormone curve, beyond which, if we excessively increase the intensity or the amount of exercise, the benefits begin to diminish, and may even be completely annulled. In this case, the hormone curve would adopt an inverted U-shape, similar to the behavior of a sedentary person. In extreme cases, it could even generate adverse effects, with the curve resembling an inverted J (Agathokleous & Calabrese, 2019; Xu et al., 2021).

It should be noted that the hormetic curve varies considerably between individuals, and the scientific community has not yet established a definitive consensus on the exact intensity that marks the inflection point. However, heart rate can be a useful indicator to determine the appropriate intensity and duration of exercise (Buecker et al., 2021).

To elicit beneficial responses, physical exercise should increase heart rate by a moderate percentage, between 60% and 70% of the individual maximum heart rate. In some cases, a slightly higher increase, between 70% and 80%, may also be effective (Chan et al., 2019; McGreevy et al., 2019).

Neuromotricity and psychomotricity are the same.

The term Neuromotricity is named for the first time in 1974 by Lapierre, making a general neurophysiological description of the areas related to movement. It is important to note that in no case does he make any allusion or difference to motricity or psychomotricity (Lapierre, 1974), which is why his definition is applicable to any type of movement linked to gross motor skills. Subsequently, Romero Naranjo (1998, 2018, 2018, 2020a, 2020b) is the first author to link it for the first time in history by unifying movement with executive functions with a clear intervention of "language" for dual-task work.

Several authors (Collado Martínez et al., 2018; Del pozo, 2019; Martínez-Díaz, 2023) confuse neuromotricity with the same activities that are applied in psychomotricity but justifying which areas of the brain are involved or which possible executive function they are performing. For example, if they perform a circuit with cones they talk about the cerebellum, basal ganglia, prefrontal cortex and if they relate it to executive functions they link it to cognitive flexibility, planning, decision making, etc. This vision is completely incorrect.
Therefore, the contributions of the above-mentioned authors are not correct because they neither offer clear and precise activities that identify neuromotricity as a discipline different from psychomotricity, nor do they define it clearly from a conceptual point of view, thus lending to a clear methodological confusion.

The clear difference between motricity, psychomotricity and neuromotricity is established academically as follows, thanks to the contribution of the official research group of the University of Alicante called Neuromotricity and Motor Literacy (Andreu-Cabrera & Romero-Naranjo, 2021; Romero-Naranjo & Andreu-Cabrera, 2023a, 2023b, 2023c). Motricity are unconscious acts that are directly related to implicit memory and, therefore, to procedural memory.

In contrast, psychomotor activity is a conscious act that requires the executive control network due to the challenges or obstacles it faces. Psychomotricity require my ability to orient myself and my memory to remember the directions I have been given. This is why psychomotricity fall within the parameters of cognitive functions (memory, praxias, spatial orientation, attentional network, visuospatial ability, etc).
Neuromotricity on the other hand is a higher function that requires a high use of working memory, cognitive flexibility and inhibition due to the constant use of the voice as an executive function to always implement dual-task activities. For this reason, neuromotricity employs dual-tasking within the "cognitive-motor-rhythmic" paradigm (Romero-Naranjo, 2021, 2022, 2023).
In conclusion, it is important to highlight that:
- Neuromotricity is not passing a test of executive functions to any sport activity (basketball, soccer, karate, etc).
- Neuromotricity is not performing any motor movement and explaining it from the brain.
- Neuromotricity does not use activities from psychomotricity.
- Neuromotricity has no relation with the classical schools of psychomotricity (French and German) nor with their relevant authors (Dupre, Wallon, Aucouturier, Le Boulch, Acouturier, Parlebas, Vayer, Fonseca, Bertherat, Kiphard, Zimmer, Sabinarz, Frostig, etc).
If the following points are considered Neuromotricity:
- Specific newly created activities involving the use of language in relation to the dual task under the motor-rhythmic-cognitive paradigm.
- Neuromotricity requires in a compulsory way the use of language independently of the movements that use the upper and lower extremities.
- The use of language in neuromotricity can be spoken, recited or sung and the activities are never repetitive.
The evaluation in the study of neuromotricity requires a control group and an experimental group with validated tests, never questionnaires, where the experimental group executes new activities with a double task, with a clear use of language, always in a compulsory way in front of a control group.

Conclusions.

Neuromyths, misconceptions or oversimplifications about how the brain works, proliferate in today's society. Their spread can have negative consequences, such as the implementation of educational practices or learning strategies based on false information. Therefore, it is crucial to develop strategies to combat them, which are described below:

Cultivate Critical Thinking:

It is essential to foster a critical approach to information about the brain. This involves:

- Identifying sources: Evaluate the credibility of information sources, prioritizing those with scientific rigor and academic backing.

- Search for scientific evidence: Look for scientific studies that support or refute claims about the brain.

- Consider the complexity of the brain: Avoid oversimplifications and recognize the complex and multifaceted nature of brain functioning.

Promote Neuroscience Literacy:

There is a need to disseminate basic knowledge about brain functioning in an accessible and rigorous manner. This can be achieved through:

- Formal education: Implement educational programs that include neuroscience in a cross-cutting manner at different educational levels.

- Scientific dissemination: Encourage the creation and dissemination of reliable informative materials on the brain in different formats (books, articles, videos, etc.).

- Teacher training: Provide training to teachers so that they can address neuroscience topics in the classroom in an appropriate manner.

Combat Disinformation:

It is crucial to identify and combat the spread of false information about the brain. This involves:

- Fact-checking: Using fact-checking tools to identify fake news or misleading information about the brain.

- Reporting false content: Report false or misleading content to online platforms and relevant authorities.

- Promotion of reliable sources: Disseminate reliable sources of information about the brain, such as websites of scientific institutions or specialized journals.

Foster Dialogue between Neuroscience and Society:

It is important to establish fluid communication channels between the scientific community and the general public. This can be achieved through

- Science outreach events: Organize talks, workshops and conferences that bring neuroscience closer to the public in an enjoyable and understandable way.

o Media: Collaborate with the media to disseminate accurate and rigorous information about the brain.

o Social networks: Use social networks to share informative content and combat misinformation about the brain.

Therefore, avoiding neuromyths requires a joint effort from various sectors of society. By cultivating critical thinking, promoting neuroscience literacy, combating misinformation, and fostering dialogue between neuroscience and society, we can move towards a more accurate and evidence-based understanding of how the brain works. This will have a positive impact on education, health, and individual and societal well-being. This publication belongs to the academic program of the Bapne method that has an official research group called "Neuromotricity and motor literacy" of the University of Alicante, which currently has more than 3000 academic citations and a high number of publications in Web of Science and Scopus (Figure 1).

The BAPNE method is a methodology that provides academic publications in different fields (Di Russo et al., 2022, 2023, 2024; Navarro-Maciá & Romero-Naranjo, 2024a, 2024b), although a large part of its scientific production has focused mainly on its relationship with executive functions. Its main objective is to produce academic publications with validated tests that can promote teaching resources and not fall into a neuromyth.

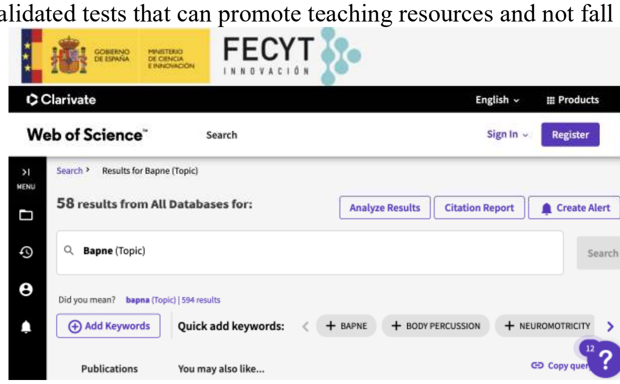

Figure 1. Publications of the BAPNE method in Web of Science

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