Neuromotricity as a new paradigm

FRANCISCO JAVIER ROMERO-NARANJO[1], ELISEO ANDREU-CABRERA[2]

[1]*Department of Innovation and Didactic Training, Faculty of Education, University of Alicante, Spain*
[2]*Department of Developmental Psychology and Didactics, Faculty of Education, University of Alicante, Spain*

ABSTRACT

The review of the existing narrative shows the theoretical evolution of the concepts of motricity and psychomotricity, which have led to a new paradigm of movement called neuromotricity. In this new approach to motor action, cognitive functions, and especially executive functions, form part of its essence. This is why neuromotricity, as a discipline independent of psychomotricity, proposes a completely different set of activities in which the dual task is always present. The methodology of applied neuromotricity could promote the generation of neural networks through stimulation protocols of increasing complexity, which in turn improve brain functions.
Keywords: Neuromotricity; Phycomotricity; Motricity; Neurotrophins; Brain; Executive functions; Motor learning; BAPNE.

Cite this article as:
Romero-Naranjo, F.J., & Andreu-Cabrera, E. (2023). Neuromotricity as a new paradigm. *Journal of Human Sport and Exercise*, *18*(1), 194-208. https://doi.org/10.14198/jhse.2023.181.16

Corresponding author. *Department of Developmental Psychology and Didactics, Faculty of Education, University of Alicante, Spain.* *https://orcid.org/0000-0002-1377-0966*
E-mail: eliseo.andreu@ua.es
Submitted for publication August 09, 2021.
Accepted for publication September 22, 2021.
Published January 01, 2023 *(in press* December 07, 2021).
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202.

doi:10.14198/jhse.2023.181.16

INTRODUCTION

We understand motricity as the ability of the central nervous system to produce the contraction of a muscle. It is also defined as the capacity of a body to move or produce movement. In the field of physical activity and sport sciences, motricity refers to the study of human movements, their characteristics and meaning. Motricity as a discipline studies human movements and their kinetic and kinematic characteristics.

In a world in which information and communication technologies are clearly disrupting our habits, and possibly encouraging a sedentary lifestyle (as well as low cognitive stimulation), it is important to think about new paradigms that justify other ways of moving and being more effective. The relationship between movement, physical activity and executive functions is one of the lines of research that has been most developed in recent years in different fields. From the documentary review carried out, it is clear that in the motor field, physical exercise is one of the best protectors against senile dementia, Alzheimer's disease and depression.

Our bodies, and therefore our brains, were created to move. Exercise increases the production of neurotrophins, a protein responsible for helping us to produce more neurons, helping us to have a healthy and flexible brain. That is why every time we want to learn something new, our brain must modify itself and create new structures, as Santiago Ramón y Cajal pointed out at the beginning of the 20th century.

In the process of learning a new activity, the role of mirror neurons (Rizzolatti, 1996) and imitation are a fundamental pillar as new synaptic pathways are created based on and guided by the observed model. However, it is the cognitive functions, and above all the executive functions, which are responsible for the success of this learning for different reasons. On the one hand, correct observation linked to the attentional channel intervenes and, on the other hand, active listening is fundamental in order to be able to plan the response a posteriori.

Psychomotor development is linked to the acquisition of knowledge through motor action, which allows exploration of the environment and the acquisition of relevant information for the formation of thought. In the field of neuropsychiatry, numerous investigations have demonstrated the relationship between motor disorders and mental disorders. Brain and motricity become an essential binomial in the learning process.

Conscious and voluntary movement and language, among others, are characteristics that distinguish us as a species. Thanks to the body and movement, as axes of educational action, our brain develops. Human interaction and the stimulation of the environment provoke new nervous connections in the individual. As Pinzón et al. (2020) point out, "*numerous behavioural studies at the cellular and molecular level in animals show significant effects of brain enrichment in response to environmental stimuli, implying enhanced levels of sensory, cognitive and motor stimulation through dwelling in complex and novel environments*".

Recent research agrees that early and rich stimulation, at sensitive stages of human evolution, will facilitate motor and cognitive maturation.

We have reviewed articles and works that cite neuromotor activity and its relationship to brain development, as well as the effects of physical activity on the generation of neurotrophins and new neuronal synapses. To do so, we consulted the following databases Analytical Abstracts, ASSIA, Biblioteca Virtual en Salud (BVS), Web of Science, CINAHL, Cochrane, CSIC, Cuadernos de Pedagogía, CUIDEN, Dialnet, ERIC, Erihplus, JSTOR, MEDES, Pascal-Francis, Proquest central, Psicodoc, Psycinfo, PubMed, Ulrich's.

The criteria for the selection of information were: articles in English, Spanish, French and Portuguese that mention neuromotricity as a science or as a methodology. The search route was used: neuromotricity, neuromotricidad, neuromotricité y neuromotricidade.

From the Sciences of Physical Activity and Sport, the existing polysemy pushes us to delimit similar terms such as motricity, psychomotricity or neuromotricity. Neuromotricity as a science and neuromotricity as a methodology for brain development through cognitive stimulation, within the field of human motor skills.

Neuroscience studies the structure, function and development of the nervous system, which lays the foundations for cognition and behaviour. Cognitive neuroscience studies the complexity of the functioning of the mind, the millions of neurons, their plasticity and the influence of the environment on this neural network. Cognitive neuroscience focuses on the analysis of brain activity in relation to the psyche (consciousness), in order to understand the biological process that conditions learning and behaviour. For all these reasons, this science becomes the framework for research into motor behaviour and neuromotricity as a discipline and method for motor learning.

PSYCHOMOTRICITY: A CONCEPTUAL APPROACH

The concept of psychomotricity was first developed in Germany in the mid-19th century by Wilhelm Griesinger, the founder of neuropsychiatry. The oldest reference to the term psychomotor is provided by Renard, K. (2019), citing Jean-Michel Lehmans. This author states that W. Griesinger (1843) used the term "*psychomotor*" as a symptom in the hypotonia of a depressed person.

According to various studies, researchers do not agree on the origin of psychomotricity, assigning its authorship and birth to different authors and different dates. During the 19th century, the body was studied from the field of Neurology, trying to understand the functioning of the brain and its neuronal structures. In the same way, psychiatry studied the grey mass as the origin of some of the pathologies of the human being.

Ernest Dupré (1925), within the pathological field, seems to be the one who coined the term psychomotricity in his studies on motor weakness in special populations. He established relationships between certain neurological and psychic anomalies and certain problems in motor development. In the scientific field and from the perspective of developmental psychology, Henri Wallon (1925) stands out as a precursor of psychomotricity, who developed the first methods of psychomotor re-education. From a psychobiological orientation, Wallon argues that movement is the only expression and instrument of the psyche.

Piaget (1969) affirms that motor skills intervene in the evolution of intelligence, at different levels in the development of cognitive functions. For this author, quoted by Ruiz Pérez (1987), all cognitive mechanisms are based on motricity.

In the Soviet school, Vygotsky (1962) and Luria (1979) emphasise the importance of the social environment as the origin of movement (sociomotricity). For the Soviet authors, human motor skills are fundamental for child development, which, together with language and thought, favour adaptation to society.

Nowadays, psychoneurology has new techniques and technology, advances in neurochemistry and neuropharmacology, which allow a more precise and effective diagnosis and treatment. In the field of education, according to Fonseca, knowledge in psychoneurology should be applied to the education and re-education of children with special needs. To this goal, he proposes psychomotricity as a tool.

Pastor Pradillo (2002) differentiates two meanings of the term psychomotricity. On the one hand, as a science that is interested in the study of the relationship established between the psychic and the motor. On the other, as a method or technique for achieving different motor objectives. Whether as a science of movement, as a methodology or as an educational, re-educational and therapeutic discipline, all researchers seem to agree that psychomotricity develops motor competence, cognitive capacity and socio-fective intelligence. Cognitive psychology moves from an interest in motor performance to an interest in internal processes.

Psychomotricity understands the human being as a multidimensional being (psychosomatic dimensions) and aims at intellectual development through the use of conscious and voluntary movement as a means of knowledge of one's own body, people and the environment. For Romero-Naranjo (2004) psychomotricity can be worked with musical-motor activities, creating the term "*rhythmic psychomotricity*" for those activities related to body percussion through the BAPNE method (1998).

From the definitions of psychomotricity that have been compiled, we propose the following:

* Psychomotricity as a discipline
Science that understands the human being as an integral and multidimensional being (physical, social, cognitive, emotional) and pursues its harmonious development, integrating the psyche and conscious and voluntary motor skills, for cognitive development based on knowledge of one's own body, the environment and other peers.

* Psychomotricity as a method
Psychomotricity is a methodology which, depending on its objectives, can be educational, re-educational or therapeutic, and which is based on techniques and recreational activities in which the body and movement are used as the axis of action, with the aim of contributing to their integral development as a person.

NEUROMOTRICITY: ORIGIN AND EVOLUTION

Santiago Ramón y Cajal (1906), laid the foundations of knowledge about the functioning of the central and peripheral nervous system, with the discovery of synaptic clefts (the space that separates neurons), thanks to the chemical messengers that allow communication between them. According to the Spanish Nobel laureate, the brain maintains the genuine capacity to reorganise itself throughout life.

A speciality of neuroscience whose object is the study of the complex neural network that organises and controls human movement, is neuromotricity. Lapierre (1974:40) in the chapter Psychomotricity and Neuromotricity, points out that all motor education is essentially psychomotor, since movement is the link between thought and action. He also maintains that psychomotricity as an educational method possesses the characteristics of consciousness and voluntariness. In addition to the above, it should be noted that the scientific community gives him the authorship of the term neuromotricity, although it only appears as the title of the chapter.

Lapierre does not provide a definition either as a discipline or as a method. However, in relation to the brain and movement, he states that between the psychism and the mechanics of a muscle, there is a whole neurological structure of transmission and regulation, which the author calls the psychoneuromotor system. Based on these principles, Lapierre (1974) explains in detail the essential neurophysiological bases that govern the elaboration and execution of voluntary, automatic and reflex movements.

As it is a relatively new discipline, we set out to study the existing scientific production on neuromotricity as a discipline or as a method. After an extensive search in the databases of the Library of the University of Alicante (19 May 2021), we found that the term neuromotricity offers few records.

The results of this search are given below:

WOS only provides 9 records.
PROQUEST provided 15 entries using the variants of neuromotricity, neuromotricité, neuromotricidade and neuromotricity.
PASCAL-FRANCIS provides 6 records using the term neuromotricité.
DIALNET provides 10 records including articles and books.
Erihplus 1 entry.
CINAHL 1 entry.
Cuadernos de Pedagogía 4 entries.

As conclusions to the records obtained, we can state that there are few definitions of neuromotricity as a discipline or science. All the records found are provided in the bibliography section at the end of this article.

According to Hernando and Useros (2007), neuromotricity is the nervous response from cortical and subcortical nerve centres that activates motor neurons to produce a motor response.

The most recent definition of neuromotricity is provided by Díaz Jara, an expert in educational neuropsychology, in Martín Lobo et al. (2015), a monograph of the MECD (Ministry of Education, Culture and Sport) on Processes and instruments of educational neuropsychological assessment. It defines neuromotricity as the analysis of the neurological aspects involved in the development of a movement, its programming, its control and the acquisition of its execution models.

The Spanish Ministry of Education and Vocational Training defines neuromotricity as the science that studies the relationship between neurosciences and motricity, without forgetting the psychomotor part of movement.

As for neuromotricity as a methodology, the records found do not exceed twenty. It is a subject that is spreading, leaving behind motor re-education or motor therapy. Knowledge of the brain in the 21st century has an unequivocal impact on new procedures that promote the stimulation of the cortex, perception, movement programming, motor control and decision-making in the field of motor skills. Finally, it should be noted that the term "*neuromotricity*" is cited in research related to motor development and learning, as well as in studies on neuromotor and cognitive aspects, especially in developmental disabilities or disorders. In conducting a conceptual review of motor-related terminology, we will focus on neuromotricity as the discipline at the apex of motor work. At the base of the pyramid (Romero-Naranjo & Andreu-Cabrera, 2021) is motricity, as movement in itself, without consciousness or voluntariness. It would be followed on the second step by psychomotricity, with the properties widely analysed in previous sections, and fundamentally assimilated as a discipline and method of conscious movement with different functions relating to intellectual development through motor action. At a third level, neuromotricity is situated as a science that studies the relationship between neurosciences and motor skills, without forgetting the psychomotor part of movement.

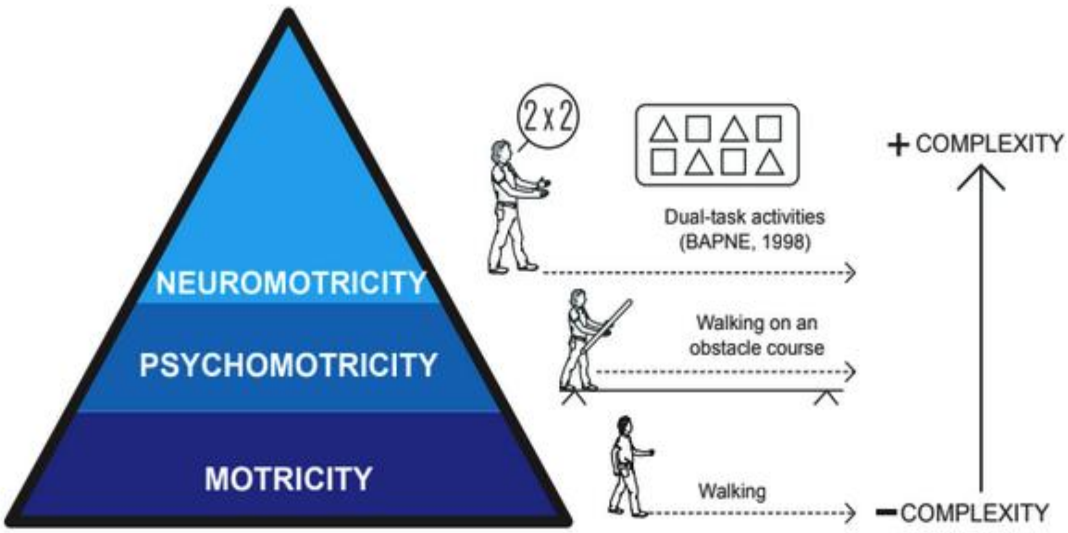


Figure 1. Pyramid of Neuromotricity. (Romero-Naranjo & Andreu-Cabrera, 2021).

After reviewing these documents, we propose two definitions:

* Neuromotricity as a science
Part of Neuroscience that studies the neurological processes that influence the generation and mastery of human motor skills, and that plan, organise, evaluate and control movement, in order to achieve motor milestones in adaptation to the environment and in function of environmental stimulation.

* Neuromotricity as a method
Neuromotricity is the educational and neurorehabilitative methodology within the motor field, which affects cognitive and socioemotional stimulation, through specific work on the executive functions of the brain, in relation to learning and motor skills.

NEUROTROPHINS, PHYSICAL ACTIVITY AND NEUROMOTRICITY

As noted above, certain neurogenerative diseases such as Alzheimer's disease, epilepsy and Parkinson's disease are closely related to deficits in neurotrophins (Tuszynski, 2009). González and Guerrero (2020) argue that neurotrophic factors are molecules that regulate neuronal survival, nervous system plasticity and other functions of neurons and glial cells, as well as some non-nerve tissues.

Tuszynski et al. (2009) found that brain-derived neurotrophic factor (BDNF), in rats and primates with certain brain lesions, prevented the destruction of neurons.

He showed the broad neuroprotective effects of BDNF administration in several models.

(BDNF) in several animal models, with therapeutic benefits extending to the degenerated hippocampus. In mice, after disease onset, they showed that BDNF, among other effects, reverses synapse loss and restores learning and memory. In aged rats, BDNF infusion reverses cognitive decline, and in aged primates, BDNF reverses neuronal atrophy and improves age-related cognitive decline. Tuszynski advocated the therapeutic administration of BDNF as a potential therapy for Alzheimer's disease.

Gómez-Pinilla, F. et al. (2002), investigated possible mechanisms by which exercise may promote changes in neuronal plasticity through modulation of neurotrophins. In their research, rodents were exposed to voluntary wheel running for 3 or 7 days (1-2 km per day), and the lumbar spinal cord and soleus muscle were assessed for changes in BDNF, its signal transduction receptor and downstream effectors of BDNF action on synaptic plasticity. As conclusions, these researchers stated that exercise increased the expression of BDNF and its receptor, synapsin, among others. These results indicate that basal levels of neuromuscular activity are necessary to maintain normal levels of BDNF in the neuromuscular system and the potential for neuroplasticity.

In the absence of further research with advanced instrumentation, such as helmets to monitor brain function and brainwaves, as well as the use of specialised software for neuroimaging and analysis, we propose here our "*Switched-on brain Hypothesis*" in relation to neuromotor activity (Neuromotricity). Motor activity and brain activity seem to be the key to activating and increasing neurotrophic factors. The greater the brain activity, the greater the number of neurotrophins, as well as the greater the number of synapses. Thanks to neuromotricity, the brain is likely to awaken the largest number of brain areas, thus enhancing executive functions. If with motricity, certain areas of the brain are worked and with psychomotricity these work areas are expanded, thanks to neuromotricity, we probably achieve that through stimulation and challenges of increasing complexity, the brain uses most of its potential, depending on the programmed activities. If we can draw a parallel between the fair and the brain, while with motricity, a few light bulbs of the fair are switched on, and with psychomotricity a few attractions of the fair are switched on, with neuromotricity, all the attractions are at full capacity and the brain is a burst of lights and mechanisms.

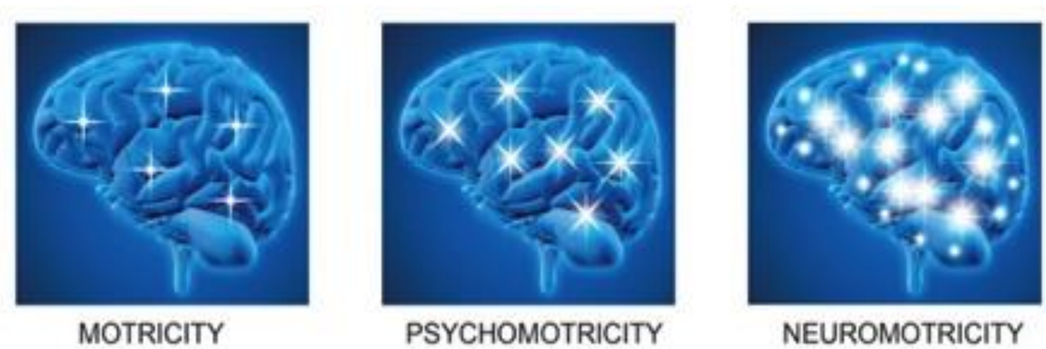


Figure 2. Neuromotricity: Switched-on brain Hypothesis. (Andreu-Cabrera y Romero-Naranjo, 2021).

As stated by Cotman and Engesser (2002) physical activity, in the form of voluntary wheel running, induces changes in brain gene expression. As conclusions from their research, they showed that exercise improves and enhances brain function. Exercising animals showed an increase in BDNF, a molecule that increases neuronal survival, improves learning and protects against cognitive decline.

In other research Cotman and Berchtold (2002) argued that extensive human research suggests that exercise may have benefits for general health and cognitive function, particularly in older age. Specifically, they argue that voluntary exercise can increase levels of brain-derived neurotrophic factor (BDNF) and other growth factors, stimulate neurogenesis, increase resistance to brain injury, and improve learning and mental performance. For these authors, exercise could provide a simple means to maintain brain function and promote brain plasticity.

According to Bayona et al. (2011), neural plasticity "*allows for adaptive and/or reorganisation changes, under normal or pathological conditions. The former includes, for example, conditioned and unconditioned learning processes; the latter includes adaptive and maladaptive events that ultimately accompany the evolution of established neurological diseases*".

Pinzón et al. (2020) state that through exercise protocols, with clinically significant duration, intensity and sequence, the effectiveness of physical activity in favouring brain plasticity in neural ageing processes has been demonstrated. In this sense, they argue that exercise increases aerobic capacity by increasing encephalic blood flow, which favours neurogenesis and synaptic connections. Similarly, cognitive function is improved, the risk of neurological pathologies can be reduced and the rate of ageing can be slowed.

At the same time, some authors argue that routine activities that do not challenge the brain do not generate brain plasticity. Automatic motor activities do not seem to generate neurotrophins, hence the importance of external stimulation and the environment. Movement and an environment rich in stimuli create brains rich in synapses (brain plasticity). In other words, aerobic physical exercise and the assumption of new challenges in new situations (voluntary, different and non-automatic psychomotor experiences) generate new neurons and new learning of all kinds, especially spatial-temporal structuring. Likewise, neuromotor activities (varied and of increasing complexity) activate and connect these neural networks, improving higher cognitive functions.

A neuromotor programme that develops global and fine motor skills, with a wide variety of activities and with execution times appropriate to the age of the child, will provoke changes at a cerebral level, specifically in terms of neuronal plasticity. This will have a positive impact on the cognitive functions of the practitioners.

NEUROMOTRICITY: ACTION PROTOCOL

Neuromotor activities are designed in a progression of psychomotor difficulty to work on the following executive functions according to the BAPNE Method:

Processing speed: this reflects the amount of information that can be processed per unit of time or even the speed at which a series of cognitive operations can be carried out, but also the time that elapses from the appearance of the stimulus to the execution of a response (Ríos et al., 2004). It can be visual (letters and numbers), auditory (language and singing) and movement. We work with the "*BAPNE Cognitive Plates*", the Clap Change, through question/answer structures of rhythmic and melodic oral text, verbalising mathematical operations and moving in different "*horizontal metres*" (geometric figures) in space.

Working memory: also called working memory, this is the ability to record, encode, maintain and manipulate information for a very specific interval of time in order to maintain a sense of unity of cognitive activity. In various types of activities using varied repetitions and combining new rhythmic structures both verbally and with body percussion.

Verbal fluency: related to the processes that carry out the appropriate strategies for searching for information and responding appropriately in the shortest possible time. It works through the ability to improvise verbally within certain structures provided by the teacher. It is related to dual task as it is carried out at the same time as moving in certain geometric figures.

Dual task: the ability to perform two completely different tasks simultaneously and paying equal attention to both of them constantly. It involves working in parallel on a visual task and a visuospatial task. In BAPNE all the activities present dual tasks as the aim is to make the lower limbs independent from the upper limbs with different movements and the voice (spoken or sung).

Inhibition or interference control: is the ability to inhibit or control impulsive responses, interferences or distracters while performing a task. It can be worked on at motor, attentional and behavioural levels. Multiple activities related to psychomotor melodies, canon, concentric circles and reverse reaction.

Cognitive flexibility: this is the ability to make changes to what was previously planned and thus adapt to the circumstances of our environment. The teacher constantly provides indications that modify psychomotor movement.

Planning: this is the ability to generate objectives, develop action plans to achieve them and choose the most appropriate one based on the anticipation of consequences. When given indications of what to do next, the participant develops action plans to achieve it.

Decision-making: is the process of making a choice between several possible choices based on needs, evaluating the results and consequences of each one of them. It mainly works with Clap Change and Handsball Change.

Branching: this is the ability to organise and carry out three tasks simultaneously in an optimal way, intercalating them and knowing where each one of them is at any given moment. When the lower limbs move to perform a geometric figure, the upper limbs perform Handsball Change and the voice intones, for example, on the 1st beat C, on the 3rd beat E and on the 4th beat G, with these tasks being changed almost continuously by the teacher, modifying the psychomotor sequence.

METHODOLOGY TO PROMOTE ENDOGENOUS NEUROGENESIS

Methodologies inspired by the 19th century, taught by 20th century teachers, for 21st century students deserve a revision of the educational paradigm. We cannot think of neuromotricity using the same classical activities from psychomotricity. Therefore, one of the objectives of this article is to clearly differentiate the concepts of motricity, psychomotricity and neuromotricity at a conceptual and practical level.

Based on this theoretical justification, we provide examples that imply an increase in the complexity of execution. For the correct execution of these activities, a basic knowledge of neuropsychology is essential for all teachers, where the link between brain, body and mind must always be present. Knowledge of the physical and functional changes of ageing, especially at the cerebral level, can contribute to the implementation of effective actions by the Neuromotricty specialist. This professional must know how the brain works in order to be able to carry out an intervention adapted to the evolutionary characteristics and needs of the individual.

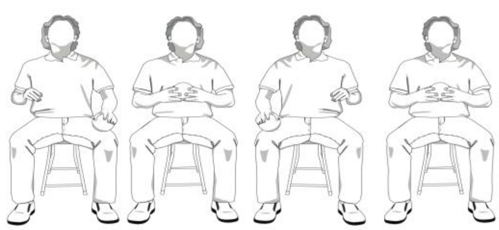
NEUROMOTRICITY

The BAPNE method is an example of a protocol to promote brain plasticity, which can stimulate maturing brains, repair neurodegenerative lesions or promote normal brain ageing. The BAPNE method offers more than 800 activities based on neuromotricity, in which the double task is always present. A typical activity is shown below.

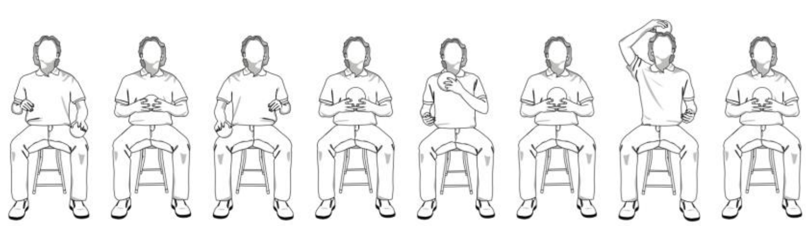
Read the plate in the direction indicated by the teacher (up-down; down-up; right-left; left-right). The square is called TA and the triangle is called KI.

	1	2	3	4	5	6	7	8	9	10	11	12	
A	□	△	△	△	□	△	□	□	□	△	□	△	I
B	□	△	□	△	△	□	□	△	□	△	□	△	J
C	□	△	△	□	△	△	□	△	□	△	△	□	K
D	△	□	△	□	□	□	△	△	△	□	△	□	L
E	□	△	□	△	△	□	□	△	□	△	□	△	M
F	△	□	□	□	△	□	△	△	□	△	△	△	N
G	□	△	□	△	□	△	□	△	□	△	□	□	O
H	□	△	□	△	△	□	△	△	△	□	□	△	P
	13	14	15	16	17	18	19	20	21	22	23	24	

You should do the reading while doing the following activity with a ball in your hands and moving your feet alternately.



Once this ability has been acquired, we can vary the coordination of the upper limb with the following proposal while reading the upper plank:



The same activity can be varied but in a bipedal position, standing, and moving in a square or another geometric figure. There are many variations and the possibilities of working on the double task are very varied.

Another different example would be to carry out the movement of the hands with the ball described above (sitting or standing) and to carry out some activities such as the following ones:

A. Asking geography concepts, e.g., what is the capital of France?
B. To say opposites. Sweet - Salty
C. To translate into another language. Silla - Chair
D. Repeating onomatopoeic words. Normal or inverted repetition
E. Memorizing digits, memorizing numbers, memorizing names of musical notes, memorizing proper names or names of objects.
F. Perform arithmetic tests. Division, addition, subtraction, multiplication.

CONCLUSIONS

The aim of this article is to present the different meanings of the terms motricity, psychomotricity and neuromotricity. In recent years, knowledge and research on the brain has provided new channels of development, with neuromotricity taking on special relevance.

As far as motor control is concerned, it is essential to know, at a neuropsychological level, the principles of motor coordination linked to cognitive functions and executive functions. We consider it essential for the educator to have a broad base of knowledge about the brain, since all educational action has a direct effect on this organ. Neuropsychological and neuroscientific knowledge will facilitate a pupil's development process and improve psycho-pedagogical intervention methodologies.

By way of conclusion, we would like to advocate that neuromotricity, as a science and as a method, has become, in the 21st century, a common core between neuroscience and the Sciences of Physical Activity and Sport, with a transversal vision of other disciplines.

AUTHOR CONTRIBUTIONS

FJRN and EAC conceptualized the review; EAC performed literature search and wrote the first draft; FJRN reviewed and edited the original draft. Both authors read and agreed to submit it into JHSE.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

REFERENCES

Andreu-Cabrera, E. & Romero-Naranjo, F.J. (2021). Neuromotricidad, Psicomotricidad y Motricidad. Nuevas aproximaciones metodológicas. Retos, 42, 924-938. https://doi.org/10.47197/retos.v42i0.89992

Bayona, J. et al. (2011) Neuroplasticidad, neuromodulación y neurorrehabilitación: Tres conceptos distintos y un solo fin verdadero. Salud Uninorte 2011; 27(1), pp. 95-107.

Castelló-Juan, Beatriz & Antón-Suay, María & Flores-Morales, Nuria & Vicedo-Reche, Manuela & Romero Naranjo, Francisco Javier. (2019). Evaluating Executive Functions In Primary School Children In Alicante Using Body Percussion. https://doi.org/10.15405/epsbs.2019.04.02.70

Cotman C.W. and Berchtold, N. C. (2002). Exercise: a behavioral intervention to enhance brain health and plasticity. Trends in Neurosciences. 25 (6), pp. 295-301. https://doi.org/10.1016/S0166-2236(02)02143-4

Cotman C.W. and Engesser, C. (2002) Exercise enhances and protects brain function. Exercise and Sport Sciences Reviews, 30 (2), pp. 75-79. https://doi.org/10.1097/00003677-200204000-00006

Cozzutti, Giorgio & Guaran, Francesca & Blessano, Elena & Romero Naranjo, Francisco Javier. (2017). Effects on Executive Functions in the BAPNE Method; A Study on 8-9 Years Old Children in Friuli Venezia Giulia, Italy. Procedia - Social and Behavioral Sciences. 237. 900-907. https://doi.org/10.1016/j.sbspro.2017.02.126

Da Fonseca, V. (1998). Manual de observación psicomotriz. INDE Publicaciones.

De la Mora, D. (2019) O que a arte ensina. CE Noticias Financieras. Portuguese ed.; CENFPT. Content Engine LLC, a Florida limited liability company . Miami. 7 Jan 2019.

De la Mora, D. (2019) Lo que el arte enseña. CE Noticias Financieras , Spanish ed.; CENFPT. Content Engine LLC, a Florida limited liability company . Miami. 7 Jan 2019.

De la Mora, D. (2019) Lo que el arte enseña. CE Noticias Financieras , Spanish ed.; El Norte. Suplemento Softnews; Editora El Sol, S.A. de C.V. Monterrey, Mexico. 27 Jan 2019: 24.

Dupré, E. (1925). Pathologie de l'imagination et de l'emotivité . Payot.

Falk, B.; Usselman, C; Dotan, R. et al. (2009) Child-adult differences in muscle strength and activation pattern during isometric elbow flexion and extensión. Applied physiology, nutrition and metabolism. Vol. 34. Num 4, pp. 609-615. https://doi.org/10.1139/H09-020

Gasc, JP. (2001). Comparative aspects of gait, scaling and mechanics in mammals. Comparative biochemistry and physiology a-molecular & integrative physiology. 21st International Congress of the European-Society-of-Comparative-Physiology-and-Biochemistry. Vol. 131, pp. 121-133. Liege, Belgium.

Gómez-Pinilla, F. et al. (2002).Voluntary exercise induces a BDNF-mediated mechanism that promotes neuroplasticity. Journal of Neurophysiology. Nov, 88(5), pp. 2187-95. https://doi.org/10.1152/jn.00152.2002

González Abreu, L. y Guerrero-Heredia, H. (2020). El papel del factor neurotrófico del cerebro en la enfermedad de Alzheimer. Vol 24. Retrieved from: https://psiquiatria.com/bibliopsiquis/volumen.php?wurl=el-papel-del-factor-neurotrofico-del-cerebro-en-la-enfermedad-de-alzheimer

Gradenigo, B. (2002) Assessing and rehabilitation of car driving ability: A holistic approach. Europa Medicophysica. Turin Vol. 38, Iss. 1, (Mar 2002): 33.

Guilmain, E. et Wallon, H. (1935). Fonctions psychomotrices et troubles du comportement. Foyer central d'hygiène.

Hernando, A. y Useros, A. (2007). Intervención fisioterápica en el proceso rehabilitador de pacientes con daño cerebral adquirido. Acción psicológica, 4, n 3, p.p. 35-48. https://doi.org/10.5944/ap.4.1.472

Jasmin, E. (2013) Évaluation écosystemíque des besoins des enfants au primaire ayant un trouble de l'adquisition de la coordination (ou une dyspraxie) pour favoriser leur participation sociale. Thése doctoral. Dissertations Publishing. Université de Sherbrooke. Canada.

Lakshmithathachar, M.A. (2010). Contribution of Ancient Indians to 'Writing' (With Special Emphasis on South Asian and Indian Writing Systems). Frontiers in Handwriting Recognition, International Conference on, Kolkata, India, 2010 pp. 491. https://doi.org/10.1109/ICFHR.2010.130

Lapierre, A. (1974). La reeducación física (Tomo I,II,III). Científico-Médica.

Martín-Lobo, P. et al. (2015). Procesos y programas de neuropsicología educativa. Catálogo de publicaciones del Ministerio: mecd.gob.es Catálogo general de publicaciones oficiales: publicacionesoficiales.boe.es Ministerio de educación, cultura y deporte. Secretaría de Estado de Educación, Formación Profesional y Universidades. Centro Nacional de Innovación e Investigación Educativa (CNIIE).

Martín-Lobo, P. et al. (2015). Procesos e instrumentos de evaluación neuropsicológica educativa. Catálogo de publicaciones del Ministerio: mecd.gob.es Catálogo general de publicaciones oficiales: publicacionesoficiales.boe.es Ministerio de educación, cultura y deporte. Secretaría de Estado de Educación, Formación Profesional y Universidades. Centro Nacional de Innovación e Investigación Educativa (CNIIE).

Mucchielli, A. (2009) Les prérequis neuropsychomoteurs fondamentaux contribuant à l'amélioration des apprentissages scoaires de base, à travers la méthode Ouros (Le Bon Départ): Psychomotricité et troubles neuropsychologiques=Basic neuropsychomotor skill prerequisites helping improve School learning through the Ouros method (For a good start). ANAE. Approche neuropsychologie des chez lénfant. Vol. 104-105 pp 439-447.

Padilha de Lima, A. & Bruno Cardoso, F. (2017) A eficácia da estimulação cortical no desenvolvimento perceptivo motor de adolescentes com síndrome de Down. Universidade Nove de Julho (UNINOVE). ConScientiae Saúde. Sao Paulo Vol. 16, Iss. 3, (Jul-Sep 2017): 311-317.

Perfetti, C. & Puccini, P. (1976) La progettualita assente. Neuromotricita e psicomotricita nella rieducazione del soggetto affetto da paralisi cerebrale infantile=Absence de projection. Neuromotricité et psychomotricité dans la readaptation du sujet souffrant d'une paralysie cerebrale infantile. Neuropsichiatr. Infant. Ital. No 184-185, pp 1035-1040.

Piaget, J (1969). El nacimiento de la inteligencia en el niño. Aguilar.

Pinzón, I.D. y Moreno, J. E. (2020). Envejecimiento neural, plasticidad cerebral y ejercicio: Avances desde la óptica de fisioterapia. Archivos de Medicina, 20 (1), pp. 187-206. https://doi.org/10.30554/archmed.20.1.3459.2020

Plamondon, Réjean. (2010). Neuromuscular Studies of Handwriting Generation and Representation. 261 - 261. https://doi.org/10.1109/ICFHR.2010.129

Plamondon, Réjean & Djioua, Moussa & O'Reilly, Christian. (2009). Recent Developments in the Study of Rapid Human Movements with the Kinematic Theory. Traitement du Signal. 26. 377-394.

Renard, K. (2019). Repères historiques et chronologiques de la psychomotricité comme soin, site personnel internet de l'auteure, lescarnetsdesentiers.com, 19-02-2019, np.

Rodríguez, I. (2016) Percusión corporal: ritmo que ayuda al desarrollo del cerebro. La Nación. Miscellaneous; Grupo de Diarios América. San José, Costa Rica. 22 Oct 2016.

Rodríguez, A. (2016) En armonía. Reforma. Suplemento Softnews. Editora El Sol, S.A. de C.V. Mexico City. 25 Apr 2016: 17.

Romero Naranjo, F.J. (2013b). Science & art of body percussion: a review. Journal of Human Sport and Exercise, 8(2). pp. 442-457. https://doi.org/10.4100/jhse.2012.82.11

Romero-Naranjo, F.J. (2004). "Body Music-Body Percussion" Propuestas didácticas sobre psicomotricidad rítmica. Música y Educación. Año 17, nº 60. Pp. 53-80.

Romero Naranjo, F.J. (2019) BAPNE for children. Canons and Rhythms: Neuromotricity and executive functions. 2-99 years old. Bodymusic - Bodypercussion Press.
Romero Naranjo, F.J. (2019) Cognitive solfege: Step by step activities and rhythms. Bodymusic - Bodypercussion Press.
Romero Naranjo, F.J. (2019) BAPNE for children: 3-6 years old. Bodymusic - Bodypercussion Press.
Romero Naranjo, F.J. (2019) Africa for children: Neuromotricity and Executive functions. 2-99 years. Bodymusic - Bodypercussion Press.
Romero Naranjo, F.J. (2019) BAPNE for children & Gross motor skills. Neuromotricity and Executive functions. 2-99 years old. Bodymusic - Bodypercussion Press.
Romero Naranjo, F.J. (2019) Cognitive solfege: Neuromotricity and Executive functions. 2-99 years old. Bodymusic - Bodypercussion Press.
Romero Naranjo, F.J. (2019) Cognitive solfege: Beat and motor control. 2-99 years old. Bodymusic - Bodypercussion Press.
Romero Naranjo, F.J. (2019) BAPNE for children & Fine motor skills. Neuromotricity and Executive functions. 2-99 years old. Bodymusic - Bodypercussion Press.
Romero Naranjo, F.J. (2020) Percusión corporal y solfeo cognitivo. Recursos pedagógicos según el método BAPNE. Pensamiento actual. Diciembre 2020-mayo 2021.Vol. 20, Num 35, pp. 105-121. https://doi.org/10.15517/pa.v20i35.44398
Ros-Silla, Enrique & Valcarcel-Marsa, Sven & Jaikel-Arce, Djamill & Berlai, Silvia & Giglio, Roberto & Payro-Escobar, Alvaro & Romero Naranjo, Francisco Javier. (2019). Attention In Conservatoire Students Using Body Percussion Following The Bapne Method. https://doi.org/10.15405/epsbs.2019.04.02.57
Ruiz Pérez, L. M. (1987). Desarrollo motor y actividades físicas. Gymnos.
Sánchez, Osmila & Elena, Claudia & López, Romeu & Romero Naranjo, Francisco Javier. (2019). The European Proceedings of Social & Behavioural Sciences EDUHEM 2018 VIII International conference on intercultural education and International conference on transcultural health: The value of education and health for a global, transcultural world pilot study of executive functions in elderly adults in care homes. https://doi.org/10.15405/epsbs.2019.04.02.95
Serna Carrión, M. (2020). Relación entre el desarrollo neuromotor y el lenguaje oral en Educación infantil. Journal of neuroeducation. Vol. 1. Isue 1. July 2020, pp.100-107. https://doi.org/10.1344/joned.v1i1.31721
Silva, J.R.V et al. (2009) Sinergia entre o lóbulo frontal e parietal durante provas de coordenação motora global. Fitness & Performance Journal. Rio de Janeiro Vol. 8, Iss. 5, (Sep/Oct 2009): 360-365.
Torró-Biosca, Ricardo & Aparici, Francisco & Arnau Mollá, Antonio & Ulate-Orozco, Richard & Dailyn, Adriana & Cabrera-Quirós, Francisco & Romero Naranjo, Francisco Javier. (2019). Pilot Study Into The Executive Functions Of Children Aged 8-9 BAPNE Method. https://doi.org/10.15405/epsbs.2019.04.02.94
Tuszynski, M.H. et al. (2009). Neuroprotective effects of brain-derived neurotrophic factor in rodent and primate models of Alzheimer's disease. Nature Medicine. March, 15(3), pp 331-337. https://doi.org/10.1038/nm.1912
Vadillo, R.C. (2014) Integración e inclusión educativa vs. integración e inclusión excluyente: un desafío educativo. Revista Mexicana de Investigación Educativa. Consejo Mexicana de Investigacion Educativa. Mexico City Vol. 19, Iss. 63, (Oct-Dec 2014): 1285-1290.
Vaivre-Douret, L.;Favarelle, I; Cabrol, D. et al. (2003) Le repérage de la douleur dórigine posturale chez le nouveau-né à terme en période néonatale: étude pilote=Screening for posture-related pain once babies start walking: Pilot study. Revue internationale de pédiatrie. N 324, pp 9-15.

Vaivre-Douret, L. (2006) Un outil normé pou l'évaluation des fonctions neuro-psychomotrices de lénfant: la Batterie NP-MOT= A standard tool for assessment of child neuro-psychomotor functions: The NP-MOT Battery. ANAE. Approche neuropsychologie des chez lénfant. Vol. 88-89 pp 237-240

Vaivre-Douret, L. (2009) Contribution au diagnostic par l'évaluation standarisée des fonctions neuro-psychomotrices chez l'enfant=Contribution to the diagnosis by the standardized evaluation of the neuro-psychomotor child's functions. Evolutions psychomotrices(Paris). Num 83, pp 10-17.