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Neuromotricity in early childhood education. Development tables as an interdisciplinary proposal according to the BAPNE method

Neuromotricidad en educación infantil. Tablas de desarrollo como propuesta interdisciplinar según el método BAPNE

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Abstract. The aim of this research is to review the basis of neurodevelopment in early childhood education and provide interdisciplinary development tables that encompass cognitive, kinesthetic, and musical aspects. After reviewing numerous authors, and in order to provide early childhood education teachers with a reliable overview of the subject, we present here tables that are always conditioned by genetic and environmental factors. The development tables offer guidance information in areas such as language, motor coordination, gross motor skills, fine motor skills, spatio-temporal relationships, time horizons, logic, numerical relationships, and rhythmic motor, melodic, and socio-musical aspects, among others.
Keywords: Neurodevelopment, Neuromotricity, Bapne, Body percussion, cognitive functions, executive functions.

Resumen. El propósito de esta investigación es realizar un recorrido sobre las bases del neurodesarrollo en infantil para finalmente aportar unas tablas de desarrollo de carácter interdisciplinar que engloben aspectos cognitivos, cinestésicos y musicales. Tras la revisión de numerosos autores, con el objetivo de ofrecerle un panorama fidedigno al docente de educación infantil, aportamos unas tablas que siempre están condicionadas por factores genéticos y ambientales. Las tablas de desarrollo aportan información orientativa en áreas como el lenguaje, coordinación motora, motricidad gruesa, motricidad fina, relaciones espacio-temporales, horizonte temporal, lógica, relaciones numéricas, aspectos rítmico-motores, aspectos melódicos y aspectos sociomusicales entre otros.
Palabras clave: Neurodesarrollo, Neuromotricidad, Bapne, Percusión Corporal, funciones cognitivas, funciones ejecutivas.

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Introduction

Neurodevelopment is closely related to genetics, the environment, and the stimulation and affectivity that surround the child (Britto et al., 2017; Horta et al., 2015, Mora & Palacios, 1990; Wanjohi et al., 2016), all of which impact on the potential increase in the production of neuronal synapses (Victoria et al., 2015). According to Volpe (2008), humans begin to generate their first neurons 42 days after conception and reach 100 trillion neurons at birth. During their growth (Salgado, 2007; Volpe, 2008), the brain undergoes a total of four basic developmental stages called: neuronal proliferation, migration, brain organization and lamination, and myelination. Volpe emphasizes that these stages are not consecutive because they naturally overlap, but they can be affected simultaneously when there is an external or internal factor that disturbs them. These changes can be associated with environmental (Evans, 2006) and emotional situations, the use of drugs, tobacco, or alcohol by the pregnant mother, or even with the malnutrition of the baby (Valadez et al., 2020). Several authors have studied the possible psychomotor disorders resulting from the situations described above and have provided specific classifications (Ajuriaguerra, 1983; Ajuriaguerra & Marcelli, 1996; del Barrio, 1986; Bucher & Serra, 1976; Bulbena, 1993; Cobos-Álvarez, 2005; Hugette, 1988). The purpose of this article is not related to psychomotor disorders, an issue already addressed by many researchers (Cánovas et al., 2010; Monge-Alvarado & Meneses-Montero, 2002), but to show all the motor, cognitive, and musical possibilities between the ages of three and six years to serve as a global framework when working on a practical level with students.

Neuromotricity is a discipline that is academically justified due to its precise connection to cognitive and executive functions. (Andreu-Cabrera & Romero-Naranjo, 2021; Asurmendi & Romero-Naranjo, 2022; Romero-Naranjo & Andreu Cabrera, 2023a, 2023b). The term "neuromotricity" was first introduced by the researcher André Lapierre in 1974 (Andreu-Cabrera & Romero-Naranjo, 2021; Romero-Naranjo & Andreu Cabrera, 2023a, 2023b). Currently, there are several bibliometric and review studies that provide a comprehensive overview of the field based on academic engines (Arnau-Mollá & Romero-Naranjo, 2022a, 2022b, 2024; Di Russo & Romero-Naranjo, 2023). These publications present valuable insights into the existing literature. (Alonso-Marco & Romero-Naranjo, 2022; Alonso-Sanz & Romero-Naranjo, 2015; Romero-Naranjo, 2013, 2016, 2017, 2018, 2020b, 2022; Romero-Naranjo et al., 2022; Romero-Naranjo & Romero-Naranjo, 2022; Romero Naranjo & Andreu Cabrera, 2023a, 2023b, 2023c, 2023d; Romero-Naranjo & Sayago-Martínez et al., 2023; Romero-Naranjo & Pujalte-Cantó et al., 2023).

Table 1.
Publications on body percussion worldwide (Arnau-Mollá & Romero-Naranjo, 2024, p.1040)

			Collaboration						Intervention with acts. B.P						Gender participation	
Research group	Docs.	Cit.	O.M	Cit.	O.W	Cit.	Mix	Cit.	Int.	Cit.	No int.	Cit.	Prot.	Cit.	M.P	F.P
BAPNE	161	1232	91	783			70	449	18	214	135	928	8	90	267	145
Secondary engines	118	682	76	513			42	169	3	7	114	675	1		185	93
1st Order	118	682	76	513			42	169	3	7	114	675	1		185	93
Primary engines	43	550	15	270			28	280	15	207	21	253	7	90	82	52
1st Order	43	550	15	270			28	280	15	207	21	253	7	90	82	52
No BAPNE	84	333	29	125	34	116	21	92	24	99	59	227	1	7	61	67
Secondary engines	55	167	21	103	22	31	12	33	17	57	37	103	1	7	38	39
1st Order	22	36	10	19	8	13	4	4	7	10	14	19	1	7	17	15
2nd Order	33	131	11	84	14	18	8	29	10	47	23	84			21	24
Primary engines	29	166	8	22	12	85	9	59	7	42	22	124			23	28
1st Order	8	42	3	12	2	2	3	28	4	15	4	27			8	9
2nd Order	21	124	5	10	10	83	6	31	3	27	18	97			15	19
TOTAL	245	1565	120	908	34	116	91	541	42	313	194	1155	9	97	328	212
Secondary engines	173	849	97	616	22	31	54	202	20	64	151	778	2	7	223	132
1st Order	140	718	86	532	8	13	46	173	10	17	128	694	2	7	202	108
2nd Order	33	131	11	84	14	18	8	29	10	47	23	84			21	24
Primary engines	72	716	23	292	12	85	37	339	22	249	43	377	7	90	105	80
1st Order	51	592	18	282	2	2	31	308	19	222	25	280	7	90	90	61
2nd Order	21	124	5	10	10	83	6	31	3	27	18	97			15	19

For this reason, it is important to understand the difference between motor skills, psychomotor skills, and neuromotor skills: **Motricity.** It is the ability to control body movements in a voluntary and coordinated manner using the motor system. Examples of motor skills include walking, jumping, running, rolling, crawling, and going up or down stairs, among others. **Psychomotricity.** It is the set of cognitive, emotional, symbolic, and sensorimotor interactions that enables individuals to express themselves in a psychosocial context (Andreu-Cabrera & Romero-Naranjo, 2021). **Neuromotricity.** It is an educational and neurorehabilitative process that has an impact on cognitive stimulation through executive functions, where dual task and mainly language (spoken, sung, recited, etc.) coexist, resulting in a superior stimulation. (Mas-Mas et al., 2023; Romero Naranjo & Andreu Cabrera, 2023a, 2023b, 2023c, 2023d).

Table 2.
Classification of the five paradigms of Dual Task (Romero-Naranjo & Andreu-Cabrera, 2023b, p.360)

	Dual Task Paradigms
1	Motor/Motor. These are two tasks that have a motor component (Amboni et al., 2012; Beurskens & Bock, 2013; Hung et al., 2013; Lee et al., 2017; Shim et al., 2016). They are classified into two major blocks: A. Balancing tasks: This can be observed in the hospitality industry when we see a waiter carrying a tray, several plates on his hands or a simple glass of water. B. Oculo-manual tasks: An example of this is walking forward while fastening the buttons of a shirt.
2	Cognitive/Cognitive. These are two activities that involve cognitive processes (Baddeley & Hitch, 1974; Corlu et al., 2015; Wang & Gathercole 2013). A practical example would be to write the alphabet on a piece of paper while answering questions such as the capital of Germany, the opposite of white, the result of 2x9, the translation of the word "chair" into English, etc.
3	Cognitive/Motor. It consists of performing one task with a cognitive component and another one with a motor component (Bridenbaugh & Kressig, 2015; Crockett et al., 2017; Falbo et al., 2016; Fok et al., 2011; Hawkins et al., 2018; Lin & Lin, 2016). The literature on this paradigm is abundant, resulting in multiple variants of the activities. The voice plays a fundamental role since the individual must speak continuously according to the verbal fluency tasks given. Here, we present a few variants: A. Walking and performing arithmetic operations (addition, multiplication, division). B. Walking and training the working memory (remembering words from a story). C. Walking and working on verbal fluency (saying backwards the days of the week). D. Walking and working on semantic fluency (saying words beginning with the letter "N"). E. Walking and working on categorical fluency tasks (saying only the names of fruits or musical instruments).
4	Rhythmic/Motor. It consists of performing both a rhythmic and a motor task (Park et al., 2014; Kim et al, 2017). A practical example of this is walking forward while playing a percussion instrument following a rhythmic pattern. Another example is performing a rhythmic structure by clapping.
5	Rhythmic/Motor/Cognitive (Romero-Naranjo et al, 2023a). It consists of performing a task with a motor component linked to movement, another with a cognitive component and another with a rhythmic component. The BAPNE method offers several practical variations where the novelty lies in the fact that the individual not only has to speak but also has to sing, recite, hum, etc. To achieve this, the methodology employs not only the body but also various objects such as hoops of different sizes, feathers, strings, chopsticks, and cones, among others. The neuromotricity chart (Figure 4) helps with the initial activities. These are divided into three main groups: A. Dual-task activities while walking freely in the space. B. Bipedal dual-task activities with geometric figures (Figure 8). C. Seated dual-task activities. Each of these activities involve moving the lower limbs completely independently of the upper limbs while performing verbal, rhythmic or melodic fluency tasks.

The following neuromotricity chart illustrates many variants of motor coordination based on the dual task (Figure 1).

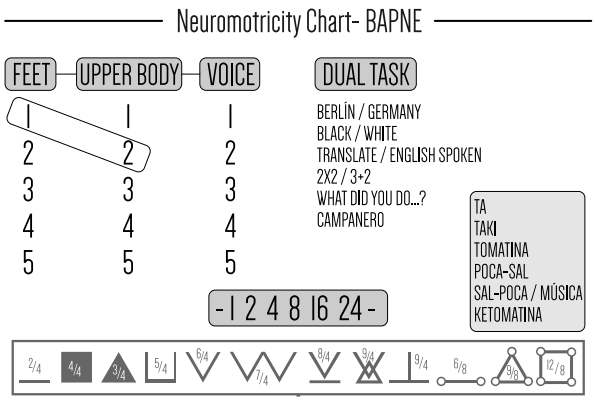


Figure 1. Neuromotricity chart

The importance of 6 months of age

In terms of neurodevelopment, the first 6 months of life are crucial, as babies begin to acquire a series of skills that allow them to better interact with the environment (Eliassen et al., 2000; Ferré-Veciana, 2013; Gooijers & Swinnen, 2014; Serrien et al., 2001). Motor practice induces a reorganization of motor and synaptogenic representations in the motor cortex. Many experts affirm that it is important to remember that the cerebral cortex matures from bottom to top and from back to front.

At this age, babies begin to manipulate objects by bending their elbows downwards and moving their arms with a certain degree of flexibility, allowing them to move objects where they want them to go. They are also more attracted to visual stimuli and have an improved ability to perceive sounds (Rigal, 1987, 2006).

During the first few months of life, the two hemispheres of the brain tend to work alternatively, with little interaction between them, a phase called the "ipsilateral alternating phase". From six months of age, infants enter the crawling phase, during which both hemispheres begin to communicate with each other, transitioning into the so-called "duolateral phase".

From this point forward, the crossed pathways are stimulated due to the permeabilization of the circuits involved in each contralateral movement made by the infant. It is important to note that in 1710, François Pourfour du Petit demonstrated that motor control depends on the hemisphere opposite to that of the innervated limb, since there is a crossing of the pathways of the motor signals sent from the brain to the medullary pyramids. This led to the understanding that thanks to this crossing, our brain shows that we have a contralateral motor, sensory and perceptual functioning.

The corpus callosum plays a major role in the connection of the hemispheres, whose respective functions contribute to a better interaction. It is important to highlight the process of interaction and increased interdependence between the two hemispheres through contralateral crawling. The corpus callosum is divided into three parts:

A. Posterior third
B. Middle third
C. Anterior third

Stimulating children's fine psychomotor skills is crucial during their first year of life since their hands become the architects of civilization and, above all, the architects of their minds. The hands play a fundamental role. In fact, infants explore and perceive the outside world through their hands and mouth. This is why families and educators must have tools to stimulate this important aspect.

The hands enable the recognition of objects by their texture, shape, weight, temperature and, of course, by manipulating them. It is a complex skill to use them with great precision since it involves the release of the shoulder girdle, the rotation of the radius and the ulna, the independent mobility of the fingers, and the dissociation between the phalanges, metacarpals, and carpal bones. Therefore, infants require time and specific stimulation for the proper development of the 27 bones connected by a complex network of tendons and muscles.

The mobility discussed here is related to the coordination function of the eye movements when focusing their attention and the subsequent manipulation. Any form of manual manipulation requires programming, adapting and verification capabilities that encompass stimulation activities from birth to adulthood. Mothers play an important role in the infant development through activities that involve singing, playing games and providing motor stimulation. These will contribute to the child's future motivation.

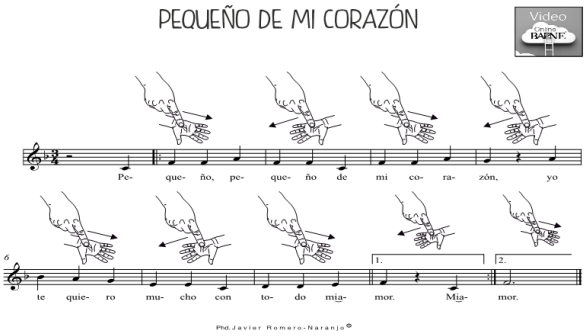


Figure 2. Practical example of a psychomotor melody for babies from 0 to 3 months

From 0 to 3 months

During the first months of life, the infant is exploring a completely new environment. Throughout this time, they exhibit the palmar grasp reflex in their hands, which is common in apes. A clear example of it can be observed when babies rub their palm, causing them to unconsciously close their fist. A baby usually keeps its hands closed with its fingers flexed and occasionally opens them slightly. When touching an object, they clench their hands, an important primitive reflex. They are usually able to hold an object when it is placed in their hand and can support their body weight when holding onto an adult's thumbs.

At BAPNE, we recommend the following process during the first few months in which the mother sings melodies while alternately rubbing both palms. Figure 2 shows a melodic example.

It is normal for this reflex to disappear at around 4-5 months, when the infant begins to explore with his hands, although he does not yet have much motor precision because his prefrontal area, basal ganglia and cerebellum are in the process of maturing.

At this age, the baby can lie on its stomach, raise its chin, follow a moving light with the eyes, fix its gaze momentarily on an object or a person, put its hands to its mouth, and react to sounds and first vocalizations other than crying.

From the second month of birth, infants hone their hand movements a little more, making wider movements that allow them to play a little with their hands. Their perception of the external world revolves around their mouth and hands, which is why they begin to experience the feeling of touch, leading them to visuomotor stimulation in the future. To this end, the mother can sing to him holding his little hands and bringing them together at the beginning of each measure.

At this age, the baby can lie on its stomach, raise its head and shoulders, keep its head upright for a few seconds when seated, fix both eyes on a single target (binocular convergence), move its arms energetically, and smile. Figure 3 provides a practical example.

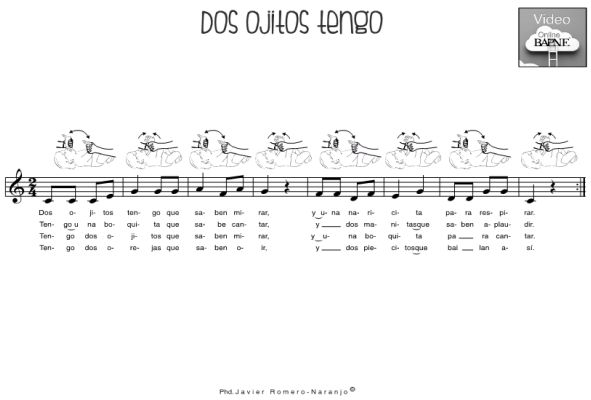


Figure 3. Basic activity to introduce the musical beat

The suggested activity is designed to be carried out three times a day, usually before meals. It can also be done four times and may be increased if deemed necessary. Each session should last five minutes and be at an appropriate level of intensity for a child of a few months, but always without fear and in a natural way. The bathing session should be recreational and involve movements prompted by the baby-adult relationship. The degree of affectivity and the connection between the adult (parent) and the baby have a high value in terms of socialization.

From 2 to 4 months

This period is very interesting because the baby begins to perfect its visual-motor coordination. They begin to perceive the location of the objects and the colors, which leads to an interest in "grabbing" the things they see. During this phase, they try to grasp objects, often with little success, but with effort and depending on the size, they manage to hold it. As a practical activity, we suggest using a small ball that they can grab with their mother's help.

From 4 to 5 months

During this period, the baby begins to develop its visual abilities and can distinguish objects. Its cerebellum, basal ganglia, and prefrontal area allow it to reach, grab, and observe objects and potentially put them in its mouth. Auditory stimulation is crucial, so the baby will search for a sound source by moving the head and follow a moving object with the eyes.

At this stage, the hands serve as an instrument for reaching objects, although the baby is not yet fully aware of them. Additionaly, fine motor skills begin to be continuously stimulated. This type of fine psychomotor skill is usually pinching, where the thumb and index finger play a special role. Babies gradually improve their hand-eye coordination, allowing them to pick up objects they see by controlling and coordinating their movements.

From 6 to 9 months

This period is essential as it marks the beginning of the movement by the process of "creeping". It is also the time when they can hold a small object with ease. The grasping period is also associated with hitting with both hands. During this stage, the stimulation of the somatosensory cortex begins and they feel pain when they are hit hard. Therefore, hitting an object happens usually 3 to 4 times in a row at the most.

In terms of motor development, several types of locomotion can be distinguished in human infants. Each type of movement has its own postural and motor patterns, starting from ventral decubitus and dorsal decubitus in a systematic, gradual and spontaneous way. All of them require automatic postural control, the displacement of the center of gravity especially directed towards orientation behavior (visual orientation, grasping function and full locomotion), standing up straight against gravity, and purposeful, goal-oriented physical activity.

Rolling over: It is the movement from dorsal decubitus through lateral to ventral decubitus or crawling position and vice versa. It begins in the 4th month of life.

Drag: It is a locomotor movement in ventral decubitus that starts between the seventh and ninth month of life. It consists of an alternative and coordinated support of the body on the elbows to create a traction force that pulls the trunk in a volitional way towards an attainable goal for the child. The legs do not contribute to the impulse.

Crawling: It appears between the ninth and tenth month of life, based on a crossed pattern on the hands and knees in the sagittal plane, with the trunk elevated. The flexion of the ankles indicates a more mature crawl, which appears later.

Osseous: It is a locomotor movement that sometimes

begins between the tenth and eleventh month of life. It starts from the crawling position, but raising the knees and leaning on the hands. Its purpose is to eventually stand in a bipedal position. The proper positioning of the ankle, along with the function of the legs in generating the necessary impulse, plays a decisive role.

Gait: Gait can be defined as a series of alternate and rhythmic movements of the trunk and limbs that induce a forward displacement of the center of gravity through a combination of automatic and voluntary postural components while standing. A normal gait is one that is performed in an efficient, coordinated, rhythmic, and economical manner.

Infants crawl until they are about one year old because they are not yet physically capable of standing up. The human hip is naturally designed for childbirth. The femur lacks the angle in its proximal part next to the hip, which allows us mammals and dinosaurs to stand upright. It is straight, like that of crocodiles, resulting in narrower hips, and the acetabular bone is flat so that in breech deliveries a dislocation of the hips occurs. After about a year, the hips acquire the form of an adult's. It is as if the child's brain connected the "chip" of walking allowing them to stand up and walk. Any attempt to make the infants stand up or walk before the first year can harm the development of the acetabular bone and increase the risk of hip arthrosis later in life. In other words, children should not be encouraged to walk before they are physically capable of doing so on their own. Around the age of one year, when the hips and the brain have matured, they will get up and walk.

At eight months, infants begin their crawling stage, which allows them to refine their control of visual-motor skills. During the crawling process, several factors such as the distance from the head to the ground, the movement of the hands in relation to the knees, the distance at which objects are observed, the color of the objects, and the use of toys as goals for touching or grasping are essential for future motor development. Figure 4 illustrates a practical proposal.

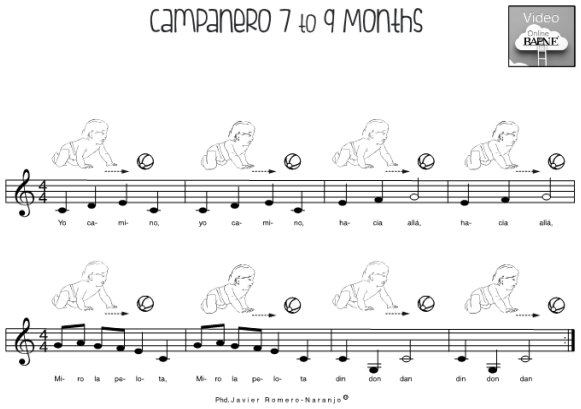


Figure 4. Illustrates a practical proposal

From 9 to 12 months

In this period, the crawling process is perfected and some attemps to stand up can be observed. The infant's attentional process improves, especially sustained attention, which is why they observe objects with curiosity before reaching for them. The index finger begins to play a prominent role, being the instrument for touching, pushing and even gently "scratching". The musculature of the fingers develops little by little to improve motor precision in grabbing.

From 12 to 15 months

Their hands begin to perform slightly more complex tasks in which the infant's fingers play a special role. They can gather objects together or separate them. And the hands become a tool for holding, grasping, and manipulating objects according to the baby's creativity.

From 1 to 2 years

The flexor muscle of the thumb is not yet fully developed, so movements tend to be performed impulsively. Therefore, it is normal that when grabbing a pencil, the child performs the movements without control. The motion is carried out from the shoulder and elbow joints since the wrist and fingers have a secondary function, which is why the child is more concerned about the action and the movement in broad terms. A child of this age uses different types of movements:

A. Homolateral. These movements originate from the axes of the body and have a clear tendency to go to the right when performed with the right hand, keeping in mind that laterality is defined from the age of 5-6 years. The same occurs when executed with the left hand, as it tends to go to the left. That being said, it is important not to force the child to use a specific hand to hold a pencil.

B. Sweeps. They always start from the central axis and are articulated by means of horizontal or oblique back and forth movements.

This period is referred to as "stage 1" because the child grabs the pencil with the palm and thumb pointing upwards and moves it around with shoulder and arm movements.

- Between 14 and 15 months of age: Great independence in movements. The toddler is able to walk and hold a cup and drink from it independently.
- From 16 to 18 months of age: The toddler exhibits physical abilities such as climbing steps on all fours, walking backwards, and crouching. They play construction and matching games and are able to imitate some gestures. Additionally, they can scribble and use 6-7 words.
- 20 months of age: They are able to run and jump and identify some body parts. Their vocabulary consists of 12 words. Also, they can use a spoon correctly and pour water from one cup to another.

From 2 to 3 years

This phase is vital for the toddler as he transitions from crawling to standing, that is, taking his first steps in which balance and posture (mainly controlled by the cerebellum) must improve. The first steps are usually taken with the legs

open because the gluteal muscles are not yet developed, nor is the position of the spine and head in order to have a correct balance. By the end of the second year, the child can walk, synchronizing arms and legs, and even hit a ball.

The hands give the toddler the ability to manipulate objects with greater precision and therefore his cognitive faculties are better developed (for example, he is able to copy horizontal movements). He can insert one object into another, perform simple construction processes, open and close drawers, hit objects, build towers with cubes, pull a rope to drag objects, paint with his hands, pick up a book or a comic book and manipulate its pages, move levers, turn a steering wheel, and dress and undress himself with some help. His vocabulary consists of 20 words and can use short and simple sentences. Figure 5 shows a fine psychomotor skills activity.

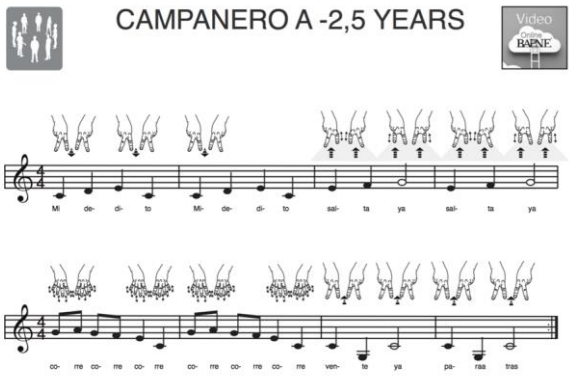


Figure 5. Basic fine psychomotor skills activity

At the motor level, the toddler can ride a tricycle, climb stairs alternating both feet (although going down is still challenging), can eat without help, and undress and dress by himself (simple clothes without buttons or zippers). Figure 6 shows a gross psychomotor skills activity.

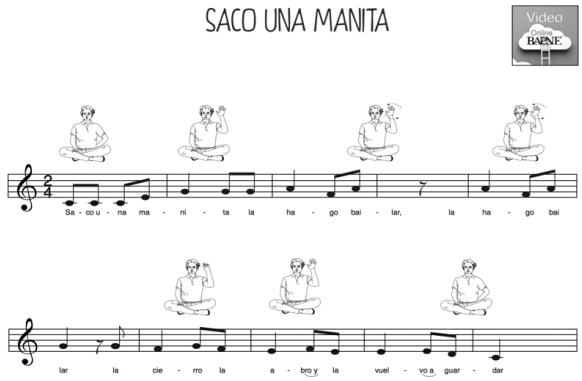


Figura 6. Basic gross psychomotor skills activity

From 3 to 4 years

The toddler experiencies a change in socio-emotional management because of the transition from the family environment to the preschool stage. Their emotional management in front of other children and another authority figure (teacher) changes their perception of the world around them.

Additionally, their motor skills improve as they can now fasten buttons, tie shoelaces, use cutlery correctly, and hold a pencil with some precision. In the classroom, they begin to develop their skills with the pencil by practicing simple movements, circles, and trying to draw people. Figure 7 shows a motor activity for this age group alternating hands.

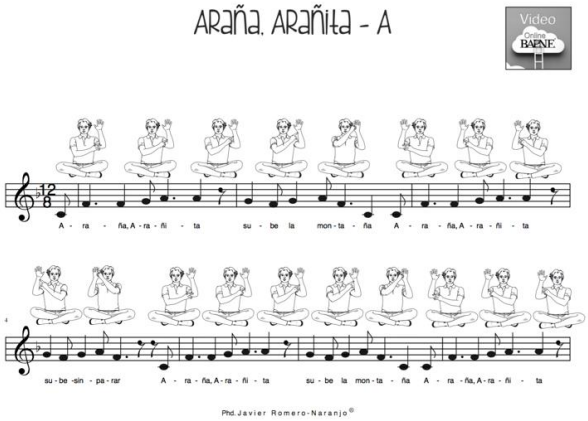


Figure 7. Motor activity alternating hands

Playdough, modeling clay, sand and soil are didactic tools that teachers use with toddlers of this age to stimulate fine motor skills. These materials help them develop basic spatio-temporal notions such as up-down, front-back, before-after, fast-slow, among others. An example of a music-motor activity is shown in Figure 8, and an example of a fine motor activity can be found in Figure 9. Both of them are designed for three-year-olds.

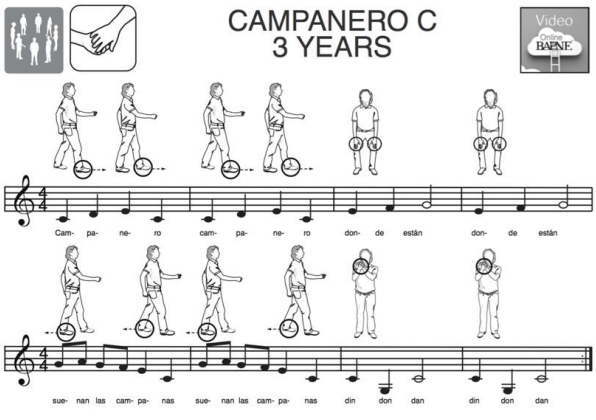
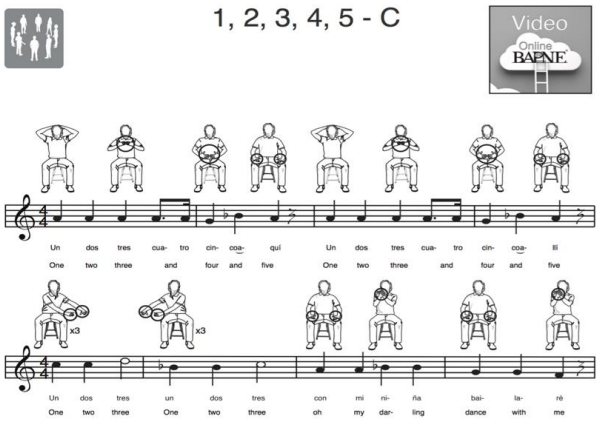


Figure 8. *Musical-motor activity for three-year-olds*

From 4 to 5 years

At the age of four, children are capable of using a pencil with greater precision, so they can draw geometric figures, cut with scissors, shape a body with playdough or design a small house with clay. In terms of gross psychomotor skills, they are already able to descend a staircase using one foot

per step or to balance on one foot for 4 to 8 seconds. Their brain processes a vast amount of information through stim-



uli and gradually classifies it. This includes distinguishing geometric shapes such as triangles, squares, and circles, as well as understanding spatial terms like "far", "near", "next to", "above", "below", "behind", "in front", etc. Figure 10 shows an activity to work on body schema with children of four and five years old.

Figure 9. *Musical-motor activity with fine motor skills for three-year-olds*

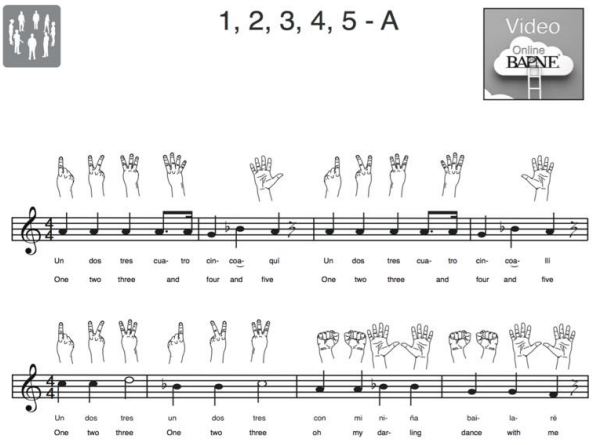


Figura 10. *Basic activity to work on body schema*

From 5 to 6 years

The child's fine motor skills have improved, enabling him to fasten buttons, pull up his zipper and improve his ability to tie his shoes. The ability to cut out simple shapes will gradually progress, as well as the ability to pass a thread through the perforations of a sheet of paper or to create more complex figures with playdough and clay. At this age a child may already have the ability to ride a bicycle, jump several meters, catch a bouncing ball, draw a triangle, a square, and a rhombus, or write his name. Figure 11 presents an activity to work on laterality and Figure 12 displays a closing activity. Both of them are appropriate for five and six-year-olds.

State of the art

Regarding the topic of this article, there are publications on specific aspects of development such as language, borderline intelligence and neurodevelopmental disorders (Ardila & Solís, 2008; Artigas-Pallarés et al., 2007; da Fonseca, 1996; Medina, et al., 2015) or executive functions (Bausela, 2014; Flores et al., 2014; Flores & Ostrosky, 2008; Gutiérrez & Ostrosky, 2011; Moraine, 2014; Rosselli-Cock et al., 2008). Based on a variety of scales, questionnaires, tests and tables mentioned below, we propose some interdisciplinary development tables that can be of great help to teachers of children from three to six years old.

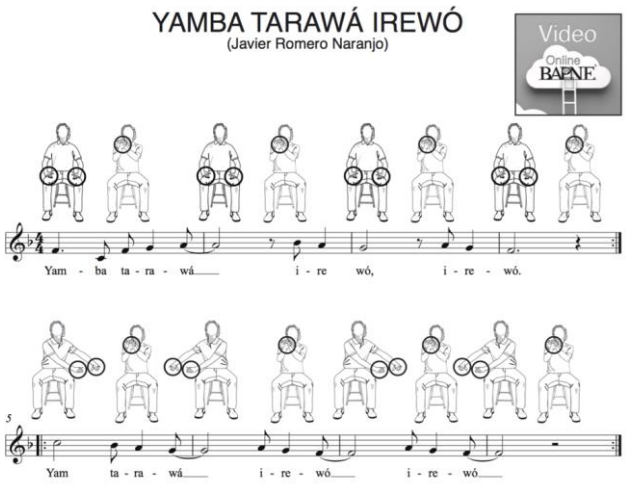


Figura 11. *Activity to work on laterality*

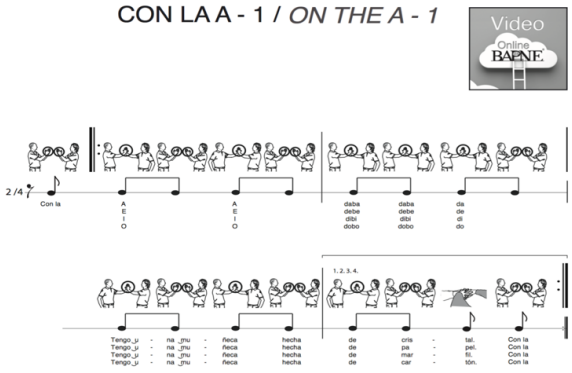


Figure 12. *Closing activity to end a lesson*

Screening tests for integral development

Comprehensive developmental scales are those that assess all areas of child development to identify the possible risk of developmental delay. They contain standardized or norm-referenced tests and normally evaluate areas related to language, physical, cognitive, communication, socio-emotional, and adaptive development. Some of them also include psychomotor aspects. Among them are the Battelle Developmental Inventory (Newborg et al., 1984), the Bayley Developmental Scale (Bayley, 1936), the Denver scale which aims to identify young children, up to six years of age, with developmental problems (Frankenburg & Dodds, 1967), the Haizea-Llevant Scale (Fernández-Álvarez, 1991), the Merrill-Palmer Scale (Roid & Sampers, 2004), the

McCarthy scale of aptitudes and psychomotor skills (Kaufman & Kaufman, 1977), the School Neuropsychological Maturity Questionnaire CUMANES (Portellano et al., 2012), the Child Neuropsychological Maturity Questionnaire CUMANIN-2 (Portellano, Mateos, Martínez, & Sánchez, 2021), and the Child Neuropsychological Screening NEURO KID (Portellano, Mateos, & Martínez-Arias, 2021), among others.

It is important to highlight that the WHO has presented the so-called Global Scales for Early Development (GSED), which focus on the assessment of children up to 36 months of age with the aim of measuring their cognitive, socio-emotional, language and motor skills (Cavallera et al., 2023; McCray et al., 2023).

Motor development scales

The interest in psychomotor development dates back to the last quarter of the 19th century when C. Darwin paid significant attention to this aspect. In this section, we will mention the scales focused on motor development to gather the most important authors who have nourished the developmental tables that we provide in this publication. In the first half of the 20th century, the contributions of Bayley (1936), Espenschade (1980), Gesell (1949, 1980, 1981), Illingworth (1992), Brunet and Lézine (1980), André-Thomas et al. (1944), Saint-Anne (1977), Totsika and Sylva (2004), among others, stand out. It is also important to highlight the contribution of tests and scales such as the Gesture Imitation Test (Bergès & Lézine, 1981), The Alberta Infant Motor Scale - AIMS (Piper et al., 1992), the Test of Infant Motor Performance - TIMP (Campbell et al., 1995), the Peabody Developmental Motor Scales (Van Hartingsveldt et al., 2005), and the Bruininks-Oseretsky Test of Motor Proficiency BOT-2 (Bruininks & Bruininks, 1978; Deitz et al., 2007). Also, The Preschool Psychomotricity Assessment Scale - EEP (de la Cruz et al., 1988), the Picq and Vayer's Psychomotor Profile (Picq & Vayer, 1977; Vayer, 1977), the McCarthy Scales (McCarthy, 1996), the Kaufman Assessment Battery for Children K-ABC (Kaufman & Kaufman, 1997), and the M. Stambak Rhythm Test (Zazzo, 1969).

To fulfill the objectives of this study, the following research questions are posed:

A. Can transversal aspects related to the areas of music, mathematics, psychomotor skills, and language be integrated in an interdisciplinary table for children?

B. Can the neuromotor activities of the BAPNE method be used for this age group in order to achieve the intended goal?

C. Can specific activities be provided to address kinesthetic, mathematical, or linguistic aspects through movement?

Neuromotricity in infants. A look from the BAPNE method

After reviewing the aforementioned authors, we would like to provide some interdisciplinary development tables that will be useful for professionals working with children from three to six years old in areas related to language, music and mathematics (Fernández-Bravo, 2006, 2007, 2019; Macias-Merlo, 2006). The BAPNE method has an extensive repertoire that is connected to the "Bapne for Children" (Romero-Naranjo, 2019a, 2019b, 2019c, 2019d, 2019e) and "Solfeo Cognitivo" (Romero-Naranjo, 2019f, 2019g, 2019h, 2020a) programs. In this way, specific activities for each age group have been organized into Tables from 3 to 11 which present the developmental, musical, and cognitive abilities of children of three, four, and five years old.

Table 3.
Development table for three-year-olds - BAPNE Method. Development 3 years

Age	Gross motor skills	Fine motor skills	Perceptual motor skills	Adaptation of motor behavior
3 years + 1 month	Jump off a step with two feet together. Run forward. Walk forward and alter the route by following directions. Drag. Imitate postures (legs open or closed, standing or sitting).	Make a bridge using three cubes. Grab an object with various fingers.	Reproduce a circle. Reproduce a square. Reproduce a symbolic hand movement (e.g. a duck quacking by opening and closing hands).	Drink with a straw. Begin to eat while holding a fork continuously.
3 years + 3 months	Hop once. Slide down a slide. Skate.	Copy shapes. Cut with scissors while holding the sheet of paper.	Complete an easy puzzle.	Eat properly with a spoon and a fork.
3 years + 6 months	Jump over a rope at 20cm off the ground. Climb stairs, one foot per step. Set out and stop.	Place ten cubes in a pile. Roll playdough on a table.	Classify into general families or categories (animals, plants, toys). Answer the questions "who?", "when?", "where?", "how?".	Put on and take off their clothes independently. Button and unbutton clothes independently. Put on shoes.
3 years + 8 months	Throw a ball at 2 or 3 meters while standing still. Ride a tricycle. Kick a ball. Walk on tiptoes.	Roll playdough on a table to make a cylinder. Play games with hands and fingers.	Walk to a beat.	Wash and dry their hands. Use the bathroom, but without being able to clean themselves independently. Blow their nose.

Table 4.
Development table for 3-year-olds - BAPNE Method. Musical aspects 3 years

Properties and relationships	Spatio-temporal relationships	Logic	Numerical relationships
Identify intuitively big and small.	Differentiate between the front and the	Initial recognition of characteristics:	Can start counting.

Identify geometric shapes that they are able to differentiate.	back of people. Can follow a line with clear indication of the direction. Move forward and backward. Differentiate between full and not full. Differentiate between above and below. Differentiate between inside and out (of a box, a glass). Differentiate between long and short.	same/different. Classify. Identify similarities and differences. Simple seriations. Simple periods of time.	Perceive and distinguish between quantities: many/few. Unity and plurality: one – multiple. Establish connections between elements like "as many as", "where there are more".
Rhythmic and motor characteristics	Melodic characteristics	Melodic and motor characteristics	Socio-musical characteristics
Motor coordination abilities are more precise as they are able to walk, run and jump. Begin to perceive the beat when participating in guided activities led by the teacher in which they hold hands in a circle. Coordinate strokes with hands. Coordinate "upward" and "downward" movements with the hands. Can coordinate movements in a group both "inside" and "outside" a circle drawn on the ground. Begin to distinguish between fast and slow. Enjoy experimenting rhythmic patterns. Can perform rhythmic structures of three or four elements.	Can reproduce the intonation of short songs. They are not yet able to sing in tune, so may go off-key when singing. Have a limited vocal range. Can sing melodies with onomatopoeias. Voice usually has a range from the A on the ledger line to the central E.	Can reproduce rhythmic and melodic patterns, although not completely in tune. Begin to distinguish between the graphical representations of certain values of musical notes.	Can sing in tune both individually and in a group, but not perfectly. Like and enjoy music. Enjoy experimenting with percussion instruments. Enjoy moving with a group and performing choreographed movements while holding hands.

Table 5.
Development table for 3-year-olds - BAPNE Method. Cognitive aspects 3 years

Language development	Time Horizon	Touch perception and discrimination	Notions of space	BAPNE resources
Minimum vocabulary of 1000 words. Sentences of at least 4 words. Start to use conjunctions.	Vague memories from the previous year. Use of the past participle and imperfect tenses. The term "tomorrow" is used to refer to an indeterminate near future.	Distinguish and identify geometric shapes (circle, square, and triangle). Feel hard and soft.	Experience notions of space: inside/outside, upwards/downwards.	Saco una manita. Campanero I. 1, 2, 3, 4, 5,-I. Araña, arañita I. Dos ojitos tengo.
Begin to use verbs.	The term "tomorrow" is used with a slightly more precise meaning.	Distinguish and identify the size (big-small) of geometric shapes.	Experience notions of space: above/below.	Campanero II. 1, 2, 3, 4, 5,-II. Araña, arañita II. Los zapatos.
Regular use of verbs and articles. Sentences of more than three words.	Use of the past participle and imperfect tenses with more fluency.	Distinguish between hot and cold. Distinguish between objects with eyes closed (square, triangle, and circle).	Experience notions of space: up/down.	Campanero III. Este dedito. Camino del Baobab I.
Initial use of prepositions.	The use of the term "tomorrow" is more precise when associated with more precise actions.	Distinguish between rough and smooth.	Experience notions of space: inside/outside, up/down, near/far.	Simama Kaa. Campanero IV. Araña, arañita III. Las extremidades. Pasa la pelota.

Table 6.
Development table for 4-year-olds – BAPNE Method. Development 4 years

Age	Gross motor skills	Fine motor skills	Perceptual motor skills	Adaptation of motor behavior
4 years + 1 month	Go down stairs with one foot on each step. Maintain balance by standing on one foot for 4-8 seconds.	Clear manual reference. Fold a piece of paper. Paint.	Catch a 25cm diameter ball with arms bent. Point out the similarities and differences between two objects.	Brush their teeth. Use the toilet without help.
4 years + 5 months	Throw a 25cm diameter ball at 4 metres. Run and jump (80cm). Walk while imitating animals (bear, elephant, frog). Change directions.	Roll playdough between fingers. Make forms with playdough.	Draw a square. Hold a pencil correctly and move it using wrist movements.	Imitate a static pose made by a classmate in a symmetrical way (mirror game).
4 years + 8 months	Go up stairs. Walk like an adult. Identify and locate the limbs and their parts (elbow, wrist, knee, heel) by placing different colored stickers following the teacher's instructions (e.g., "put the green sticker on your knee").	Make a puzzle of more than 8 pieces. Cut out simple shapes. Knead malleable materials such as various types of modelling clay and flour dough. Use toys that require precision with the fingers.	Fit objects together. Paint animal figures (monkeys). Point out the similarities and differences between three objects.	Understand the spatial terms "far", "near", "next to", "on top", "under", "behind", "in front". Hang up their clothes. Use the words "yesterday" and "tomorrow" correctly.

Table 7.
Development table for 4-year-olds – BAPNE Method. Musical aspects 4 years

Properties and relationships	Spatio-temporal relationships	Numerical relationships	Rhythmic and motor characteristics

Distinguish between various geometric shapes such as "triangle", "square" and "circle". Can associate a square with thigh slapping and a triangle with handclaps. Recognize "bigger than", "smaller than". Can associate a very large square with a strong slap and a small square with a gentle slap.	"Longer than", "shorter than". Can associate these expressions with longer and shorter musical figures. Full/empty. Inside/outside. Forwards/backwards. Can walk forward guided by a rope and clap when seeing a vertical stick.	Percieve and distinguish between numerical forms. Can associate the shape of number 1 with one clap and the shape of number 2 with two claps, alternating between them.	Walk freely around the classroom while music is playing. Walk to the beat of the music with the help of the teacher. Enjoy exploring and trying out objects that make sounds, such as drums, maracas, and rattles. Coordinate thigh slaps and handclaps. Differentiate between faster and slower. Confuse intensity and speed.
Melodic characteristics	Melodic and motor characteristics	Socio-musical characteristics	Logic
Have more vocal control and a higher melodic range. Prefer melodies with a minor third interval. Start to recognize simple melodies and remember them. Melodies are simple and pleasant and are composed of intervals of seconds, thirds, and some fifths, making them easy to intonate. The tessitura of a song should be between the E on the first line of the stave and the C in the third space in treble clef, since this is the most common vocal range amongst young children. Distinguish between high and low. Increase auditory memory and the repertoire of songs. Create melodies with a certain degree of coherence in form and tone. Can perform sequences of three sounds.	Sing a melody clapping on the strong beats. Move in a circle to the beat of a melody while singing in a group. Walk forward or backward while holding hands in a circle to the rhythm of a song following the teacher's instructions. Acquire more fine psychomotor skills and can combine finger movements with melodies appropriate to their age. Coordinate a melody while seated alternating thigh slaps and handclaps.	Can perform songs with classmates, largely in tune. Enjoy singing for others. Enjoy songs in which they have to make gestures related to a theme (bear, drummer, frog, etc.). Facial expressions are used to communicate. Like and enjoy music. Enjoy moving in a group in a choreographed way.	Same/different. Classify.

Table 8.
Development table for 4-year-olds – BAPNE Method. Cognitive aspects 4 years

Language development	Time Horizon	Touch perception and discrimination	Notions of space	BAPNE resources
Understand concepts like "early in the morning", "next month", "at any time", "next year". Point out color red, blue, yellow, and green.	Distinguish between and use the words "day" and "night". Use the words "quickly", "slowly".	Distinguish and identify geometric shapes with eyes closed. Distinguish and identify size (large-small).	Move hands forward, backward, and to the right.	El canto del Baobab I. Campanero V. 1, 2, 3, 4, 5. Simama Kaa II. El camino del Baobab II.
Can complete an analogy (e.g. "the opposite of pretty is…"; "an elephant is big and a mouse is…"). Ask questions using "who?", "why?"	Recognize night and day.	Differentiate hot and cold. Differentiate objects with eyes closed (square, triangle, and circle).	Recognize and name the start and the end of an itinerary.	El camino del Baobab III-IV. Pin Pon II. Pato amarillo. Los zapatos II.
Use the past tense correctly. Pronounce correctly the Spanish phonemes: /m/, /n/, /p/, /f/, /w/, /y/, /ll/, /k/, /b/, /d/, /g/, /r/, /ch/, /s/.			Recognize and name the notions of open/closed; one side/another; together/apart. Explore and discover directionality (left/right) in the vertical and horizontal plane.	Cabeza, cara, hombros, pies. Campanero VI. Cuadrado. Le Coq est mort I.

Table 9.
Development table for 5-year-olds – BAPNE Method. Development 5 years

Age	Gross motor skills	Fine motor skills	Perceptual motor skills	Adaptation of motor behavior
5 years + 1 month	Jump with both feet. Kick a ball in the air. Draw a square with their feet.	Cut out simple shapes. Pass a thread through the perforations of a sheet of paper.	Reproduce a triangle. Catch a bouncing ball.	Use a knife to spread butter on bread.
5 years + 5 months	Run at a rate of 3.5m/second and change direction. Ride a bike. Maintain balance on tiptoes for 10 seconds. Coordinate hands and feet more precisely and be able to dissociate.	Touch the thumb with each finger. Make a puzzle of more than 8 pieces. Make complex figures using playdough and clay.	Write their own name. Draw a person with torso and limbs. Catch a ball with the elbows close to the body.	Tie shoes with knots. Name and identify most of the body parts. Orient themselves according to the different times of the day.
5 years + 8 months	Jump rope. Forward somersault. Bounce a ball several times. Hop forward on one leg for 8m. Synchronize two movements alternating between a step and a handclap to the rhythm of a melody.	Cut some complex shapes. Make a puzzle of more than 12 pieces.	Reproduce a triangle, a square and a rhombus.	Wash themselves up and blow their nose independently. Distinguish between right and left.

Table 10.
Development table for 5-year-olds – BAPNE Method. Musical aspects 5 years

Properties and relationships	Spatio-temporal relationships	Numerical relationships	Melodic characteristics
Know the colors. Can connect and combine different geomet-	Position two straight lines and relate these to two lines of people who move at a pace. The two lines walk	Perceive and distinguish the numerical forms of numbers one to nine.	Have widen the vocal range slightly. Can create their own short melodies with the notes G, A and E.

ric shapes like "triangle", "square" and "circle" and link them to different parts of the body. Children are asked to put them in their desired order and then perform the rhythmic pattern that corresponds to each shape. Form and size; Affirmation, negation; conjunction and disjunction; true and false.	forward or touch the person in front. Left/right. Periods of time. Time sequences.		Can sing a fifth more easily. Can independently continue the second part of a melodic phrase. Can distinguish between high and low more easily.
Rhythmic and motor characteristics	Melodic and motor characteristics	Socio-musical characteristics	Logic
Can coordinate handclaps and steps while moving around (handclap, right foot, handclap, handclap, left foot). Can coordinate slaps on the chest, the thighs, the feet and handclaps. Can work in a choreographed way standing in two lines facing each other, taking steps forward and backward. Can perform hand-clapping games in pairs with coordinated movements upwards and downwards. Can perform a choreographed routine in a circle while holding hands moving towards the right, the left, forward and back. Begin to differentiate kinesthetic activities related in which the teacher can add or eliminate the voice. Begin to coordinate hand-clapping games in pairs with diagonal claps. Can make a square by stepping on the floor while counting from one to four. Can alternate between hopping on one foot and then on two to the beat of a melody. Begin to understand rhythm notation and can write it.	Can keep the beat of a song hand-clapping or using drumsticks while singing. Can perform melodic hand-clapping games in pairs and facing each other (Con la A, daba daba da). Can coordinate percussive movements in pairs while singing (Campanero in canon). Can coordinate upper and lower limbs in two lines facing each other while singing (Campanero I). Can coordinate crisscross movements while positioned in two lines facing each other and singing (Campanero II). Can coordinate simple choreographed movements in concentric circles. Can control and respond to instructions such as "faster" and "slower". Can notice the unfinished rhythmic or melodic nature of a musical phrase. Can perform more complex fine psychomotor movements to the sound of a melody (1, 2, 3). Can move around while singing simple melodies in another language.	Enjoy moving around with a group in a choreographed routine. Can stage a melody for a group imitating gestures. Can employ dramatic resources and techniques when singing a melody in front of a group. Can play simple games and add a pre-existing melody or one created on the spot.	Classifications and seriations.

Table 11.
Development table for 5-year-olds – BAPNE Method. Cognitive aspects 5 years

Language development	Time Horizon	Touch perception and discrimination	Notions of space	BAPNE resources
Discrimination between sounds has improved and the phonetic repertoire is almost complete. Can build sentences using five to six words. Possess a vocabulary of about 2000 words. Use speech sounds (phonemes) correctly, with the possible exception of Spanish /rr/ and /z/.	Carry out activities in which notions of order are involved: 1st, 2nd, 3rd. Remember and say what was done first, second, third. Remember what they did yesterday.	Distinguish between and identify familiar objects by size and touch (for example fruits, sand, mud, stones, playdough). Can also distinguish between soft and hard.	Distinguish between a straight line and a curved line. Differentiate between straight lines in horizontal, vertical, and slanted.	El camino del Baobab V-VI. El canto del Baobab II. Cuadrado. Clap Change (Simple).
Build the first complex sentences. Use of verb complements and relative clauses. Correct oral production of simple words. Start to use longer words. Recognize common opposites such as "big/small" and "hard/soft". Follow the sequence of a story. Use present, past and future verb tenses.	Adapt their movements to different rhythms. Perform actions with hoops, jumping and crouching down. Perform rhythmic actions slapping the knees, the belly and the head, and handclapping. Create itineraries and longer and shorter paths.	Distinguish hot and cold. Differentiate objects with eyes closed and arrange them in order from smallest to largest (four to five elements). Match geometric figures with eyes closed. A child can leave the classroom and someone can change his/her appearance.	Give directions, including "forward", "backward", "turn right", "turn left". Make particular shapes out of sticks.	Give me five. A paso de elefante. Ayeyango. 1, 2, 3, 4, 5 (F). Con la A.
If children have been exposed to books while growing up, they may become interested in written language and recognize that letters form messages. This is the time to teach them the first letter of their name and important words for them, such as "mom" and "dad".	Put in order different parts of a tale, a melody, a route.	Recognize and use "harder than", "softer than". With closed eyes, find soft things (wool, foam, wood, marbles, metal).	Make a complete turn or a half turn when standing still or when moving. When given an auditory signal, children who are walking forward should be able to make a complete turn or a half turn.	El camino del Baobab VII. El canto del Baobab III. Pato amarillo. Canon simple I. Clap Change (Doble). Triángulo.

Conclusions

The aim of this article is to bring together, through interdisciplinary development tables, important areas in the age group of 3 to 6 years old. The BAPNE method is concerned with providing a series of practical resources for this age group in a precise manner based on the development tables presented here.

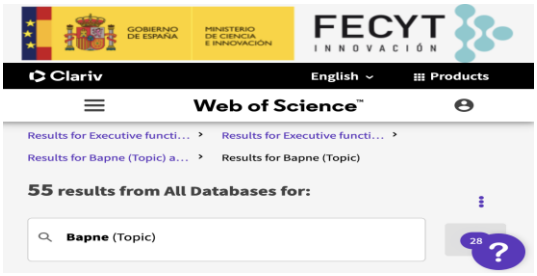


Figure 13. Scientific publications in Web of Science about BAPNE

This proposal includes musical-motor resources for children aged between three and six years old. To this end, we provide an extensive bibliography that justifies the large collection of data in order to establish interdisciplinary development tables that allow teachers to have a basis and, above all, some limits to prevent generating frustration among their students.

The goal of this methodology is to offer a specific justification of neuromotricity through new scientific publications (Romero-Naranjo & Andreu-Cabrera, 2023a, 2023b, 2023c, 2023d) as well as publications with control and experimental groups that support these hypotheses. We are well aware that more intervention studies on neuromotricity are lacking and that this is one of the first matters to be developed in the future.

Even so, the methodology has more than 50 articles in Web of Science whose objective is to offer high quality and high impact studies (Figure 13).

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