article

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Developmental dyscalculia and the teaching of arithmetic

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Abstract. *To understand Developmental Dyscalculia and organize an inclusive education that is functional to ensure the overcoming of the difficulties involved, it is necessary to know how the arithmetic is processed in the brain, both in subjects with neurotypical functioning and in those who, instead, have abnormal neural functioning that characterizes the dyscalculia disorder. From this information it is possible to address the choices of methodological practices for the classroom setting, following the directions of the research path named "Cervello, Cognizione & Educazione" which traces the basic steps to make possible a link between the Cognitive Sciences and the Educational Sciences. This article aims to describe what is numerical cognition, making a short review of the most recent researches concerning dyscalculia in the context of Cognitive Sciences and to create a possible methodological approach useful for teaching arithmetic basic competencies, in a school inclusion perspective.*

Key words. *Developmental Dyscalculia, learning arithmetic difficulties, methodology and didactics, neurobiology of dyscalculia.*

Sommario. *(La discalculia evolutiva e l'insegnamento dell'aritmetica). Per comprendere la discalculia e organizzare una didattica inclusiva che sia funzionale per garantire il superamento delle difficoltà che comporta, bisogna conoscere come l'aritmetica viene processata a livello cerebrale, sia in soggetti a funzionamento neurotipico che in chi, invece, ha un funzionamento anomalo che caratterizza il disturbo discalculico. Da tali informazioni è possibile trarre indicazioni d'indirizzo per la scelta di pratiche metodologiche per il contesto classe, seguendo le indicazioni del percorso di ricerca "Cervello, Cognizione & Educazione" che traccia i passi fondamentali per rendere possibile un collegamento tra le Scienze della Cognizione e le Scienze dell'Educazione. Questo articolo ha lo scopo di descrivere la cognizione numerica, dare una breve presentazione degli studi più recenti che riguardano la Discalculia Evolutiva nel contesto delle Scienze Cognitive e di tracciare un possibile percorso metodologico utile per la didattica dell'aritmetica di base, in una prospettiva di inclusione scolastica.*

Parole chiave. *Discalculia Evolutiva, difficoltà nell'apprendimento della aritmetica, metodologia e didattica, neurobiologia della discalculia.*

Introduction

From the 90s to today a path of international research has been concerned to establish a link between the Cognitive Sciences and the Educational Sciences with the ultimate goal of creating teaching methods that are "brain friendly", as they are based on the actual brain functioning in learning activities such as the basic skills, like those of numerical cognition. The methods created from this union are subjected to examination, through the method of the “research into action” conducted by the teachers in actual classroom activities, to establish if they are easily to be used in teaching and functional in their achievement of learning objectives that the institutional regulation demands.

The educational basis of those methods can grant an inclusive didactic approach because they are studied on “default learning brain mechanisms” and thus are able to facilitate learning in all the individuals that have a brain structure not affected by pathological diseases, that will be able to learn despite the individual and functional differences.

This research path based its knowledge on the information coming from Cognitive Sciences, which are interested in learning and brain functions both in subjects with typical or atypical functioning and in the results, on the different cognitive abilities, due to brain damage.

The information provided by the different research paths that characterize the Cognitive Sciences (neuroscience, psychology, linguistics, philosophy, artificial intelligence ...) allow to know what are the brain functions underlying learning and can become the basis for interventions that facilitate learning, by using methodological actions that are congruent to brain functioning or, also, they permit the creation of effective intervention methods for the recovery of lacking or not typical brain functioning.

In Italy the research path, called “Cervello, Cognizione & Educazione” led to the creation of a method for teaching reading, writing and calculation for the first grade of primary school, which was tested in research in action in the school years 2008/2010 in 32 first classes and is currently successfully implemented in many Italian schools.

This article aims to provide a definition of Developmental Dyscalculia that takes into account the latest and important researches in this area, providing information on the neurobiology of numerical cognition and a review of possible interventions that can be put in place in the choice of a “brain friendly” teaching method which ensures, through the use of congruent teaching actions with brain function, a learning innovative teaching approach of arithmetic, that is inclusive and effective because allows the learning of such basic skills of numerical cognition, despite of any not typical operations of the brain structure.

Developmental Dyscalculia (DD)

Arithmetic is very important in everyday activities and numerical cognition has a strong impact on education and even on occupational outcomes (Fuchs, 2009).

Developmental Dyscalculia (DD) is a learning disorder that limits the acquisition of arithmetic skills in a context of normal IQ. This difficulty in learning arithmetic at school level is common in about 5% of the pupils in primary schools and is a constant figure across the population in the countries where it has been studied.

An early sign of these difficulties can be observed in a delay of the acquisition of the pre-scholastic skills in the nursery and kindergarten years.

Dyscalculia is common both in girls and boys and children with this disorder can suffer severe emotional distress caused by their mathematical poor performance in school, which can lead to school phobia and mathematical anxiety (Marshall et al., 2006).

Commonly three subtypes of dyscalculia are considered:

- a specific isolated disorder of mathematics;

- a mathematic impairment in the context of general learning disabilities;
- dyscalculia with comorbid disorders (ADHD, dyslexia) occurs in approximately one quart cases (Kaufmann,2012) comorbidity with dyslexia seems to produce the most strong impairments.

C.M. Temple (1991, 1997) has given a definition of three kinds of DD that describes all the typical errors made by DD children:

1) "digit dyslexia" that is characterized by a difficulty in the acquisition of the lexical processes in the comprehension of the numerical system and in the calculation production.
2) "procedural dyscalculia" that is characterized by the difficulty in the acquisition of the procedures and the implicit algorithms in the calculation system;
3) "dyscalculia for numerical facts" that is characterized in the difficulty of acquisition of the numerical facts in the calculating system.

The most common behavioral characteristics of DD are:

- slow and error disposition learning and retrieval of mathematic facts from memory (Jordan and Montani, 1997);
- procedural deficit (immature calculation, problem solving, counting strategies) and delayed progress from finger counting to verbal counting (Geary, 2002);
- failed representation and access to numerical magnitude information like approximate and exact understanding of numerical quantities. (Butterworth, 1999);
- low accuracy during number comparison;
- poor performance on a range of basic numerical processing tasks including, verbal and dot counting, number comparison and number naming;
- low performance in approximate calculation in tasks that require manipulation of numerical magnitude representation (Jordan and Hanich, 2003);
- strong distance effect when it is required to compare symbolic or nonsymbolic quantities (Mussolin et al., 2010) or simple and double digit numbers (Ashkenazi et al., 2009b);
- impairments in spatial attention and spatial working memory (Ashkenazi et al. 2009a);
- basic deficit in numerical processing for number comparison and number naming.

Thanks to the help provided by these cognitive neuropsychological models it is possible to have a starting point for both diagnosis and for functional rehabilitation treatments or for the creation of effective teaching models able to offset early difficulties or to limit their effects of severity.

Neuro characteristics of Developmental Dyscalculia

In a neuroscientifical model the development of numerical processing elaborated by the brain is a neoplastic and maturational process, that, during the childhood and adolescence leads to the establishment of a complex and specialized network. At a few months of age this development begins with the ability to perform the basic skill of an approximate estimation of number for three or more items (Kaufmann, 2013).

When language appears children become able to symbolize the number linguistically using number words, they learn to count out and are able to perform simple arithmetical manipulation of quantities and numbers.

During the pre-school year and primary school children learn the Arabic number system, that is another way to symbolize numbers. In this period they learn also the Arabic place-value system and they develop a conceptual ability, the mental number line, that is a numero-spatial ability that enable them to operate with numerical symbols (Kucian et al., 2008).

The neural network that links multiple brain area is stimulated and made stronger with the increasing of practice and expertise.

Functional images have shown that multiple brain area are stimulated and different areas are active in correspondence of the different tasks:

- number words are elaborated in the left perisylvian region that are known to be the areas of speech;
- Arabic numerical representation is processed in the occipital lobe;
- basic numerical representations and numerical-spatial representation are processed in the parietal areas on both sides of the brain.

The development of these brain functions that are domain-specific, depends on the maturation of numerous functions including attention, working memory, language, sensorimotor function (or for example when using finger counting) and visuo-spatial ideation.

Their development depends also on the experiences, for example from everyday life and the type of teaching method used.

The cognitive functions that are related to number processing that, when affected, can cause the mathematical difficulties are:

- the working memory: that allows the maintenance of intermediate results of numerical procedures or of action plans needed to resolve complex calculation (Geary, 2012).

A reduction of the ability to process serial order in working memory has as result an abnormal processing in number tasks and can cause the absence of SNARC effect (Spatial Numerical Association response Code) that reflect the faster left than right hand responses to small numbers and faster right than left hand responses for large numbers (Dehaene et al.,1993; Ansari et al., 2008) that leads to low math score.

- the executive functions: that allows the monitoring of task performance and the control of the processes to improve future performances to avoid error and self-correction (Botvinic et al., 2007). Another executive function is the inhibition of inappropriate solution and mental processes to avoid intrusive errors and interference in simple math activities.

In sum mathematical problem solving is built on multiple cognitive components that are implemented by distinct and overlapping brain systems, impairment in any of these components compromises the efficiency of numerical skills.

Such a multicomponent system can explain the heterogeneity and comorbilidities observed in DD.

fMRI (*Functional Magnetic Resonance Imaging*) studies show that multicomponential neuronal networks subserve number processing and arithmetic and each subserving specific cognitive processes are together necessary to an optimal number processing.

The neural systems that are involved in number processing are:

- the visual, auditory association cortex, which helps decoding the visual form and phonological features of the stimulus, and the parietal attention system which help to build a semantic representation of quantity (Dehaene, 2003);
- the procedural and working memory systems anchored in the basal ganglia and fronto-parietal circuits (the intra parietal sulcus, the supermarginal gyrus in the parietal cortex, the premotor cortex, the supplementary motor area, the dorso lateral pre-frontal cortex) that, creating a short-term representation, supports the manipulation of discrete quantity and assure as said before, the optimization of the performances by monitoring them and inhibiting the incorrect responses;
- the episodic and semantic memory system (medial and temporal cortex and anterior temporal cortex and angular gyrus within the parietal cortex) that has an important role in long term memory and in generalization starting from individual problem characteristics;
- prefrontal control processes that are necessary to maintain attention to subserve the goal-directed decision making.

Neuroimaging researches that are focused on the investigation of neural of DD is still limited, but the most common findings is that at the brain level DD is characterized by atypical structural properties of the right intraparietal sulcus, and atypical functional modulation of this region during basic numerical processing.

DD children show an increased activation in the bilateral intra parietal sulcus, a weaker and more diffuse activation in the left intra parietal sulcus and this may suggest that the behavioral deficits in DD may depend on an impairment in the numerical magnitude representation through Arabic digits.

These findings and those given by neuropsychological and cognitive models are crucial to understand the nature and origin of DD for developing efficient remediation programs and didactic choices.

Typical development of numerical and arithmetical skills

The numerical intelligence is the ability to "intelligere" the quantity and is due both to innate abilities (Gellman and Gallister, 1978) and both to the strengthening of proximal development through education of domain specific processes (Fuson et al., 1983). The human species, even before they know how to count, can understand the phenomena in terms of quantity.

The innate numerical intelligence, does not exist only in humans, but in other species and the children of a few months (three months) are already able to perceive the numerosity of a set of visual objects, without knowing how to count (quantity distinction: one is different from many) and it is at the basis of various phenomena of different complexity (eg. plural, singular). Number sense (Approximed Number System) is innate, universal, language-independent, modal and abstract because the numerosity is mentally represented in an analogical format.

Numerical intelligence includes: the understanding of numerosity, the concept of number and the semantic encoding of the number (mentally represent the quantity that the number represents) and then to identify the position it assumes within the line of numbers. This numerical quantity system is activated when either the task is presented in analogical format and when it is presented through its representative symbols.

Among the innate abilities that contribute to the formation of numerical intelligence, there are subitizing and estimate. Subitizing is a non-intentional analogical act, a visual feature that allows a fast and accurate numerical judgment executed on numerosity of small sets of elements, what is defined as the ability “to count at a glance”, but only for a maximum quantity of six elements. The estimate is a numerical process and is the ability to determine roughly and not counting unknown values (great quantity) the greater is the quantity more the approximation is used.

Other innate abilities are: the one to one correspondence, the counting of n. + 1 and n. –1 and the semantic access through the preverbal recognition mechanisms of the quantities that process the learning of reading and writing numbers and counting systems and give rise to the calculation mechanisms and to the manipulation of the number system. This is a conceptual representation that corresponds to the “meaning” of a number.

The numerical knowledge is due to semantic mechanisms (recognizing and manipulating quantity), syntactic mechanisms (the same range in several orders of magnitude) and lexical mechanisms (say, read and write numbers).

Counting is essential and a first link between the innate ability of the child to perceive numbers and the most advanced mathematical achievements of the culture in which he was born. Learning the sequence of the words used to count is the first way in which children connect their innate concept of number with the cultural practices used in their society. The implicit principles of counting are: the numerical lexicon and counting.

According to Gellman and Gallistel (1978) it is possible to highlight these different numerical abilities in the developmental progression:

- the one to one correspondence that is the ability to associate words-number to objects and separate the objects that have just been counted from those that have to be counted;
- the ability to understand the stable order, that is, the ability to use the numerical, verbal sequence in a stable and correct way;
- the recognition of the cardinality that is the knowledge that the number of the elements of a set is the last number used to count them:
- the ability of abstraction that allows to understand that any set composed of discrete elements can be counted;
- the ability to understand the irrelevance of order that allows to understand that the order in which the items in the collection are counted does not affect the result.

The syntactic mechanisms regulate the positional value of the digits and constitute the internal grammar of the number that activates the correct order of magnitude of each digit. In verbal encoding of a number each digit takes a different “name” depending on the position it occupies. In systems of understanding and/or production of the numbers, the lexical mechanisms have the task of adequately select the digit names to recognize that of the whole number.

To summarize, we could say that understanding, comparison, seriations, subitizing and estimate are the semantic aspects of numerosity, while production, reading and writing numbers represent their lexical and syntactic aspects. The cognitive processes of the computing system are therefore: semantic processes, lexical and syntactic and are represented by the ability to “counting”, to calculate in mind, to retrieve the number facts and to produce a written calculation.

Counting is the ability to count, it foregoes the ability of calculation, is based on innate knowledge (n+1, n –1) and provides the ability to number forward or backward with reference to the quantity and to number for two or more.

Mental calculation is the ability to perform calculation mentally, it starts from the calculations (explicit count on the fingers), passes on to counting (counting from a given number) and is in need of effective learning strategies (breakdowns, rounding to the nearest ten, etc...).

The numerical facts relate to the ability to use simple operations already resolved encoded in memory, ready to be retrieved automatically if necessary (2 + 2, 3 + 2, 5 + 5, 50 + 50, ...), they include the multiplication tables in their entirety and not only the results and are the basis for facilitating the acquisition of facts such as the commutative property and, based on automatisms, they speed up the calculation processes.

The calculation script requires numerical knowledge (vocabulary, syntax, and semantics), calculation skills, the ability to perform strategic or automated facts and specific procedural knowledge (algorithms of the 4 operations). These evolutionary processes are sequential and must be learned following their evolutionary order.

Possible didactic choices

What are the useful proposals for teaching arithmetic in a learning early stage?

During the kindergarten the activities planned by the teachers should aim to develop cognitive skills of innate and analogical basis, so without the use of written symbols. Teachers should provide and organize activities that stimulate the upgrading of skill that forego those of computing and digital manipulation.

These activities should develop and stabilize:

- the subitizing and numerical estimate (an example is the use of games that require the use of dice or card games like the Italian game “Scopa”);
- the ability to one-to-one match, for example, to match the quantity and name of the number (enumeration) thanks to which the child learns to accompany the word number at the time of the count or to make the correspondence between sets in relation to the number of the elements;
- the knowledge of the size (the concept of cardinality, the ability to rearrange sequences compared to a characteristic or to the size of the elements);
- the first forms of calculation without using numerical symbols, but using an iconic representation of the quantity.

During the kindergarten the numeric symbols should not be used and the association with the quantity and the name of the numbers should be presented only during the primary school.

Other important activities to assure the numerical cognition development, at this institutional school level should reinforce the ability to control the coordination of eye and hand movement, assure the control of the graphic motor skills, the visual perception, the adaptation of the visual motor system to the graphic gesture for writing numbers and the development of visual and auditory memory needed for encoding and decoding written and listened symbols.

It should be also necessary to develop the knowledge of topological concepts like: before/after, long/short, big/small, up/down, right/left that are the prerequisite skills for the understanding of place value of the digit and the written calculations.

Other logical skills that should be acquired and enhanced at this school level are those of classification, of rhythm reproduction, the ability to create associations, logical relationships, the ability to reflect on the various possibilities and solutions with respect to problematic situations (problem solving).

Many recent scientific studies have shown that the movement has a cognitive value, for example, the study of Fisher et al., (2015) proved that the movements that involve the whole body, such as moving on a line of numbers drawn on the floor, can improve the efficiency of numerical trainings by improving the level of performance in multi-digit additions. This is another important indication that along with the other ones, should be the basis of teaching methodological choices at kindergarten school level, to ensure a development of the analogical and pre-verbal cognitive abilities of the numerical cognition. An inconsistent development or lacking of these skills does not grant the acquisition of the basic skills and becomes the basis of the difficulties in arithmetic in subsequent grade levels.

The child who comes to the Primary School must meet and master the concept of number, he must have acquired the numerical lexicon, must know how to count, use and apply simple calculation strategies.

If these skills are unreached,before proceeding with the subsequent learning,it is necessary to ensure to the child to perform activities to recover the prerequisites until they are fully achieved.

During the first year of Primary School before learning how to quickly and accurately calculate the child needs to develop and achieve a complete mastery of counting skills, of semantic, lexical and syntactic processing of the number through the use of numerical symbols, in encoding and decoding activities.

In the acquisition of the ability of mental counting, the choice of methodology and educational activities targeted to the acquisition of automatic calculation are very important.

An analogous method, based on visual recognition of submultiples of ten (the properly developed subitizing skills recognize at a glance five elements) is in line with the real brain functioning and facilitating mental math.

So, all activities involving the calculation at a glance of the quantity (sets, abacus, “Regoli”) are believed to be facilitating the computing activities.

A very recent study (Nuñez and Fias, 2015) has revealed that there is a line of mental numbers in the human brain, which has an ancestral match in the brain of other species (chicken for example) and then use the number line as one of the teaching methods for counting acquisition can only be a functional choice.

Also at this school level, physical activities will continue to be a consistent choice in strengthening the acquisition of numerical cognition and should not be considered as mere physical activities, but they have to be considered as real cognitive activities.

Activities to improve working memory appear to be equally functional to improve the arithmetic performance of the calculation and should be considered as an integral part of the mathematical learning program (Bergman-Nutley and Klingberg, 2014).

When teaching the graphics trace of the numerical symbol the teacher should make sure that children reach the ability to distinguish the signs without error, through multisensory and motor activities, to avoid the effects of symmetry and make it easier to distinguish the symbols that are visually similar (2/5; 6/9).

Recognize blindfolded the number made of cardboard just by touching it with the hands, use the whole body to represent the digit, write it using different materials (cotton, wool, buttons...), use the clay to write it and other similar activities will create strong visual images of the numerical symbols and allow a proper decoding and encoding of them, avoiding any confusion in their recognition and production.

Numerous scientific researchers have directly related the use of fingers to the areas of the number (Andrea et al., 2008; Fisher, 2008; Crollen et al., 2011) and therefore, the use of the fingers for counting and calculating should be promoted and maintained at least until the automatic calculation mechanisms are not established, as they enhance the development of arithmetic skills and are not the expression of its immaturity.

The number zero should be presented as a number that represents the lack of quantity and not like a vacuum because an educational choice like this conveys and facilitates the awareness of place value of Arabic numbers by assigning to the zero a place in the space and a value related to it.

Direct learning principle, which includes the demonstration, explicitly by driving, modelling, verbalization and reinforcement should be one of the fundamental bases of the school method since the findings indicate that the obtained results in terms of learning, making this methodological choice, are an improvement in accuracy and response times in every child, with or without computational difficulties (Goldman, et al., 1988).

All this information is at the basis of the methodology and didactic activities proposed by the Method "Libera…mente imparo" for the kindergarten and the first class of Italian Primary school used in numerous Italian schools.

The Method "Libera...mente imparo" for teaching reading, writing and calculating

In these last twenty years Scientific research has been interested in cognition and has received an unprecedented boost propulsion, due to the use of neuroimaging techniques in vivo, which have allowed us to understand the underlying brain.

Cognitive Science is the field of research where all the sciences that are interested in cognition came together for a comprehensive and practical approach to understand the mechanisms of learning and behavior that characterize the human being and its specific functions. In Cognitive Science converge the hard sciences of cognition, such as Neuroscience and Computational Science that attempt to reproduce the human brain mode, through the use of computer language, but also the human sciences such as psychology, philosophy, language and even the ethology. At the end of the 90s, some scholars as Bruer (1997), Stanovich (1998), Caine (1990) and others, have begun to question whether and in what way, the knowledge of how the brain learns could be useful for educational Sciences. The main issue was to decide how to bridge the gap between the information provided by the hard sciences, which are interested in the individual neuronal spike and Educational Sciences which are interested in the human being in its complexity.

The debate was very heated and still continues today. The different scholars (Caine, 1998; Ansari, 2005, 2006; Goswami, 2015) have given different answers, but all have emphasized the enormous usefulness that Neuroscience may have for Educational sciences since the information they provide are considered useful for important purposes such as finding solutions to problems related to the evolutionary development of children; understanding long-life, introducing educational changes in the practical application of scientific discoveries that come from neuro-imaging techniques.

According to the neurolinguist Jodie Tommerdhal of the University of Texas (2010) to bridge this gap four phases are necessary. The first step is the level of Neuroscience that studies the brain at the level of its cells and how information is transmitted, during the perceptual-cognitive activities. The next level is that of Cognitive Neuroscience that studies the functions and brain architectures that can be connected directly to cognition, using the neuroimaging techniques. The level below is that of the biological mechanisms that focus on the connection between physical actions and functions, the psychological mechanisms underlying cognition.

The level of educational theories is that in which the teaching and learning theories are developed based on the information from the previous levels.

Once the method is structured in theory, it goes to the last step of the way, that is, the level of the class in which the new teaching methodological proposals are tested through research into action.

On the basis of these indications a research project called "Cervello, Cognizione & Educazione" was created in Italy whose purpose is to create a link between the information coming from Cognitive Sciences and Educational Sciences to create teaching methods based on the actual brain functioning, that can ensure an inclusive approach in teaching practice.

The idea of inclusion that comes from this perspective is very innovative, because it is based on the multiplicity of information coming from Cognitive Sciences that, studying the neurobiological basis of learning, may provide continuously updated information on brain mode "default", common to any type of learning, such as reading or speaking a second language or arithmetic. The final products of this research, the teaching methods, are inclusive just because based on the basic brain functioning that guarantees the acquisition of the fundamental biological knowledge necessary to learn and moreover, it allows any individual approaches to compensate both specific learning difficulties and cultural or linguistic difficulties those that are defined Special Educational Needs in the school context.

The research path, born in 2010, as the Doctoral Research project and final thesis of the author in Cognitive Sciences at the University of Messina, is the only one, for now, in Italy and within the international panorama, that has brought to completion all the phases needed to create a method of teaching reading, writing and calculating starting from the information given by the Cognitive Sciences through Educational Sciences by means of the experimentation in the class by research into action.

The first product of this research is the method of teaching reading, writing and calculating for the first class of Italian Primary school called "Libera...mente imparo" (Collerone, 2011, 2012, 2013, 2014), implemented in research into action in the years school 2008/2010 and which has now been adopted in numerous schools in Italy, by teachers open to innovation and new educational pathways.

The results in terms of learning were evaluated at the end of the second class of the Primary school with the national "INVALSI" test and have demonstrated the effectiveness of the Method in achieving the learning objectives set by the Education Ministry. These results exceed not only those achieved by children in parallel classes, where different teaching methods were used, but they also outnumber the results at regional and national level for the corresponding classes.

The Method has gained recognition in academic circles both at the national and international level and is currently in use in several Italian schools.

The information from the Cognitive Sciences are constantly changing, the teaching activities that operate on the brain changes must always take into account that the brain is plastic, and adaptableand is influenced by the environment and for these characteristics, constantly evolving. Moreover, teaching must on a very complex system (social and environmental), where there are many variables and each variable involves a change to the entire system.

Teachers should accept the idea that their methodological choices and their teaching actions must take into account the change, the evolution, the concept of development and "in progress" and they have to abandon a rigid and static approach to teaching and learning.

They have to accept that they need to constantly update what they know, their choices and the means used in their teaching activities as to allow each student, the first variable in the learning process, to learn in connection with the peculiarities of his individuality, in the respect of the fundamental constraints that the brain structure imposes.

Conclusion

This article outlines the view that number processing and mathematical problem solving is built on multiple neurocognitive components that are implemented by distinct and overlapping brain systems. Impairments in any of these components can compromise the efficiency of numerical problem solving skills.

The teaching method has a strong impact in early acquisition of numerical cognition, and if it takes into account the information given to typical and atypical brain functioning in learning arithmetic to build the methodology and choose the didactic activities, it can grant an appropriate learning of the skills at the basis of an adequate numerical cognition.

Future research should continue to gather information on brain functioning and should have to turn them into methodological and educational choices that can be implemented in the context of the class, to test their effectiveness in real conditions of teaching activities to ensure the development of new choices in line with the continuous proceeding knowledge in the field of cognition, functional to the creation of an inclusive education because "brain based". The teaching methodology cannot erase the atypical brain functioning that are characteristics of Developmental Dyscalculia, but it can greatly contribute to contain and compensate its effects on learning.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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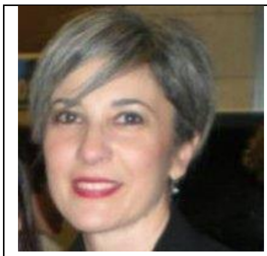

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