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LEARNING AND ACTIVATION THROUGH EXPERIENCE (L.A.T.E. PROJECT): DEVELOPMENT OF PROTO-MATHEMATICAL SKILLS IN PRESCHOOL AGE CHILDREN THROUGH CORPOREITY

LEARNING AND ACTIVATION THROUGH EXPERIENCE (L.A.T.E. PROJECT): SVILUPPO DELLE PROTO-COMPETENZE MATEMATICHE ATTRAVERSO LA CORPOREITÀ IN BAMBINI DI ETÀ PRE-SCOLARE

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Abstract

Abstract The aim of this research is to evaluate, throught an experimental teaching method, a statistical-psychometric comparison of 30 children aged 3-6 years and to ascertain the existence of a correlation between the development of numerical intelligence and motor activity (Cabbage, 2022). It is also intended to assess how this correlation can influence the development of emotional and linguistic skills.
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For example, Karen (1992) showed that 6-month-old infants have already arithmetic "expectations."
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In particular, by performing an intervention based on narration of the number, through stories, we want to increase the proto-linguistic competence. In addition, through exercises related to the stimulation of the capacity of esteem and evaluation, the aim is to icrease the development of the emotional abilities and the Theory of Mind (ToM) (Bocci, Franceschelli, 2014; Pontecorvo, 1993; Nelson, 2007; Brockmeier, 2012).
Teachers were trained with specific practices in order to carry out the protocol "Mathematics-Body Experience-Didactics". They have been provided with all the teaching tools to develop the method. The training offered to the students is scheduled in 15 bi-weekly sessions of 90 minutes each. In order to verify the proper development of skills in the children, 3 tests were administered: (1) Early-Numeracy-

Test; (2) Phonological Comprehension; and (3) Theory of Mind - NEPSY II - A consent form and information sheet were provided to all participants. The data analysis demonstrated the effectiveness of the protocol and the development of mathematical skills in the sample group, demonstrating, inaddition, the importance of learning through corporeality.

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Abstract

L’obiettivo della ricerca è quello di effettuare, attraverso un metodo di insegnamento sperimentale, a 30 bambini di 3-6 anni, un confronto statistico-psicometrico e di accertare l’esistenza di correlazione tra lo sviluppo dell’intelligenza numerica e l’attività motoria. (Chou, 2022). Inoltre si intende valutare come tale correlazione possa influenzare lo sviluppo delle competenze emotive e linguistiche.
Tale progetto si basa sulle evidenze scientifiche relative all’analisi delle capacità di sviluppo computazionale (Butterworth, 2005), alla ricerca riguardante l’intelligenza numerica (Lucangeli, 2013-2018) e alla ricerca incarnata di Borghi (2013).
In aggiunta vengono prese in considerazione le teorie sulle abilità matematiche dimostrate da Antell e Keating (1983) e testate con bambini. Cerca età
Ad esempio Karen (1992) ha mostrato come già i bambini di 6 mesi avessero “aspettative” aritmetiche. Considerando poi le abilità di subitizing (Mandler, Shebo, 1982; Butterworth, 2005), riconosciute come innate, e le teorie della connessione incarnata di Caruana e Borghi (2013), ci si pone come obiettivo valutare come lo sviluppo delle proto-competenze matematiche influenzi anche lo sviluppo di competenze trasversali nei bambini.
In particolare, effettuando un intervento basato su una modalità di narrazione del numero, attraverso racconti, si vuole incrementare la proto-competenza linguistica. Inoltre, attraverso esercizi volti a stimolare la capacità di stima e valutazione, si vuole sollecitare lo sviluppo delle capacità emotive e di Theory of Mind (ToM) (Bocci, Franceschelli, 2014; Pontecorvo, 1993; Nelson, 2007; Brockmeier, 2012).

I docenti Sono stati formati con pratiche specifiche al fine di effettuare il protocollo “Matematica-Esperienza corporea-Didattica”. Agli stessi sono stati forniti tutti gli strumenti didattici per sviluppare il metodo. La formazione offerta ai ragazzi è stata programmata in15 sessioni bisettimanali, di 90 minuti ciascuna. Per verificare il corretto sviluppo delle abilità nei bambini sono stati somministrati 3 test:

(1) Early-Numeracy-Test; (2) Comprensione fonologica e (3) Teoria della mente - NEPSY II - A tutti i partecipanti è stato fornito un modulo di consenso e un foglio informativo. L'analisi dei dati ha dimostrato l'efficacia del protocollo e lo sviluppo delle proto-competenze matematiche nel gruppo campione, dimostrando, inoltre, l'importanzadell'apprendimento attraverso la corporeità.

Keywords:

Childhood Education; Mathematical cognitive process; Emotional skills; Language skills; Learning through the body

Parole chiave:

Infanzia; Processo cognitivo matematico; Abilità emotive; Abilità linguistiche; Apprendimento attraverso il corpo.

Introduction

The idea of correlating specific pathways and motor activities to the project is based primarily on embodied theories, from the idea that cognitive processes depend on, are reflected and influenced by the body control systems.
Several studies document the close correlation between cognition, perception and movement. Specifically, it has been taken into considered a study by Fausto Caruana and Anna M. Borghi (2013) in which are presented and discussed some of the most important results of Embodied Cognition in different areas of experimental research: from the the study of convenience to that of bodily experience, from the investigation of emotions to that of language. It is therefore of fundamental importance, that during this educational experience the child has the opportunity to integrate cognitive, perceptual and motor skills in order to develop competencies.

This project wanted to experiment and analyze the learning of numerical competence through the body, designing a teaching scheme, divided into three parts, which provides: (1) a structured motor activity related to the numerical proposal; (2) a part of graphic elaboration with cards related to the planned motor activity; (3) linguistic production that involves the logical reasoning of the child out loud. We also wondered if the development of innate and cultural competences linked to mathematics could also develop the Theory of Mind.
In addition this project is based on the LATE – Learning and Activation Trought Experience- approach which has as the aim to highlight through play, the preferred channel of children, behaviours belonging to the macro-category of non-verbal communication. It is based the mental analysis through the observation grids, to be developed on a category of subjects engaged in structured and unstructured didactic situations to analyse the differences

As mentioned, the starting point of this action-research project is the study of learning through the body and perception. With the Multiple System of Sharing Intersubjectivity neuroscientist Vittorio Gallese refers to the "we-centric" space that develops in watching another person perform an action, perceiving the intention. The identification and being in empathy leads to get in touch with the movement of others - Embodied Simulation, mirror system - (Gallese 2003). Neuroscientific research shows that there are neural mechanisms that mediate between the personal experience of the lived body and the perception of both the other and the context. "Thinking about the functional processes of the sensorimotor system to put them in the service of linguistic competence, "neural exploitation" consists of the reuse of neural resources, originally evolved to guide our interactions with the world, to serve the more recently evolved linguistic **c**ompetence" (Gallese, 2013).

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The locus, therefore, of cognitive activity is located in the body and in the context of the real-world environment, and inherently involves perception and action (Perrone, Palumbo, 2018).
Learning, through motor skills allows a child to acquire new possibilities of action and reasoning and be able to better master his own actions that occur in the world, to select them, and later to discover their repercussions, to increase and regenerate the process of "learning to learn". The relationship between bodily capabilities and the physical properties of the environment exists in the interface between one's self and the world, according to a reciprocal, perception-action relationship, since perception must be able to guide action (Perrone, Palumbo, 2018).

Regarding the development of mathematical skills children, already have an innate sense of approximate number that depends on the relationship between sets of objects. This skill is called the "Approximate Number System" ANS. As we grow up the ANS becomes more developed, and we become able to distinguish between quantities that have smaller and smaller differences in magnitude. The relationship of distinction is defined by Weber's law, which links the different intensities of sensory stimuli that is evaluated. In the case of ANS, as the ability to distinguish between two increases in quantity. We hypothesize that the ANS lays the foundation for a higher level: arithmetic concepts. Research has shown that the same areas of the brain are active during non-symbolic number tasks in children and both symbolic and more sophisticated non-symbolic number tasks in adults. These results suggest that the ANS contributes during time to the development of higher level number skills that activate the same part of the brain (Guo, 2021).

Corporeality and numerical intelligence

This study aims to show the correlation between a development of motor skills and a development of mathematical skills.
This, it is intended to initially examine the relationships between preschoolers' physical well-being and numerical intelligence, while going on to show how this relationship can be extended not only to mathematical skills but also to other skills (receptive language skills, scientific skills).
This consideration was also brought demonstrated by a project involving a total of 273 children (141 boys and 132 girls), aged 4 to 5 years, from 30 different schools, who were administered tests on both physical fitness and motor skills and math and science knowledge. The results showed that children with better motor skills also had higher scores on tests related to executive function-related skills and also demonstrated better school performance; the reduction in variance among was 19.3 percent (variance refers to the dispersion of data around the mean). This underscores the importance of physical well-being and the importance of creating motor pathways in children especially at a time of preschool to elementary school transition (Chou et al., 2022).
Until the last two decades, the most significant approach in cognitive science was an idea of "mind" associated with the software of a computer: importance was given to the analysis of the functioning, without investigating the relationships with the hardware i.e., the brain and the body (Borghi & Iachini, 2002). Today, gradually, we have come to the belief that the mind is influenced by the brain, and especially by the body. This belief has created a strong relationship between three fundamental processes that were previously found to be analyzed in distinctly separate ways: perception, action and cognition.
In the past fifteen years there have been numerous studies and research on cognition without neglecting the traditional cognitive science approach. Indeed, there is no single view, but

there are several. Some emphasize the radical importance of experience and perceptions, others of the body and action. In the former case, the model is called "phenomenological," while in the latter it is regarded as a "pragmatic" model.
In the logic adopted by the pragmatic model, which is the one of interest in this study, the primacy of action can be evaluated using different keys: American pragmatism (Dewey, 1949), for example, understands concepts not as simple representations of objects, but as a set of instructions useful for interacting with objects aimed at action (Caruana, Borghi, 2013); instead, for example, Gibson's ecological approach is essentially formed on the concept of "affordances," that is, all the physical qualities of an object that suggest appropriate actions to manipulate it. Every object has its affordances, as do surfaces, events and places. The individual does not perceive only a copy of what is reported to him from the outside world, but grasps a wealth of information useful for his action (Rio et al., 2015).
Today psychological research shows that we are born predisposed to numerical intelligence as much as to verbal intelligence. It therefore turns out to be essential that school, from the earliest age, not only the development of language but also the construction of this other type of intelligence (Molin, Lucangeli, Poli 2003).
Simplistically, we can define numerical intelligence as the understanding of the world in terms of numbers and quantities.
It is to Piaget, who is credited with formulating the first cognitive theories regarding the elaboration of the concept of number (Piaget, Szeminska, 1941) by hypothesizing an inseparable relationship between the structures of 'general intelligence and the evolution of numerical competence in thinking skills.

Impact of motor activity on learning development

Physical exercise is crucial for maintaining a healthy lifestyle. In fact, motor competence and physical fitness are associated with lower rates of obesity and increased muscle strength. These are also essential in childhood, when indicators of well-being (Robinson, 2015).
Motor competence, i.e. the ability to produce fluid and efficient movements, thus appears to be an important component of the physical and mental well-being of the individual.
Specifically, fine motor skills are identified as a good predictor of school performance (Haapala, 2013). In addition, physical activity is positively associated with the development of vocabulary and generally with better academic performance (Carson, 2017).
In addition, improved muscle fitness was found to be linked to cognitive performance in children and school performance in children and adolescents (Tsai, 2020).
Exercising increases blood flow to certain areas of the brain that are important for functions such as attention, memory and learning. It follows that motor skills are also linked to the development of social knowledge, language and social interactions by children.
Several studies have supported the idea that there is a direct correlation between motor and cognitive abilities of children, highlighting how the implementation of motor intervention programs can be used to stimulate both motor and cognitive abilities (Van der Fels, 2015). Active play thus appears to be related to self-regulation that contributes to a greater development of mathematics and emerging literacy (Becker, 2014).
Focusing on the benefits of physical activity is therefore crucial, even at school.

1. Skills

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Mathematical

Mathematics is a cumulative and composite discipline that requires the use of general cognitive skills. Mathematical skills are both domain-specific (core skills), such as numerical processing, and domain-general (non-core skills) such as WM or planning.
Learning in this discipline is therefore based on a progressive increase in these skills.
At the base of mathematical skills are built-in domio-specific mechanisms that allow the building of subsequent learning.
Numerous scientific papers note and demonstrate that the ability to discriminate and manipulate numbers is innate and shared with the animal world (Butterworth, 2005).
Already in the 1970s and 1980s, studies of subitization (mechanism of individual representation of small quantities) demonstrated this competence as innate. Moreover, they appear to be related to the capacity of estimation (a rough representation related to the ability to appreciate changes in numbers that refines with age). Both develop in correlation with the environmental and cultural stimuli provided to the child.

Antell and Keating (1983) demonstrated mathematical competence with infants 1 to 12 days old.
Karen Wynn (1992) showed that 6-month-olds have arithmetic "expectations" and are able to perform simple addition (N+1) and subtraction (N-1).

Infants as young as a few months old perceive the numerosity of a set of objects immediately, without counting. The maximum distinct number, in the process of visual perception (subitizing) appears to be four (Mandler and Shebo, 1982).
In the Developmental Analysis of Computation Skills (Butterworth, 2005) it is stated that nature provides a core that classifies small sets of objects (numerosity). This core refers to the ability to recognize differences between quantities, rather than number-related numerosity.

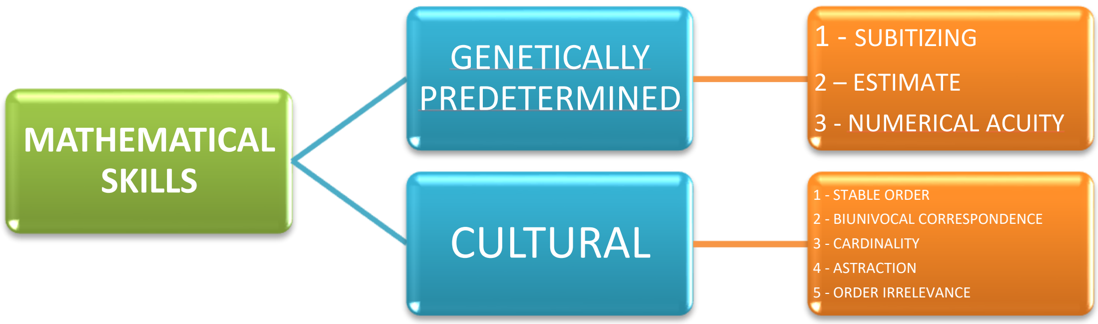

Figure 1Mathematical skills

With the development of representational age, around 18 months, the child's mental capacities expand, favoring language development, deferred imitation, and symbolic play. In language development, words such as big/small, high, more/less, again, one appear, all terms that quantify reality.
Between 24 and 28 months, the first number words appear, which will allow to integrate and develop the different aspects of quantitative reality.
Specifically, skills such as understanding biunivocal correspondence, the ability to follow a

certain order, the experience of operating on objects are developed, and, through the observation of the use of numbers by adults, acquires the preparatory skills of counting (Lucangeli, 2018).

As mentioned, the approximate number system (ANS) is a cognitive system that supports estimating the size of a group without relying on language or symbols. The ANS is attributed to the non-symbolic representation of all numbers larger than four, with smaller values performed by the parallel detection system or the object tracking system. Beginning in early childhood, to enhance mathematical skills, ANS allows an individual to consolidate estimation skills and develop measurement skills that are increasingly sensitive to differences in magnitude between groups. The accuracy of the ANS is refined during childhood development and reaches a final adult level of accuracy of approximately 15%, meaning that an adult could distinguish 100 items versus 115 items without counting. The ANS plays a crucial role in the development of other numerical skills, such as exact number concept and simple arithmetic. It has been shown that a child's level of ANS accuracy predicts later mathematical achievement in school. ANS has been linked to intraparietal sulcus of the brain. The intraparietal sulcus (IPS) is located on the lateral surface of the parietal lobe, and consists of an oblique and a horizontal part. It contains a number of functionally distinct subregions that have been intensively studied by doing both primate studies and functional neuroimaging in humans. It is primarily involved in motor-perceptual coordination (e.g., directing eye movements) and visual attention, from a point indicated by vision, grasping an object and manipulating it to achieve a desired effect. The IPS is also thought to play a role in other functions, including symbolic numerical information processing, spatial memory, and interpretation of others' intentions (Mark F et All, 2016).

Language

Language is pervasive in nature; it must be learned and applied. The school pays attention to verbal and oral communication to expand conversational skills, morphological, phonological, and semantic skills. Language is: (1) tool: of communication and regulation of one's behavior (cognitive self-regulation); (2) system: of language mastery promoted by preschool; (3) place of interaction and meaning: preschool encourages the development of symbolic identification and understanding (reading and writing).

The Project relates linguistic competence with the development of mathematical proto-competences. At the basis of these, in fact, there are mechanisms of comprehension and production of numbers supported by lexical, syntactic and phonological-graphical processes. Examples include an understanding of mathematical terms and concepts, an awareness of the questions that mathematics can answer, and the application of basic mathematical principles and processes in the everyday context.
Through storytelling, in fact, the objective was to indirectly stimulate the acquisition of digital skills.
The activities proposed, in fact, had the aim of helping children to rework mathematical reasoning and communicate in "mathematical language".

Theory of Mind

Theory of mind means being able to attribute mental states, i.e., beliefs, emotions, desires, intentions, thoughts, to oneself and others and to assume, based on these assumptions, one's own and others' behavior (Sempio et al., 2005). TOM is a skill that is used on a daily basis and that serves to have representations of the functioning of the mind of others that allow one to better manage internal states and social relationships. In fact, thanks to the theory of mind it is possible to explain, predict and act on one's own and others' behavior (More, Frye, 1991). Variables that facilitate the formation of a theory of mind in the child in interaction with an adult have been identified:

Shared attention: bringing concentration simultaneously to the same thing or game; Facial imitation: the reproduction of particular facial expressions. Pretend Play: simulation of pretend play between adult and child

Since the 1990s, a strand of studies has been consolidated to hypothesize a possible link between language and theory of mind.

Scientific studies have shown a high correlation between language skills and the development of theory of mind (TOM), both in preschoolers (Jenkins and Astington, 1996) and adults (Jenkins and Astington, 1996).

The work carried out on strengthening numerical assessment and assessment skills is therefore aimed at increasing these skills in different areas, such as assessing different situations.

According to this action-research work, improving the ability to estimate and attribute value would also improve emotional competence and the ability to assess "emotional weight."

It is therefore important to take action which takes account of potential applications outside the school environment.

According to this action-research work, enhancing esteem and value attribution skills would improve emotional competence and the ability to assess "emotional weight" as well.

It is therefore important to take action which takes account of potential applications outside the school environment.

2. Method

The exercises were designed using mathematics as a direct element (e.g. counting steps), but also indirect, such as evaluating and estimating the force to be used in a throw in order to hit the target.

The proposal submitted includes: (1) Teacher **training** course lasting a total of **6 hours** on the use of the material and the educational approach. The training for teachers includes different moments, in which, in addition to training on motor, mathematical and linguistic exercises, we reflect on the children's upgradeable skills. Specifically, a first phase focuses on the strategies adopted by the children to respond to the proposed activities. The second phase involves the recognition and interpretation of individual children's skills. Finally, if necessary, the readjustment of the educational intervention (Luciano, 2018). Although the starting work base is pre-established, this approach, leads to a reorganization of the educational action based on the observation on the children. An integral part of the method is the detection of the errors made by the children as a lever for redesigning the fields of experience. (2) **15 structured motor interventions** to develop the skills of subitizing, estimating and learning the concepts of number and quantity. The intervention had a weekly frequency of 3 days a week for 5 weeks in May - June - July 2021. Embodied theories have long correlated not only language skills, but also calculation skills with the body and the connection with movement (Caruana, Borghi, 2013).

Each intervention is a field of experience, in which the child experiences corporeality and perception as a fundamental means of acquiring teaching competence.

The approach involved work divided into three phases:

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Figure 2 Work steps

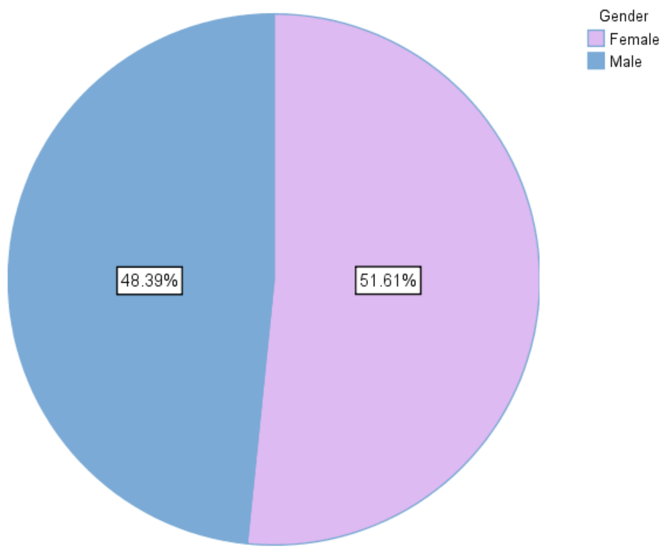
The paper tool that includes the **material** related to 15 structured educational interventions. Exercises were focused in the following areas: comparison concepts; classification; one-to-one correspondence; seriation; counting (learning and using numbers); subitizing, counting, estimating. (3) **Monitoring** of teachers halfway through the project, useful for maintaining the quality of the educational offer. Specifically, the relationships between teachers and children and between teachers themselves are taken into consideration; all the factors linked to planning (spaces, materials, time, needs, individualized paths...)

3. Tools

Three tests will be administered to children in T0 and T1 (before and after the educational-didactic intervention): (1) **NEPSY ll - L4**: tests to assess comprehension and expression functions, phonological processing, naming, syntactic comprehension; (2) **NEPSY ll - S02**: TOM (Theory of Mind) to assess the ability to understand emotions, decode and interpret others' intentions and viewpoints. Understand how these influence behaviors; (3) Test of **Early Numeracy** Test.

4. Data analysis

Sample



The sample of children is equally divided by gender. The children are all between 3 and 5 years old and attend a nursery school in the province of Milan.

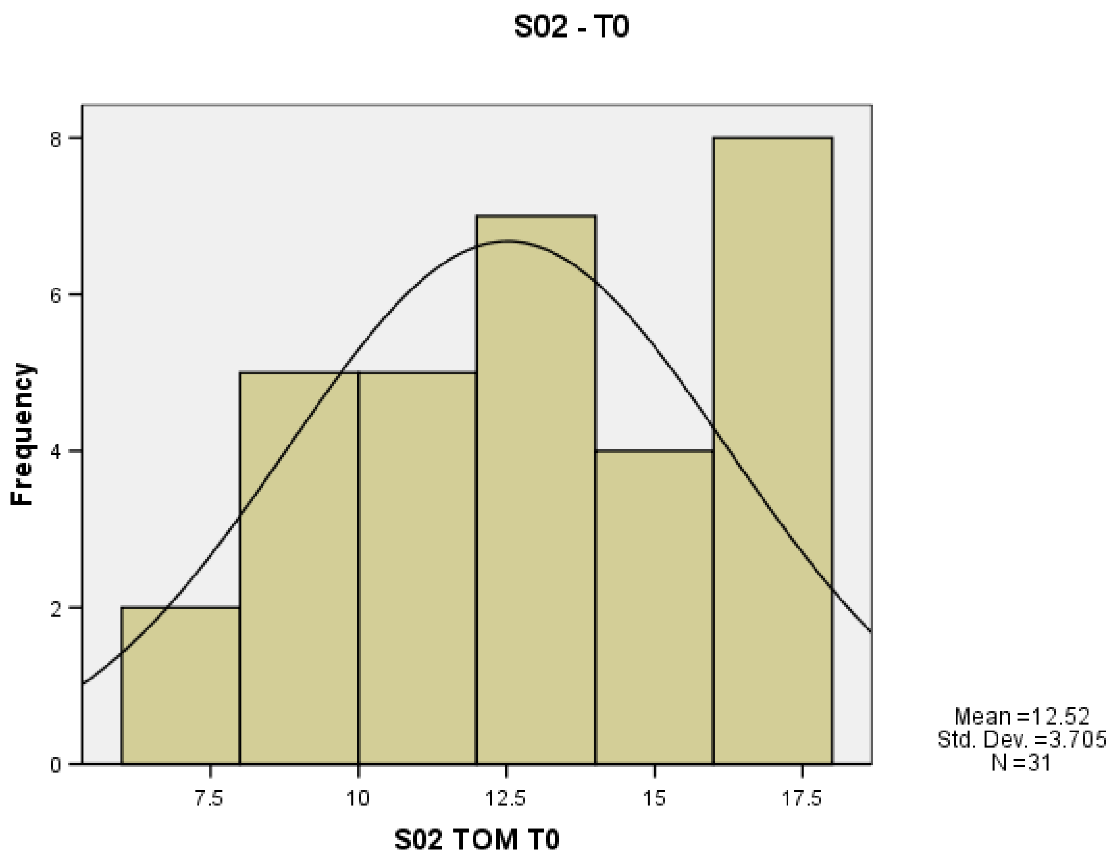
Social Perception S02

S02_T0

It is intended to test whether the mean obtained from the sample for Nepsy's S02 test of social perception has a statistically significant difference from the mean PS = 10 at temp0 T0.

The One-Sample T value test will be used to perform the analysis.

The null hypothesis H0 is therefore that there is no statistically significant difference between the mean value obtained for our sample and the mean PS = 10 value.



Graph. 1 Social perception T0

Descriptive statistics applied to our sample gives us the results in Figure:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
S02 TOM T0	31	12.52	3.705	.665

Table 1 One-sample Statistics

Thus, our sample of 31 statistical units has a mean of 12.52 relative to the S02 test at time T0. The inferential statistic shows us the following results:

One-Sample Test

	Test Value = 10					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
S02 TOM T0	3.781	30	.001	2.516	1.16	3.88

Table 2 One-sample test

df represents the degrees of freedom of the sample (df=N-1). From the conversion table we find that for a value of degrees of freedom equal to 30 and for a 95% confidence interval the critical value for the t distribution is 2.042. Having obtained a t-value equal to 3.781 this is a first indicator we must reject the null hypothesis that there is no statistically significant difference between the two averages (Mean difference = 2.516).

The p-value (Mr. 2-tails) is then equal to 0.001 which is less than 0.05. This parameter also indicates that there is a statistically significant difference between the averages.

The last indicator (the 0-value - equality between the averages - is also not present within the confidence interval (1.16 and 3.88) indicates that there is a statistically significant difference between the averages.

The null hypothesis H0 can therefore be rejected. We can therefore reject the hypothesis that there is no statistically significant difference between the mean value calculated for our sample and the Nepsy reference value for S02. The mean over the period has a higher value than the reference value.

S02_T1

We repeat the operations at time T01. We want to see if the mean obtained from the sample for Nepsy's S02 test of social perception has a statistically significant difference from the mean PS = 10 at time T1. The One-Sample T value test will be used to perform the analysis. Thus, the null hypothesis H0 is that there is no statistically significant difference between the mean value obtained for our sample and the mean PS = 10 value.

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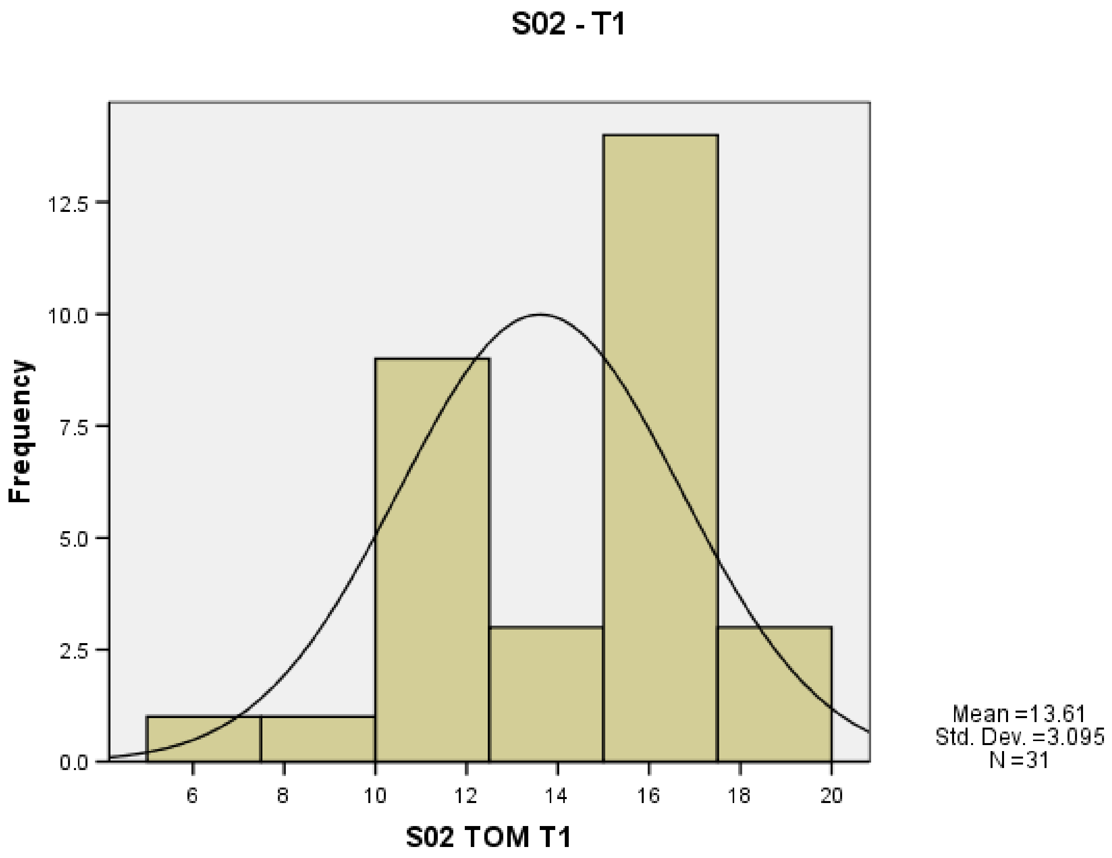


Graph. 2 Social perception T1

Descriptive statistics applied to our sample gives us the results in Figure:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
S02 TOM T1	31	13.61	3.095	.556

Table 3 One sample statistics

Thus, our sample of 31 statistical units presents a mean of 13.61 relative to the S02 test at time T1. The inferential statistics show us the following results:

One-Sample Test

	Test Value = 10					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
S02 TOM T1	6.500	30	.000	3.613	2.48	4.75

Table 4 Ona-sample test

df represents the degrees of freedom of the sample (df=N-1). From the conversion table we find that for a value of degrees of freedom equal to 30 and for a 95% confidence interval the critical value for the t distribution is 2.042. Having obtained a t-value equal to 6.500 this is a first indicator we must reject the null hypothesis that there is no statistically significant difference between the two averages (Mean difference = 3.613). The p-value (Mr. 2-tails) is then equal to 0.000 which is less than 0.05. This parameter also indicates that there is a statistically significant difference between the averages. The last indicator (the 0-value - equality between the averages - is also not present within the confidence interval (2.48 and 4.75) indicates that there is a statistically significant difference between the averages. The null hypothesis H0 can therefore be rejected. We can therefore reject the hypothesis that there is no statistically significant difference between the mean value calculated for our sample and the Nepsy reference value for S02. The mean over the period has a higher value than the reference value.

S02 – Comparison T0 vs T1

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	S02 TOM T0	12.52	31	3.705	.665
	S02 TOM T1	13.61	31	3.095	.556

Table 5 Paired samples statistics

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	S02 TOM T0 & S02 TOM T1	31	.126	.501

Table 6 Paired Samples correlations

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	S02 TOM T0 - S02 TOM T1	-1.097	4.519	.812	-2.754	.561	-1.351	30	.187

Table 7 Paired sample test

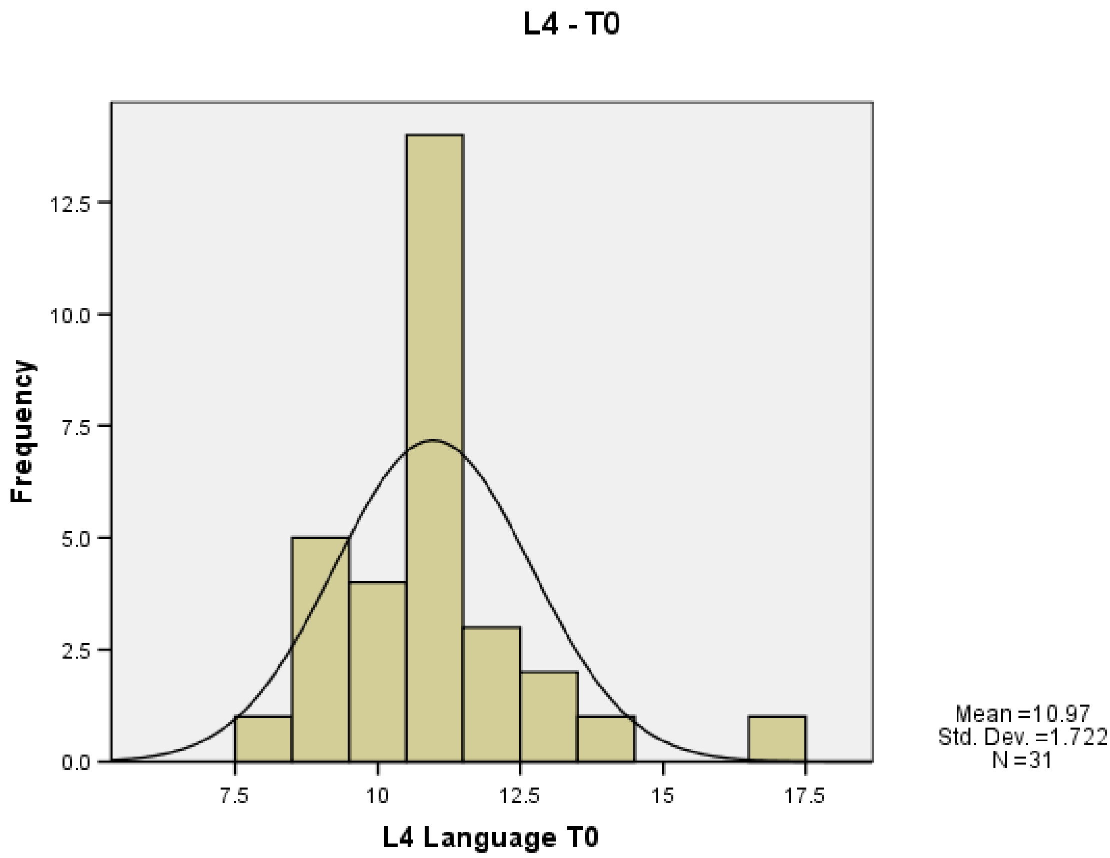
The p-value (Mr. 2-tails) is then 0.187 which is greater than 0.05. This parameter indicates that there is no statistically significant difference between the averages. The indicator (0-value - equality between the averages - is also present within the confidence interval (-2.754 and 0.561) indicates that there is no statistically significant difference between the averages. Therefore, the null hypothesis H0 cannot be rejected. Therefore, we cannot reject the hypothesis that there is no statistically significant difference between the mean value calculated for our sample at time T0 and T1 for S02. The mean at time T1 is 1.097 greater than at time T0, but the difference is not statistically significant.

Language

L04_T0

It is intended to test whether the mean obtained from the sample for the Nepsy L4 test related to social perception has a statistically significant difference from the mean PS = 10 at temp0 T0.

The One-Sample T value test will be used to perform the analysis. The null hypothesis H0 is therefore that there is no statistically significant difference between the mean value obtained for our ample and the mean PS = 10 value.



Graph. 3 Language L4 T0

Descriptive statistics applied to our sample gives us the results in Figure

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
L4 Language T0	31	10.97	1.722	.309

Table 8 One-sample statistic

Thus, our sample of 31 statistical units presents a mean of 10.97 relative to the L4 test at time T0. The inferential statistics show us the following results.

One-Sample Test

	Test Value = 10					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper
L4 Language T0	3.129	30	.004	.968	.34	1.60

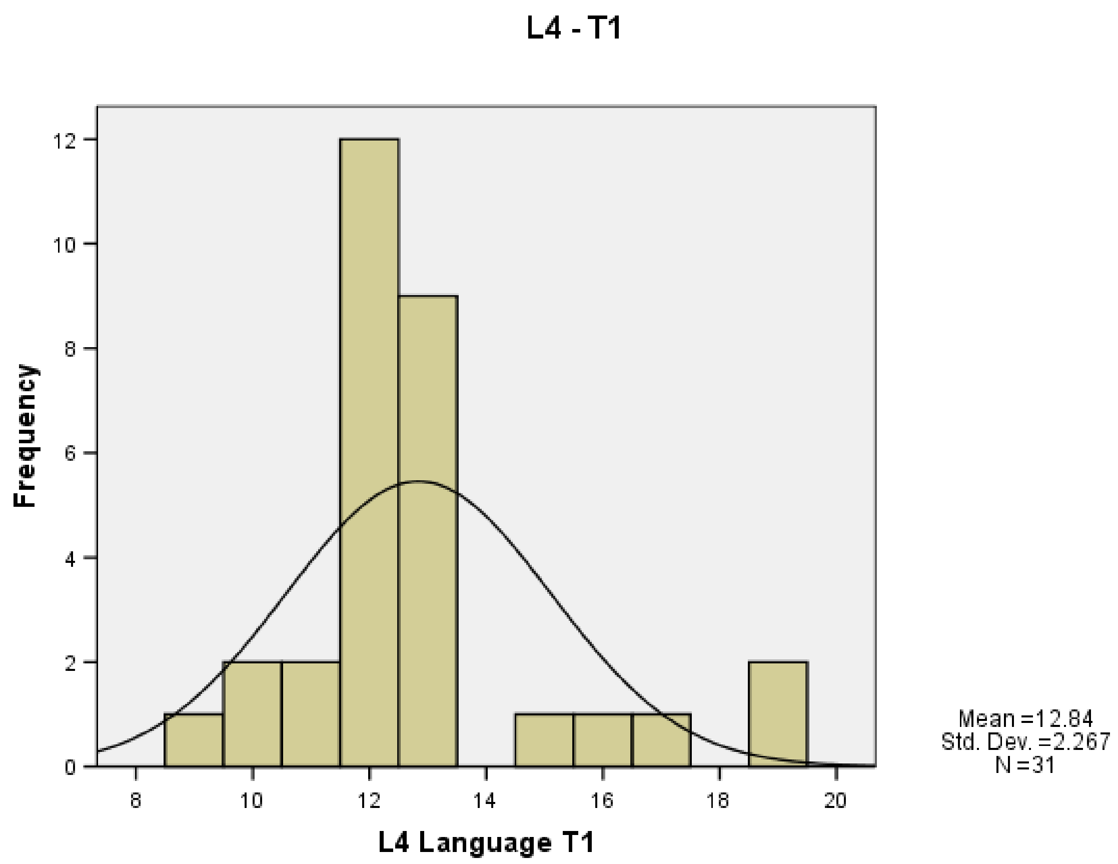
Table 9 One sample test

df represents the degrees of freedom of the sample (df=N-1). From the conversion table we find that for a value of degrees of freedom equal to 30 and for a 95% confidence interval the critical value for the t distribution is 2.042. Having obtained a t-value equal to 3.129 this is a first indicator we must reject the null hypothesis that there is no statistically significant difference between the two averages (Mean difference = 0.968). The p-value (Mr. 2-tails) is then equal to 0.004 which is less than 0.05. This parameter also indicates that there is a statistically significant difference between the averages. The last indicator (the 0 value - equality between the averages - is also not present within the confidence interval (0.34 and 1.60) indicates that there is a statistically significant difference between the averages. The null hypothesis H0 can therefore be rejected. We can therefore reject the hypothesis that there is no statistically significant difference between the mean value calculated for our sample and the Nepsy reference value for L4. The mean over the period has a higher value than the reference value.

L4_T1

We repeat the operations at time T01. We want to test whether the mean obtained from the sample for the Nepsy L4 test of social perception has a statistically significant difference from the mean PS = 10 at time T1. The One-Sample T value test will be used to perform the analysis.

Thus, the null hypothesis H0 is that there is no statistically significant difference between the mean value obtained for our sample and the mean PS = 10 value.



Graph. 4 Language L4 T1

Descriptive statistics applied to our sample gives us the results in Figure

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
L4 Language T1	31	12.84	2.267	.407

Table 10 One sample statistics

Thus, our sample of 31 statistical units presents a mean of 12.84 relative to the L4 test at time T1. The inferential statistics show us the following results:

One-Sample Test

	Test Value = 10					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
L4 Language T1	6.972	30	.000	2.839	2.01	3.67

Table 11 One sample test

df represents the degrees of freedom of the sample (df=N-1). From the conversion table we find that for a value of degrees of freedom equal to 30 and for a 95% confidence interval the critical value for the t distribution is 2.042. Having obtained a t-value of 6.972 this is a first indicator we must reject the null hypothesis that there is no statistically significant difference between the two averages (Mean difference = 2.839). The p-value (Mr. 2-tails) is then equal to 0.000 which is less than 0.05. This parameter also indicates that there is a statistically significant difference between the averages. The last indicator (the 0-value - equality between the averages - is also not present within the confidence interval (2.01 and 3.67) indicates that there is a statistically significant difference between the averages. The null hypothesis H0 can therefore be rejected. We can therefore reject the hypothesis that there is no statistically significant difference between the mean value calculated for our sample and the Nepsy reference value for L4. The mean over the period has a higher value than the reference value.

L4 – Compare T0 vs T1

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	L4 Language T0	10.97	31	1.722	.309
	L4 Language T1	12.84	31	2.267	.407

Table 12 Paired samples statistics

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	L4 Language T0 & L4 Language T1	31	.741	.000

Table 13 Paired samples correlations

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	L4 Language T0 - L4 Language T1	-1.871	1.522	.273	-2.429	-1.313	-6.845	30	.000

Table 14 Paired samples test

The p-value (Mr. 2-tails) is then equal to 0.000 which is less than 0.05. This parameter indicates that there is a statistically significant difference between the averages. The other indicator (the 0-value - equality between the averages - is also not present within the confidence interval (-2.492 and -1.313) indicates that there is a statistically significant difference between the averages. The null hypothesis H0 can therefore be rejected. We can therefore reject the hypothesis that there is no statistically significant difference between the mean value calculated for our sample at time T0 and T1 for L4. The mean at time T1 is 1.871 greater than at time T0 and the difference is statistically significant.

Total Math - T0 vs T1 Comparison

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Mat T0	14.68	31	11.146	2.002
	Mat T1	25.23	31	12.350	2.218

Table 15 Paired samples statistics

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Mat T0 & Mat T1	31	.783	.000

Table 16 Paired samples correlations

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Mat T0 - Mat T1	-10.548	7.827	1.406	-13.419	-7.678	-7.504	30	.000

Table 17 Paired samples test

The p-value (Mr. 2-tails) is then equal to 0.000 which is less than 0.05. This parameter indicates that there is a statistically significant difference between the averages. The other indicator (the 0-value - equality between the averages - is also not present within the confidence interval (-13.419 and -7.678) indicates that there is a statistically significant difference between the averages. The null hypothesis H0 can therefore be rejected.

We can therefore reject the hypothesis that there is no statistically significant difference between the mean value calculated for our sample at time T0 and T1 for mathematics. The mean at time T1 is 10.548 greater than at time T0 and the difference is statistically significant.

T0 vs T1 areas

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Concetti di confronto T0	3.48	31	1.235	.222
	Concetti di confronto T1	4.35	31	1.199	.215
Pair 2	Classificazione T0	2.32	31	1.579	.284
	Classificazione T1	3.39	31	1.626	.292
Pair 3	Corrispondenza uno a uno T0	2.13	31	1.708	.307
	Corrispondenza uno a uno T1	3.00	31	1.826	.328
Pair 4	Seriazione T0	1.16	31	1.393	.250
	Seriazione T1	2.03	31	1.958	.352
Pair 5	Conteggio verbale T0	.94	31	1.413	.254
	Conteggio verbale T1	1.52	31	1.651	.296
Pair 6	Conteggio strutturato T0	1.29	31	1.677	.301
	Conteggio strutturato T1	2.42	31	1.840	.330
Pair 7	Conteggio risultante T0	1.52	31	1.546	.278
	Conteggio risultante T1	2.16	31	1.809	.325
Pair 8	Conoscenza generale dei numeri T0	1.26	31	1.290	.232
	Conoscenza generale dei numeri T1	2.58	31	1.336	.240
Pair 9	Stimare T0	.58	31	1.361	.244
	Stimare T1	3.77	31	2.140	.384

Table 18 Paired samples statistics

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Concetti di confronto T0 - Concetti di confronto T1	-.871	1.231	.221	-1.323	-.419	-3.938	30	.000
Pair 2	Classificazione T0 - Classificazione T1	-1.065	1.504	.270	-1.616	-.513	-3.941	30	.000
Pair 3	Corrispondenza uno a uno T0 - Corrispondenza uno a uno T1	-.871	1.648	.296	-1.475	-.266	-2.942	30	.006
Pair 4	Seriazione T0 - Seriazione T1	-.871	1.360	.244	-1.370	-.372	-3.566	30	.001
Pair 5	Conteggio verbale T0 - Conteggio verbale T1	-.581	1.025	.184	-.957	-.204	-3.153	30	.004
Pair 6	Conteggio strutturato T0 - Conteggio strutturato T1	-1.129	1.910	.343	-1.830	-.428	-3.291	30	.003
Pair 7	Conteggio risultante T0 - Conteggio risultante T1	-.645	1.142	.205	-1.064	-.226	-3.147	30	.004
Pair 8	Conoscenza generale dei numeri T0 - Conoscenza generale dei numeri T1	-1.323	1.166	.209	-1.750	-.895	-6.316	30	.000
Pair 9	Stimare T0 - Stimare T1	-3.194	2.227	.400	-4.011	-2.377	-7.983	30	.000

Table 19 Paired samples test

The p-value (Mr. 2-tails) is is less than 0.05 in all areas between time T0 and time T1. This parameter indicates that there is a statistically significant difference between the averages. The other indicator (the 0 value - equality between the averages - is also not present within the confidence intervals (all negative values) indicates that there is a statistically significant difference between the averages. The null hypothesis H0 can therefore be rejected. We can therefore reject the hypothesis that there is no statistically significant difference between the mean value calculated for our sample at time T0 and T1 for all mathematical areas. The averages at time T1 are always greater than at time T0 and the difference is statistically significant (max 3.194 area Estimating and min 0.581 area Verbal Counting).

Discussion and Conclusion

The neologism didactic corporeality (Sibilio, 2011) stems from scientific reflection on the formative and educational value of the body, understood as a mediator capable of giving meaning to the educational experience, assuming in the latter its own form in a co-evolutionary dynamic.
With this project, children have developed mathematical skills through exercises that have put them in relation with the concept of number, starting from their innate skills.
Specifically, through an educational experience, which does not involve only the armetic aspect, the child has the opportunity to acquire cognitive, perceptive and motor skills in order to develop skills.
Intervention that takes various aspects into account can therefore achieve important results.
The increase in the acquisition of proto-mathematical skills can therefore be supported by the implementation of a motor protocol which, in turn, stimulates the acquisition of linguistic and emotional skills.
The initial hypothesis of finding a correlation between numerical intelligence and motor activity was confirmed.
Educational experience, the child has the opportunity to cognitive, perceptual and motor skills in order to develop competencies. It is therefore essential to offer the child a playful / educational tool that puts him in a position to develop innate proto-mathematical skills, also exploiting the body through motor paths congruent with the structure of the book that stimulate the growth mind / body.

Statistical analysis shows that compared to the Nepsy reference values, our sample has a higher mean value for S02 and L4 at both time T0 and time T1. However, for S02 we cannot say that the mean value at time T1 compared to time T0 is statistically significant, whereas we can for L4. In Total Math it is true that the delta of the mean values at times T0 and T1 is a statistically significant value and this is true for all mathematical areas considered. In the light of the data collected, we can say that the educational-didactic intervention related to mathematical competences has led the children to obtain statistically significant results, confirming the effectiveness of the proposal. Values also improved in the areas of language and Theory of Mind, but it is not statistically possible to correlate them with the intervention.

The main criticality of the research was time. Following the reopening of the services for children 0-6 years old and in compliance with current regulations about Covid-19, it was possible to apply the method only in the summer period (June and July), taking advantage of outdoor spaces. The method is being applied by the sample school in this school year as well, in order to continue the research and data collection.

Developing intervention programs to develop early mathematical skills not only serves to develop children's innate abilities and prepare them for future learning, but also allows for the detection of possible difficulties in favor of early diagnosis. Intraparietal sulcus damage can produce difficulties in counting and understanding simple arithmetic. It has been shown that damage to the intraparietal sulcus can cause acalculia, a severe disorder in mathematical cognition. Symptoms differ based on the location of damage, but may include the inability to perform simple calculations or decide that one number is larger than the other. Gerstmann syndrome, a disease that results in lesions in the left parietal and temporal lobes, results in acalculia symptoms and further confirms the importance of the parietal region in the ANS. Dyscalculia is also seen in individuals who have unexpected difficulty understanding numbers and arithmetic despite appropriate education and social environments. This syndrome can manifest in several different ways from the inability to assign a quantity to Arabic numerals to difficulty with tables of times. Dyscalculia can result in children falling considerably behind in school, regardless of having normal intelligence levels (Mark et All, 2016).

Although ANS is present in childhood before any numerical instruction, research has shown a link between people's mathematical abilities and the accuracy in which they approximate the size of a series. This correlation is supported by several studies in which school-aged ANS skills as children are compared to their mathematical achievements. At this point children have received training in other mathematical concepts, such as exact number and arithmetic. More surprisingly, ANS accuracy before any formal instruction accurately predicts better math performance. A study involving children aged 3-5 years revealed that ANS acuity corresponds to better mathematical cognition while remaining independent of factors that may interfere, such as reading ability and the use of Arabic numerals. Understanding how ANS interacts on children's learning is useful in school education to develop functional programs to enhance mathematical skills already in early childhood.

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