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Experimental Analysis on the Development of Cognitive Processes in Childhood Through Body Experience

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This study aims at comparing the effect of an innovative educational approach, based on the continuous relationship between mind and body, to traditional methodologies; more in particular, it focuses on the cognitive processes of language and memory in childhood. Previous studies showed that the Embodiment Theory of Conceptual Representations considers the extent to which the concepts are embodied, i.e., the way their conceptual features are represented in sensory and motor brain areas in an experience-dependent way. Similarly, the Motor Theory of Language suggests considering phonetic gestures, made by the speaker to produce them as language perception objects, reproduced in the brain as real invariant motor commands. This longitudinal research analyzed the impact of a museum-based education on the memory and language process of children aged 3-6 years, with the purpose of building links between the evolutionary dimension and the didactic dimension. In a wider perspective, these aspects assume great importance for educators that aim to train qualified students, ethically informed and trained as world citizens, starting from neuroscientific discoveries.

Keywords: unstructured didactics, childhood, cognitive processes, body experience, educational neuroscience

Introduction

In recent years, the world of scientific research has opened up to new scenarios of didactic intervention, aiming at enhancing cognitive processes from the pre-school period. The approach of Educational Neuroscience (EN) shows a clear picture of the links between social and relational skills on the one hand, and the cognitive domain on the other, depicting the didactic experience as something that shapes the processes underlying cognitive skills (Meares, 2012). This perspective designates the mind as *embodied and embedded*; embodied in a bodily, internal context, and at the same time, constitutively embedded in an external relational context (Morabito, 2016). This represents the essence of the Theory of Embodied Cognition (EC), which encompasses the concept that the mind is no longer independent of the body, but it is enclosed in it (Peluso Cassese & Torregiani, 2017). Therefore, the body takes on both a cognitive and a social function, realizing a close relationship with the mechanisms of thought and knowledge made explicit by behavior, communication, participation, sharing, and collaboration (Peluso Cassese, Torregiani, & Bonfiglio, 2017). Educational Neurosciences represent an attempt to build methodological and theoretical bridges among Cognitive Neurosciences, Cognitive Psychology, and Educational Practice, proposing a more scientific understanding of

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the processes involved in the educational skills acquisition (Howard-Jones et al., 2016). This interdisciplinary field contemplates how neural systems change during learning and development, offering the opportunity to reformulate and adapt educational approaches to the children's specific needs. In fact, neuroscientific cognitive research on learning can provide potential benefits to education, especially for students with special educational needs, investigating the neural mechanisms underlying atypical skills development (National Science Foundation, USA, 2007). On the basis of this scientific evidence, this research work aims at validating a didactic approach that can become an orientation of an educational practice with an unstructured matrix, which originates from the epistemology in the pedagogical field. Among the reference paradigms it is possible to trace pedagogical activism (Dewey, 1899; Vaccani, 1979), taking the view that school, intended as a laboratory, should aim at consolidating the potentialities and the intellectual resources in the realization of individuality in relation to sociality, in a learning-by-doing perspective. Experiential learning (Kolb, 1984) is seen as a process in which knowledge is created through the transformation, interpretation, understanding, and active experimentation of an experience. Significant learning (Ausubel, 1968) is considered as a proof that, in order to learn, we need to research and rework knowledge to give meaning to the latter, both through the integration of new information with those already owned, and through its use in different contexts and situations, so as to develop problem solving, critical thinking, and meta-reflection skills. Learning is significant when it allows students to become proficient in strategies by learning how to learn, relating to others and knowing how to work in a group, or through the development of meta-cognitive, attitudinal, autonomy, and creativity skills. Moreover, the enactivism arising from the theories developed by Merleau-Ponty (1969) and Bateson (1977), up to those developed by Varela, Thompson, and Rosch (1991), Rivoltella and Rossi (2017), which see

> in the didactic action the construction of affective and relational cognitive networks not producing knowledge, but being knowledge itself, so that during the action the system co-evolves together with the trajectories each subject: each action changes while the surrounding environment changes, and the action changes the system during the process. As the system changes, it learns; it is clear that change and knowledge in action are two sides of the same coin. Knowledge is not a content, an information placed somewhere in the brain, but it is a state of the person, the result of that change that involves mind and body during the action. This process is the founding core of the enactivist theory. (Rossi, 2011, p. 44)

The Activity Based Intervention (ABI) was conceived by Pretty-Frontczak and Bricker (2004); it addresses children's educational and development goals by encouraging them to participate in meaningful activities, experimenting with various learning opportunities, highlighting the importance of timely feedback, and emphasizing the development and generalization of functional skills in highlighting an environment that stimulates active participation in programs and motivation to learn. It is from these contributions that the need for Unstructured Didactics (UD) arises, which draws on the application of applied educational practice, giving value to an interactive context in which the student can experience first-hand a certain notion, with a total involvement of the body in incorporating knowledge also in the presence of a specialized educator, able to guide the student in multidisciplinary acquisition, between the neuroscientific and the educational sphere. These strategies require student activation and promote the development of active cognitive processes through the analysis, evaluation, and application of knowledge (Bishop & Verleger, 2013). The traditional didactic activity offers clear advantages when it comes, for example, to convey a certain amount of information to many people. However, when the aim is to establish an exchange and not a mere conveyance of messages, generating a comparison, a discussion, and a learning-from-one-another, the traditional lesson (and its limits) must be rethought. The limits of the face-to-face lessons are obvious and easily identifiable: the student's passivity; the knowledge based on prolonged listening and repetition; the non-consideration of feedback and collaboration; the lack of interest in the different rhythms and learning styles. The face-to-face lesson is theoretically aimed at everyone, but actually, it is inevitably carried out for the average student and does not take into account the heterogeneity of the class. If the teacher can no longer be considered as a simple information-conveyer but, on the contrary, he is seen as a "researcher" (Shon, 2006) who, by continually reflecting on his way of teaching, learns how to improve his profession, then he becomes the "Director" of the learning process. Only in this way, the teaching-learning paradigm, from individualistic, will turn into collaborative, in which the student will also play an active and participatory role. It emerges, therefore, the need to move from methodologies, where the main actor turns out to be the teacher, to methodologies where the actors are the young guys and the teacher becomes more and more the director of the learning process. This is why we should change the teaching-learning model, turning it from individualistic-competitive into collaborative-democratic (Dewey, 1916). Altet (2002) stated that the analysis of the didactic action requires the restoration of the functional articulation between teaching and learning situation, for the plurality of variables involved in the process, such as: the actors' action, communication and control modality, the interactive methods of group management, and the transactions in the situation. Only a multidisciplinary approach can describe the different and specific dimensions of the teaching practice, and can make it possible to understand its articulation and functioning. A crucial problem for the teacher is how to organize learning experiences that contribute to increasing the understanding of cultural knowledge (Gardner, 1991), the critical sense and the autonomy of judgment (Walker, 2003), the assumption of choices responsible for particular conditions and constraints (Renaud & Murray, 2008); all this through a teaching activity meant as a source of knowledge re-elaboration and production. In relation to this, the educator should design the teaching activity based on the knowledge of the brain, resulting from cognitive neuroscience evidences proving that the development of the child's nervous system takes place rapidly in the first year of life, then continuing in the years following a less accelerated pace. During this evolution, the mnemonic ability, thanks to the perceptive process, is enriched with elements coming from new explorative experiences, especially in a stimulating and motivational environment (Nagy, Westerberg, & Klingberg, 2004). Speaking of unstructured didactics, in the terms described above, we must take into account that, while distancing itself from traditional school activities, it enhances the participatory experience with the recognition and the ability to grasp links and associations also from the visual and motor point of view; recent research (Siegel, 2001; Oliviero, 2007) showed that motor activity induces the production of nutrients principles of the brain to develop synapses. The use of motor representations in learning, for example, would allow for the combination of motor, automatic and procedural memories (which are primary, solid, and long-lasting) with visual, visual-spatial, and semantic memories (the latter are late-arising, more fragile, and less lasting), through global didactic paths (Lucisano, Salerni, & Sposetti, 2013), since working memory is a system able to temporarily maintain information in active form, and represents the ability to perceive, acquire, archive and, at the same time, process information for highly complex cognitive operations. Among these, in addition to the visual-spatial skills, we can include those related to language, linguistic understanding, reading, problem solving and reasoning (Kane & Engle, 2002). Thus, according to a widely used model, working memory is a general domain component involved in a series of functions, such as attention and retrieval of information from long-term memory (Baddeley, 2000). All of this was supported in studies on children (Alloway, Gathercole, & Pickering, 2006; Bayliss, Jarrold, Gunn, & Baddeley, 2003). If, for the visual-spatial sphere, the calculation and position-in-space skills are linked, the phonological loop is taken into consideration for the learning of the early vocabulary (Baddeley, Gathercole, & Papagno, 1998). Authors like Gathercole (1998), have shown that visual-spatial memory span grows regularly between 5 and 11 years, increasing by a unit every two years from one to three years, reaching the seven units at the age of 15, and then maintained in adulthood. Current studies show how the working memory, in its dynamism, can improve with practice. Growing evidence of scientific research leads to think that the working memory skill can be amplified with targeted training. Among these, St Clair-Thompson and his collaborators (2010) employed strategic training on groups of children in schools, training them practically on a variety of strategies (grouping tests, visual images), observing improvements in working memory, as well as in mental calculation, in the ability to follow the instructions of the activities. This type of training, in addition to having had benefits in children with typical development, has been a predictor of skills even in children with limited working memory skills. For example, with this type of intervention, we have seen how children with ADHD experienced reduced symptoms by improving cognitive control (Klingberg et al., 2005). Therefore, examples of strategic training, aimed at the ability to code and process, include grouping the elements into blocks, conceiving mental stories with the use of objects, and using images to make the objects more meaningful and salient. In line with these assumptions, it appears that the use of engaging, interactive, cooperative, and experiential didactic activities is functional, in a period in which the child's language and memory skills are not yet sufficiently articulated. Scholars who dealt with linguistic development (Camaioni, 1993; D'amico & De Vescovi, 2013; Volterra, Caselli, Capirci, & Pizzuto, 2005) underlined how the evolution of phonological, semantic, syntactic, and pragmatic components is not parallel and uniform; in addition, they highlighted that the understanding skill development is a necessary prerequisite for the subsequent production skill formation. The development of the latter, according to the theory of the Embodied Cognition (Varela, Thompson, & Rosch, 1992; Clark, 1997; Barsalou, 2008), the Language Motor Theory (Liberman & Mattingly, 1985), the language learning methodologies (Asher, 1969; Caforio, Carlin, & Cossaro, 2007), and the strengthening strategies (Capobianco, 2015) agrees on the primary role of the motor system in language development, given the fact that the Broca area, responsible for controlling ear-face movements, is very close to areas of the primary motor cortex, which would allow for its execution. The corroboration of the body in action for the linguistic domain, highlighted by neuroscientific evidence (D'Alessio & Minchillo, 2010), has led us to conceive how the interaction among mind, body, and environment, and human relationships generates changes at molecular level, with broad implications on language learning, according to the principle of brain plasticity. Once established that language is a system which gets shared with other individuals in a social situation favoring their development, for these characteristics, it finds fertile ground within the educational context, seen as the primary place of interaction and in which the child is required to take part daily. Based on these considerations, we work we are proposing aims at highlighting the importance of unstructured didactics aimed at stimulating the brain areas responsible for mnestic and linguistic processes in childhood, through the possibility of living an educational environment that leads to an improvement of cognitive performance in view of a qualitative inclusion in future learning.

Research Methodology

Research Goal and Assumption

In consideration of the scientific evidence described above, as regards the importance assumed by experiential and meaningful activities (which presuppose a complete involvement of corporeity) in the learning and strengthening of the mnemonic and linguistic faculties, the goal of this contribution is to trace a deconstructing scientifically based didactic approach, taking into account the developmental stages of the memory and linguistic process, as well as the neural mechanisms involved in it. In these terms, and with the aim of achieving scientific support for the benefit produced by the unstructured approach, the assumption underlying this research was developed, assuming that such educational plans can favor the development and strengthening of cognitive skills, to a greater extent than the effect deriving from classic (formal) or Montessori didactics, with reference to memory and language in pre-school children.

Experimenting Conditions

As an experimental condition of unstructured didactics, this research has employed museum didactics for its informal learning characteristics of topics related to notions of science, technology, art, botany, nutrition, and sustainability, experimented through playful activities. In a document, promoted by the National Science Council, the US Scientific Academies propose strands of science learning, i.e., six aspects of learning related to what learners, especially those still at school, can acquire or develop from the point of view of cognitive, social, and emotional development in museum settings. In particular, they can:

(1) Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world;

(2) Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science;

(3) Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world;

(4) Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena;

(5) Participate in scientific activities and learning practices with others, using scientific language and tools;

(6) Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science.

Pellerey (2006), starting from activist theories, prefigures a didactics carried out outside of the classrooms, but connected as a practical-behavioral application of the relational and mental skill already shaped in the child, subdivided into many special skills that range from an intellectual comprehension of the facts (of a work, of an object or of a machine, as of an experimental phenomenon), to

> the ability to know how to practice the same things that are shown and learned in a museum (...). This provision is the ability to acquire skills that are themselves specialized behaviors, in a very broad sense of the term. (Pellerey, 2006, p. 14)

Braund and Reiss (2006) argue that initiatives and activities carried out by schools in informal contexts, following museum or laboratory experiences, can complete the formal technical-scientific teaching activity and face the vocational crisis spreading in the sector, with appropriate teaching strategies, and a more motivating and engaging curriculum choice. An interpretative key to their assumption is the authenticity. The structure identified ad hoc for this phase was Explora, the Children's Museum of Rome; in particular, for the purposes of the research, six laboratory paths were selected, referring to the theme of colors, digital, science, senses, environment, and nutrition:

Me and the colors. Path aimed at the dynamic activation of the senses, specifically in the perception of colors, through the implementation of workshop games in line with the topic. The educational objective is to intrigue and stimulate the desire for knowledge, encouraging the development of cognitive faculties, fostering the discovery of primary colors, in the expression of artists in movement, in order to achieve and acquire the ability to decode, develop reflective learning and stimulating critical sense.

Me and the senses. The path is divided into different game sessions of symbolic transformation of tactile, olfactory, gustatory, visual and auditory experiences. The didactic objective is represented by the comparison of one's own perceptive experience in the group context, developing the ability to grasp and recognize similarities and differences, in order to consolidate the child's perceptive, motor, linguistic and intellectual skills, acting on the awareness of one's own perceptions.

Me and the food. A physiological path from the mouth to the intestine is explained, with notions related to the vitamin and nutrient elements, as energy functions for the brain. The child is plunged into a laboratory environment that stimulates the discovery and knowledge of food by categories, which includes the importance of a balanced diet, the association between product and seasonal period, the respect for the environment; moreover, he recognizes the main olfactory and taste sensations related to food and acquires knowledge related to food processing.

Me and sciences. The path aims at enhancing the centrality of the child in learning concepts related to natural elements (water, earth, fire, and air). He plays the role of a scientist and experiments with his observation, analysis, and experimentation skills.

Me and the environment. The path aims at intriguing and stimulating the desire for knowledge, encouraging the development of cognitive faculties by identifying the relationship between daily activities and environmental impact, promoting civic sense and respect for the environment, stimulating thoughtful thinking, association and the ability to identify relationships and raise assumptions.

Me and the digital. The path aims at stimulating and motivating the child to acquire knowledge, developing the cognitive faculties towards computational thinking through the use of the "digital", through which it is possible to build real representations of the world in which we interact, promoting logical thinking and problem-solving skills.

The sessions, lasting 1h and 45 minutes each and carried out by museum professionals-educators, represented the unstructured didactics training lasting for 90 days.

Sample and Procedures

A total sample of 82 children aged between three and six was recruited for the analysis. This was divided into an experimental group (unstructured training) consisting of 24 children, and two control groups, one of which of Montessori didactics matrix, consisting of 30 children; the other, instead, was of classic (formal) didactics matrix and composed of 28 children. The last two did not carry out unstructured training in order to assess the actual benefit of unstructured didactics. Due to the lack of randomization of the sample, the work is to be considered as an almost experimental design, but the research was structured with repeated measurements in two times for the entire sample. An ex-ante evaluation was carried out through specific psychometric tests to identify the linguistic level of each child in each group. At the end of the series of meetings, the same tests, carried out in the initial phase, were repeated to the whole sample (Bonfiglio & Peluso Cassese, 2018; Torregiani & Peluso Cassese, 2018).

Instruments

The measurement was performed by using the neuropsychological test battery NEPSY-II (Urgesi, Campanella, & Fabbro, 2006). NEPSY is a unique neuropsychological assessment battery as the tests are specifically designed to assess both the basic and the complex aspects of basic cognitive skills, to learn and be effective, both within the school environment and in everyday life. The tests are aimed at ascertaining the cognitive skills related to the disorders, generally diagnosed for the first time in childhood, and at assessing the skills required to succeed at school, thus allowing describing the child's cognitive profile and delineating strengths and weaknesses. While employing it, the authors (Korkman, Kirk, & Kemp, 2007) found a particular sensitivity of NEPSY-II in assessing multiple pathological patterns, such as ADHD, Learning Disorders (in reading and calculation), Language Disorders, Autism Spectrum Disorders, Asperger Syndrome, Brain Damage of Traumatic Origin, Deafness and Hypoacusia, Emotional Disorders, as well as Mean-Degree Intellectual Disability. In particular, for this study, the linguistic and mnemonic NEPSY-II tests, specific for the age group between three and six years, were selected, such as: Immediate Drawings Memory (M3), Narrative Memory Recall (M6-REC), Narrative Memory Recognition (M6-Recognition), Comprehension of Instructions (LI), Speeded Naming (L3), and Phonological Processing (L4).

Data Analysis

In the presence of two or more categorical variables, the logic of interactions is applied; more specifically, if the effect of one variable changes when the other changes too, then we will have an interaction, being the effects of categorical variables defined by the differences between the means of the dependent variable in the groups defined by the independent. We can affirm that the interaction defines how the differences between groups defined by a variable change for the different groups defined by the other one. In particular, the interaction between categorical variables is very relevant, and often constitutes the most interesting effect in the study of factorial drawings, i.e., those research drawings that cross two or more independent categorical variables. The majority of experimental studies are based on factorial drawings, in which every single case belongs to a group, and the group consists of the crossing of the categories defined by the independent variables (factors). The primary advantage of this type of study is the possibility to investigate both the main effects of the independent categorical variables and their interactions. An experiment with more than one factor is called factorial. In repeated measurements drawings (RMD) there are several categorical independent variable factors, which define the cells of the drawing, and the effects of the factors are estimated by assessing the differences between the cell means defined by the factor levels (main effects), and by the combination of the levels of several factors (interaction effects). From the statistical point of view, the fact that each analysis unit expresses multiple scores makes every score correlated with each other, which makes the remaining ones non-independent. We can imagine repetitive drawings as drawings in which a series of measurements are made for different levels of independent variables, but in which the observations are grouped in clusters, i.e., using a criterion that makes the measurements made within each single cluster more similar than the ones made within different clusters. In classic repetitive measurements, clusters are generally the objects of the research, which means that the correlation between measures within the single analysis unit, or clusters, is an advantage, as it allows to better estimate the error of the statistical model used (Gallucci & Leone, 2016).

The first two assumptions of the Two-Way Mixed ANOVA refer to the presence of a continuous dependent variable, from a "between-subjects" categorical factor composed of two or more levels. To better understand this logic underlying the analysis, we take into consideration the cells of the experimental drawing. First of all, let's consider a simple case of a One-Way ANOVA for repeated measurements, looking at the effect of the "Time" factor on "Memory", which we can diagrammatically represent in the following table:

Table 1

Example1

Time	
Pre	Post
M3	M3

We can consider the two levels of the "within-subjects" factor, the time (i.e., "pre", "post"), as two cells of a table that represents the study design. Therefore, let's say that there are two cells of the drawing (in this example the values in the cells can be replaced with the mean values obtained on the memory dependent variable). Subsequently, if we include a second "between-subjects" factor, the so-called "treatment", by including the conditions, we can modify the table as follows:

Table 2

Example 2

	Time	
Didactic type	Pre	Post
Classic	M3_C_PRE	M3_C_POST
Montessori	M3_M_PRE	M3_M_POST
Unstructured	M3_D_PRE	M3_D_POST

Outcomes

M3-Immediate Drawings Memory Outcomes

As for the model assumptions, there are no outliers and the data are distributed normally, as evidenced by Shapiro-Wilk's normality test ($p > 0.05$). Mauchly's sphericity test indicates that the assumption of sphericity is confirmed for the interaction with didactics * time, $\chi2$ (2) = 0.973, p = 0.757. The initial inspection of the line graph (Figure 1) and of the pairwise comparisons (Table 3) allows obtaining an initial impression of the interaction between the "between-subjects" factor and the "within-subjects" one, which seems to exist among the participants under investigation. To investigate the effect of the interaction in the population (Fox, 2008), we refer to the F-test. There was a statistically significant interaction between didactics and time on M3, F (2, 42) = 9.832, $p < 0.001$, partial $\eta^2 = 0.319$. This value indicates that, from the initial inspection, we correctly interpreted that there are different effects of the different groups (type of didactics) on "M3 memory" mean over time. In practice, this means that M3 mean changes differently over time depending on the type of didactics, i.e., if it is of classic, Montessori or unstructured type. Moreover, the M3 mean is lower for the Classic-type didactics group (-3.57 ± 0.68, $p = 0.001$) and for that of Montessori-type (-2.27 ± 0.55, p = 0.001) on a statistically significant level compared to unstructured-type didactics (the data are mean ± standard error if not indicated differently).

M6-Narrative Memory Recall Outcomes

As for the model assumptions, there are no outliers and the data are distributed normally, as evidenced by Shapiro-Wilk's normality test ($p > 0.05$). Mauchly's sphericity test indicates that the assumption of sphericity is confirmed for the didactics * time interaction, χ^2 (2) = 0.957, p = 0.632. The initial inspection of the line graph (Figure 2) and of the pairwise comparisons (Table 4) allows obtaining an initial impression of the interaction between the "between-subjects" factor and the "within-subjects" one, which seems to exist among the participants under investigation. To investigate the effect of the interaction on the subjects (Fox, 2008), we refer to the F-test. There was a statistically significant interaction between didactics and time on M6-Recall, $F(2, 42) = 18.374$, $p < 0.001$, partial $\eta 2 = 0.467$. This value indicates that, from the initial inspection, we correctly interpreted that there are different effects of the different groups (type of didactics) on the "M6-Recall memory" mean over time. In practice, this means that M6-Recall mean changes differently over time depending on the type of didactics, i.e., if it is of classic, Montessori or unstructured type. Moreover, M6-Recall mean is lower for the Classic-type didactics group (-4.45 ± 0.48, $p = 0.001$) and for that of Montessori type (-3.75 ± 0.48, $p = 0.001$) on a statistically significant level compared to the unstructured-type didactics (the data are mean ± standard error if not indicated differently).

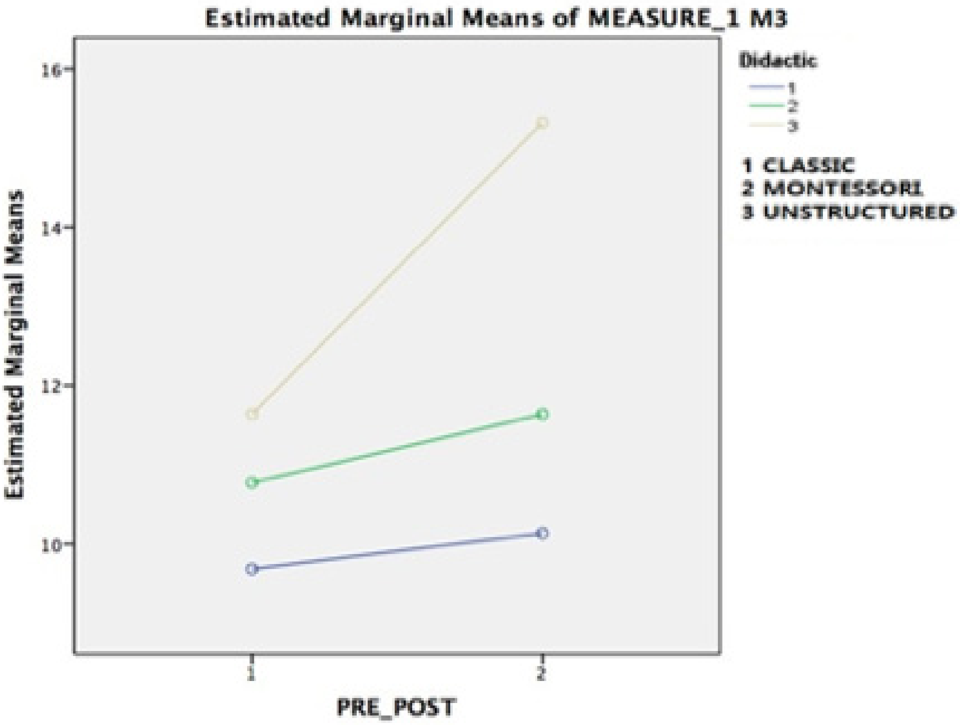

Figure 1. M3-Immediate Drawings Memory Outcomes.

Table 3
Pairwise Comparisons

Measure: Measure_1						
(I) Type_Didactic	(J) Type Didactic	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-1.295	0.657	0.186	-3.004	0.413
	3	-3.568*	0.680	0.000	-5.337	-1.799
2	1	1.295	0.657	0.186	-0.413	3.004
	3	-2.273*	0.552	0.001	-3.709	-0.836
3	1	3.568*	0.680	0.000	1.799	5.337
	2	2.273*	0.552	0.001	0.836	3.709

Notes. Based on estimated marginal means, *. The mean difference is significant at the 0.05 level; b. Adjustment for multiple comparisons: Bonferroni.

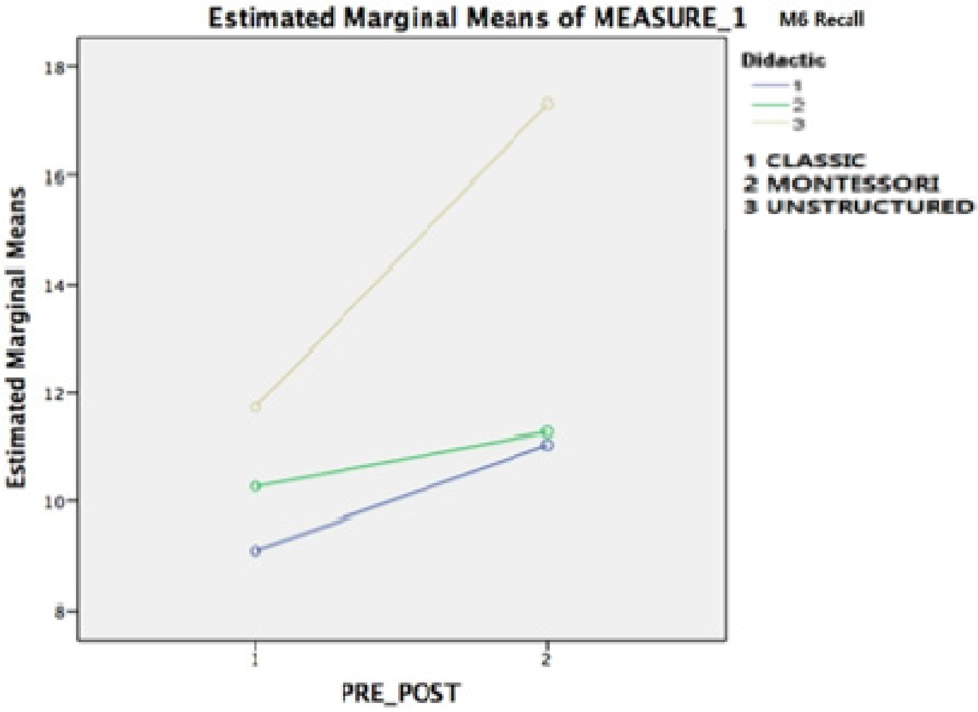

Figure 2. M6-Narrative Memory Recall Outcomes.

Table 4

Pairwise Comparisons

Measure: Measure_1						
(I) Type_Didactic	(J) Type_Didactic	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-0.705	0.576	0.705	-2.203	0.794
	3	-4.455*	0.482	0.000	-5.709	-3.200
2	1	0.705	0.576	0.705	-0.794	2.203
	3	-3.750*	0.480	0.000	-4.998	-2.502
3	1	4.455*	0.482	0.000	3.200	5.709
	2	3.750*	0.480	0.000	2.502	4.998

Notes. Based on estimated marginal means, *. The mean difference is significant at the 0.05 level; b. Adjustment for multiple comparisons: Bonferroni.

M6-Narrative Memory Recognition Outcomes

As for the model assumptions, there are no outliers and the data are distributed normally, as evidenced by Shapiro-Wilk's normality test ($p > 0.05$). Mauchly's sphericity test indicates that the assumption of sphericity is confirmed for the didactics * time interaction, χ^2 (2) = 0.950, $p = 0.876$. The initial inspection of the line graph (Figure 3) and of the pairwise comparisons (Table 5) allows obtaining an initial impression of the interaction between the "between-subjects" factor and the "within-subjects" one, which seems to exist among the participants under investigation. To investigate the effect of the interaction on the subjects (Fox, 2008), we refer to the F-test. There was a statistically significant interaction between didactics and time on M6-Recognition, $F(2, 42) = 5.293$, $p < 0.009$, partial $\eta 2 = 0.201$. This value indicates that, from the initial inspection, we correctly interpreted that there are different effects of the different groups (type of didactics) on the "M6-Recognition memory” mean over time. In practice, this means that the M6-Recognition mean changes differently over time depending on the type of didactics, i.e., if it is of classic, Montessori or unstructured type. Moreover, M6-Recognition mean is lower for the Classic-type didactics group (-4.59 ± 0.63, $p = 0.001$) and that of Montessori type (-3.14 ± 0.56, $p = 0.001$) on a statistically significant level compared to the unstructured-type didactics (the data are mean ± standard error if not indicated differently).

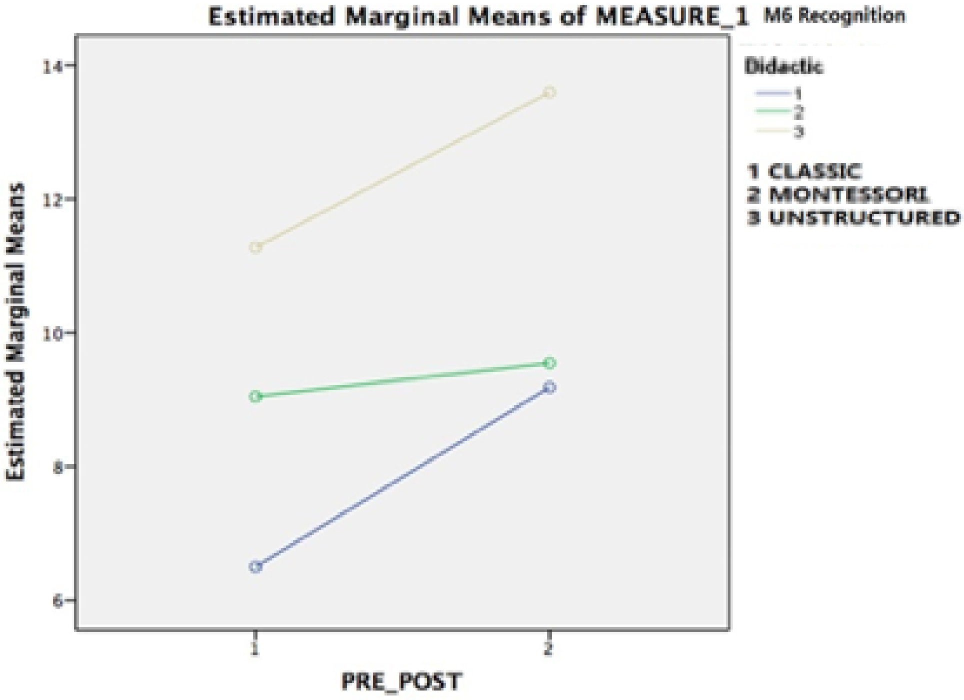

Figure 3. M6-Narrative Memory Recognition Outcomes.

Table 5
Pairwise Comparisons

Measure: Measure_1						
(I) Type_Didactic	(J) Type_Didactic	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-1.455	0.762	0.210	-3.438	0.528
	3	-4.591*	0.626	0.000	-6.218	-2.963
2	1	1.455	0.762	0.210	-0.528	3.438
	3	-3.136*	0.557	0.000	-4.584	-1.689
3	1	4.591*	0.626	0.000	2.963	6.218
	2	3.136*	0.557	0.000	1.689	4.584

Notes. Based on estimated marginal means, *. The mean difference is significant at the 0.05 level; b. Adjustment for multiple comparisons: Bonferroni.

L1-Comprehension of Instructions Outcomes

As for the model assumptions, there are no outliers and the data are distributed normally, as evidenced by Shapiro-Wilk’s normality test ($p > 0.05$). Mauchly’s sphericity test indicates that the assumption of sphericity is confirmed for the didactics * time interaction, χ^2 (2) = 0.788, $p = 0.044$. The initial inspection of the line graph

(Figure 4) and of the descriptive statistics (Table 6) allows obtaining an initial impression of the interaction between the "between-subjects" factor and the "within-subjects" one, which seems to exist among the participants under investigation. To investigate the effect of interaction on the subjects (Fox, 2008), we refer to the F-test. There was a statistically significant interaction between didactics and time on L1, $F(2, 42) = 25.765$, $p < 0.001$, partial $\eta^2 = 0.551$. This value indicates that, from the initial inspection, we correctly interpreted that there are different effects of different groups (type of didactics) on the "L1 language" mean over time. In practice, this means that L1 mean changes differently over time depending on the type of didactics, i.e., if it is of classic, Montessori or unstructured type. Moreover, L1 mean is lower for the Classic-type didactics group (-3.87 ± 0.84, p = 0.001) and that of Montessori type (-3.02 ± 0.67, p = 0.001) on a statistically significant level compared to the unstructured-type didactics (the data are mean ± standard error if not indicated differently).

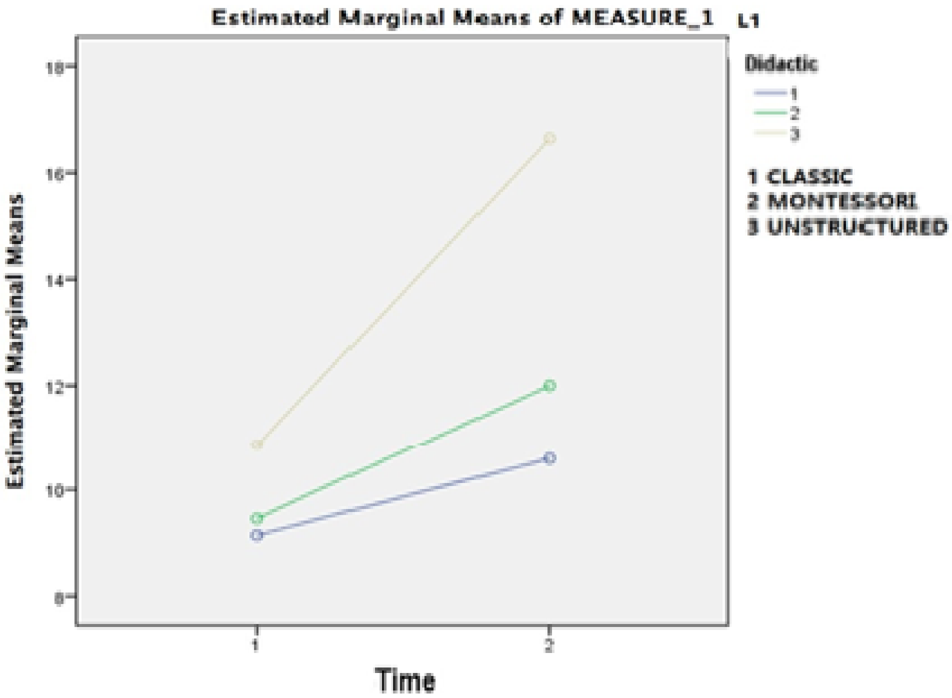

Figure 4. L1-Comprehension of Instructions Outcomes.

Table 6
Pairwise Comparisons

Measure: Measure_1						
(I) Didactic	(J) Didactic	Mean Difference (I-J)	Std. Error	Sign.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-0.864	1.083	1.000	-3.680	1.953
	3	-3.886*	0.841	0.000	-6.073	-1.700
2	1	0.864	1.083	1.000	-1.953	3.680
	3	-3.023*	0.671	0.001	-4.769	-1.276
3	1	3.886*	0.841	0.000	1.700	6.073
	2	3.023*	0.671	0.001	1.276	4.769

Notes. Based on estimated marginal means, *. The difference is significant at the 0.05 level; b. Adjustment for multiple comparisons: Bonferroni.

L3-Speeded Naming Outcomes

As for the model assumptions, there are no outliers and the data are distributed normally, as evidenced by Shapiro-Wilk's normality test ($p > 0.05$). Mauchly's sphericity test indicates that the assumption of sphericity is not confirmed for the interaction between didactics * time, χ^2 (2) = 0.05, p = 0.795. The initial inspection of the line graph (Figure 5) allows obtaining an initial impression of the interaction between the "between-subjects" factor and the "within-subjects" one, which does not seem to exist among the participants under investigation. In fact, the three lines seem to be quite parallel to each other. To investigate the effect of interaction on the subjects (Fox, 2008), we refer to the F-test. Actually, there is no statistically significant interaction between didactics and time on L3, F (2, 42) = 0.761, p = 0.473, partial η^2 = 0.03. This value indicates that the initial inspection correctly interpreted the absence of different effects of the different groups (type of didactics) on the "Language L3" mean over time. In practice, this means that L3 mean does not change differently over time depending on the type of didactics, i.e., if it is of classic, Montessori or unstructured type.

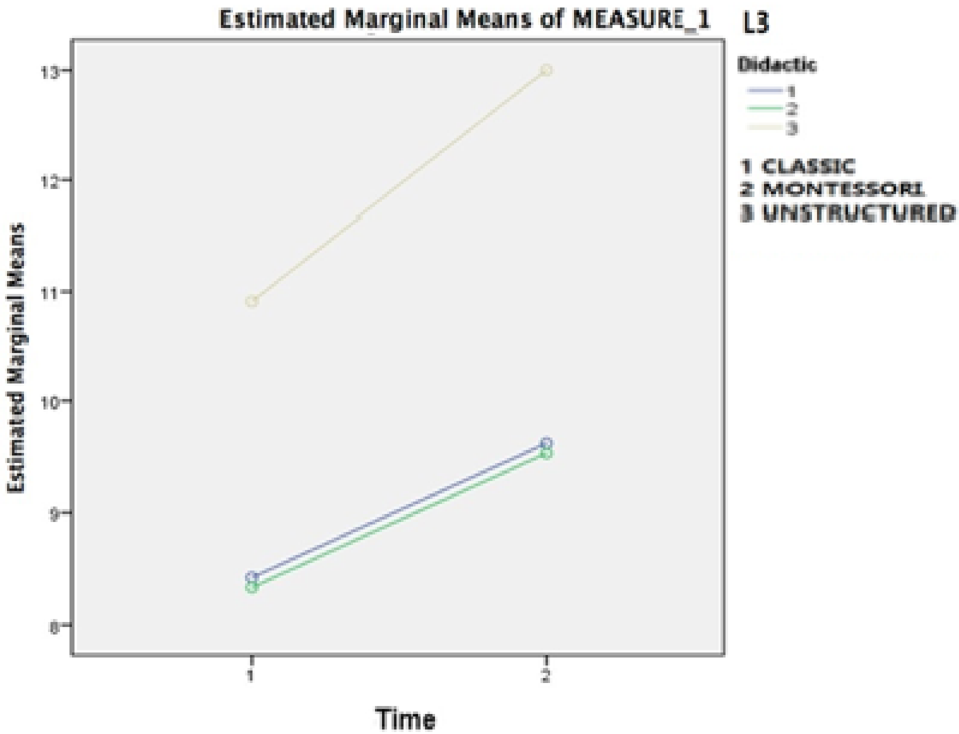

Figure 5. L3-Speeded Naming Outcomes.

L4-Phonological Processing Outcomes

As for the model assumptions, there are no outliers and the data are distributed normally, as evidenced by Shapiro-Wilk's normality test ($p > 0.05$). Mauchly's sphericity test indicates that the assumption of sphericity is not confirmed for the interaction between didactics * time, χ^2 (2) = 0.3, p = 0.898. The initial inspection of the line graph (Figure 6) allows obtaining an initial impression of the interaction between the "between-subjects" factor and the "within-subjects" one, which does not seem to exist among the participants under investigation. In fact the three lines seem to be quite parallel to each other. To investigate the effect of the interaction on the subjects (Fox, 2008), we refer to the F-test. Actually, there is no statistically significant interaction between didactics and time on L4, F (2, 42) = 2.295, p = 0.113, partial η^2 = 0.1. This value indicates that the initial inspection correctly interpreted the absence of different effects of the different groups (type of didactics) on the "Language L4" mean over time. In practice, this means that L4 means does not change differently over time depending on the type of didactics, i.e., if it is of classic, Montessori or unstructured type.

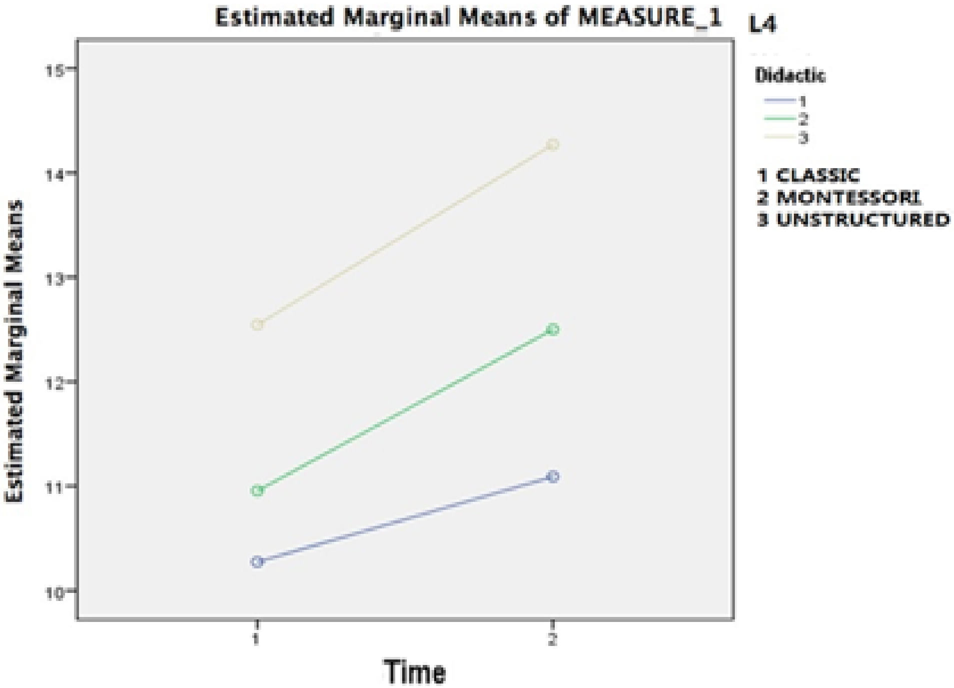

Figure 6. L4-Phonological Processing Outcomes.

Discussion

Overall, such evidence shows a real impact of the unstructured didactics on the upgrading of mnemonic skills (M3, M6-Recall, M6-Recognition), the declarative and working memory aspects considered, to support the initially defined hypothesis according to which unstructured education plans can favor the strengthening of the memory process since pre-school age. The statistically significant increase of the working memory aspects related to an improvement in Comprehension of Instructions Language Skills (L1) take us to scientific literature references; these shall agree on the evidence that working memory connects thoughts developed at a certain time with the actions carried out an instant later, retaining the instructions related to what should be done shortly and then its implication in language skills (Baddeley, 2012; Kane & Engle, 2002). However, it seems to necessary to consider a temporally longer training for an extensive Speeded Naming (L3) and Phonological Processing (L4) development, since, in both variables, the increases in the unstructured experimental group appear to be parallel to the related differences in control groups, thus not showing an actual gain resulting from the training period. In fact, these linguistic functions require productive and comprehensive skills not yet extensively developed for the evolutionary age taken into consideration.

Conclusions

From these evidences, therefore, the hope is to consider the opportunity to draft further more in-depth analyses which can turn the unstructured didactic approach into a modus operandi in the educational training process, favoring the alternation between formal and informal models, as well as a prospective-type clinical approach to be applied (given the neuroscientific evidence) also to subjects showing atypical development. Acting on the cognitive processes of subjects under development is advantageous if based on the improvement of the child's educational qualities, since its development takes place in the continuous interaction between its predisposition to receive and process information and the environment that provides the possibility of growth. In fact, we do not speak of acquiring knowledge by means of a transfer-reception mode, but through an appropriation-discovery mode that leads to greater mastery of subjective skills. In fact, everything is aimed not only at making children prepared for the later stages of their educational process, but also and above all at improving meta-needs such as self-esteem and self-awareness, as well as constructs like social cognition. Given the outcomes of this study, we can suppose that the same improvements are available in the areas of attention and in the recognition of emotions, which would highlight even more the need to favor a deformalization of didactics by acquiring the unstructured approach, in order to make the learning process individualized and, above all, multilateral towards the student who could benefit substantially from it.

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