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DECLARATION

Although it has been concerted and reviewed by all the authors, the following paper:

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has been written as specified below:

- Antonio Calvani: 3.1.Procedure;
- Paola Damiani: 1.1.Neuroscience and education; 1.2.How to teach reading;
- Sergio Miranda: 3.3.The sample; 4.1.Pupils at risk for reading and writing difficulties; 4.2. The teachers' evaluation;
- Lorena Montesano: 3.4. Measures; 4. Results;
- Luciana Ventriglia: 3.2.The Alfabeto 140 programme;
- all the authors participated jointly to conceive and write 2.Objectives and 5.Conclusions.

On trust,

Antonio Calvani

Paola Damiani

Sergio Miranda

Lorena Montesano

Luciana Ventriglia

TEACHING TO READ: AN INTERESTING INTERFACE BETWEEN NEUROSCIENCE AND EDUCATION

NEUROSCIENZE E ISTRUZIONE: UN CROCEVIA INTERESSANTE, LA QUESTIONE DELLA LETTURA

Antonio Calvani[A], Paola Damiani[B], Sergio Miranda[C], Lorena Montesano[D*] and Luciana Ventriglia[E]

A) Scientific Association SApIE, Turin, Italy, antonio@calvani.it

B) University of Modena and Reggio Emilia, Modena, Italy, paola.damiani@unimore.it

C) University of Salerno, Salerno, Italy, scmiranda@unisa.it

D) University of Calabria, Arcavacata di Rende, Italy, lorena.montesano@unical.it

E) Associazione Italiana Dislessia, Bologna, Italy, lucianaventriglia@hotmail.com

*corresponding author

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ABSTRACT The work presents the results of a large experimentation carried out in Italy, which aimed to verify the advantages and sustainability of a rigorous phono-syllabic programme (Alfabeto140) compared to programmes that include marked traits of global and ideo-visual methods. The evaluation made use of tools in line with the different evolutionary phases of the reading and writing process, assessing at the pre-test the skills related to the prerequisites of reading and writing, and at the post-test those related to the acquisition of the alphabetical phase. The experimentation shows how the experimental group achieves significantly better results over 7 months of activity than the control group, with a more consistent systematic reduction of the subjects initially at risk for reading and writing difficulties, and an excellent appreciation by the teachers who have tried the programme.

KEYWORDS Neuroscience; Education; Reading Education; Alphabetical and Phono-Syllabic Methods.

SOMMARIO Il lavoro presenta i risultati di una vasta sperimentazione attuata in Italia, che ha inteso verificare i vantaggi e la sostenibilità di un rigoroso programma fono-sillabico ($Alfabeto_{140}$), rispetto a programmi che conservano al loro interno tratti marcati di metodi globali e ideovisivi. La valutazione si è avvalsa di strumenti in linea con le differenti fasi evolutive del processo di lettura e scrittura, misurando in ingresso abilità relative ai prerequisiti della lettura e scrittura e in uscita quelle connesse all'acquisizione della fase alfabetica.
La sperimentazione dimostra come il gruppo sperimentale consegua, nell'arco di 7 mesi di attività, risultati nettamente migliori rispetto al gruppo di controllo con una riduzione sistematicamente più rilevante dei soggetti inizialmente a rischio di difficoltà di lettura e scrittura e un ottimo apprezzamento da parte degli insegnanti che hanno sperimentato il programma.

PAROLE CHIAVE Neuroscienze; Istruzione; Lettura; Metodo Fono-Sillabico e Alfabetico.

1. INTRODUCTION

1.1. Neuroscience and education

Recent decades have seen a significant acceleration of educational research in particular, with the influence exerted by evidence-based education (Hargreaves, 1996; Davies, 1999; Coe, 1999; Hattie, 2009; Education Endowment Foundation, 2021), which aims to take stock of "what works under what circumstances" and to provide research summaries (best evidence synthesis, systematic reviews, meta-analysis). The most interesting aspect is that this development has favoured an integration with other fields of research, such as experienced teacher observation (Rosenshine, 2010), instructional design (Gagné & Briggs, 1974; Merrill, 2002), and cognitive sciences: it is from the triangulation between these different orientations that it is possible to derive basic principles of learning and teaching, from which highly reliable didactic indications can be deduced.
From the field of cognitive sciences, if the main insight towards education has so far come from cognitive psychology based on experimental observational and empirical methods, cognitive neuroscience is also playing an increasing role today, supported by neuroimaging techniques (Education Endowment Foundation, 2021).
Regarding neuroscience and education, a general issue deals with how evidence can be translated by teachers into practice (Goswami, 2006; Geake, 2009; Sabitzer, 2010; Churches et al., 2020; Gola, Angioletti, Cassioli, & Balconi, 2022), avoiding at the same time the risk of reductionism or neuromythology (Geake, 2008; Howard-Jones, 2014; Kim & Sankey, 2017).
Specific contributions have concerned issues such as attention difficulties (Posner, 2004; Amso & Sherif, 2015), of calculation (Dehaene, 1997; Izard, Dehaene-Lambertz, & Dehaene, 2008) the influence of emotions on thinking and learning (Panksepp, 1998; Immordino-Yang & Damasio, 2007; Immordino-Yang, 2015) or special educational needs, through the contributions of Embodied Cognition (Abrahmson, Flood, Miele, & Siu, 2019; Tancredi, Chen, Krause, Abrahmson, & Gomez Paloma, 2021).
In the specific field of reading processes, nowadays the works of Stanislas Dehaene stand out, a convinced supporter of the advent of "*neuro-psycho-pedagogy, a unified and cumulative science in which the freedom of the teacher is not denied but aimed at the pragmatic choice of a better structured and more effective teaching*" (Dehaene, 2009, p. 381).

1.2. How to teach reading

As is commonly known, according to the classification introduced by the UNESCO Conference of 1951, the methods for reading have been divided into:

- synthetic, which the alphabetical method belongs to, with the phonic versions (centred exclusively on the single sound) or phono syllabic (starting from the individual sounds to get to the syllables);
- analytical, also called ideo-visual or global, which takes as a starting point the word, the phrase or the story;
- analytical-synthetic, which in varying degrees starts from the whole word, and then moves on to the analysis of the letters and vice versa.

The two basic methodologies (synthetic and analytical) are rooted in starkly contrasting assumptions. The synthetic or alphabetical methods argue that oral language and reading follow different evolutionary paths: while oral language is a natural skill, a writing system is an artefact, a secondary code whose acquisition can only be achieved through a consciously finalised cognitive process. On the contrary, the global methods start from the premise that learning to speak and learning to read and write are two situations of the same type, laced in the continuum of a natural linguistic development.

Over the years this old dispute has been dissolving; it has been recognised that it has historically been conditioned by ideological preconceptions of activism, which saw the global method as more congenial to its vision of the naturalness of learning. The groundlessness of the global method has already been demonstrated in the 90s by I.Y. Liberman and A. M. Liberman (1990). Numerous researches, generally in English-speaking settings, have recognised that phonological awareness is the most important competence that interacts with the learning of reading, although some differences depend on the orthographic system of reference (Kamirloff-Smith, 1986; Morais, 1989; Goswami, Gombert, & Barrera, 1998; Carretti & Zamperlin, 2010).

Although most of the evidence on the processes of reading has been collected in the realm of educational psychology or cognitive science, from the front of neuroscience some specific insights have been added. Dehaene (2009) presented a powerful synthesis of these advances showing how the mechanisms of reading have been largely mapped through neuroimaging technologies. From these data we find that all children in the world possess the same brain circuits and all benefit from a rigorous learning of phoneme grapheme correspondences, with languages such as Finnish or German, Italian offering some advantages given their greater transparency, that is, a minimal discrepancy between the written code of words and their oral pronunciation. Neuroimaging shows also that the global method activates processes different from those of expert readers and allows us to glimpse interesting possibilities for dyslexia: the dyslexic brain is mainly characterised by a decrease in activity in the left posterior temporal region; however, intensive re-education of dyslexia produces progress with the return of activity in this region and other compensatory pathways; educational pathways for dyslexics do not require different methods, but only more time and patience; in this way most of them can become acceptable readers (Dehaene, 2009).

Dehaene's work also provides some important instructional directions: the teaching of reading must be based on decoding and development of phonemic consciousness, it must start before primary school, and must be arranged in progression from simple to complex, with repetitions interspersed with periods of rest.

2. OBJECTIVES

In addition to the evidence mentioned above, in recent years other empirical research has been conducted in Italy, converging in the rejection of global and ideo-visual approaches. An interesting contribution came from the Institute for Educational Technologies of the CNR of Genoa (Midoro, Massari, & Strisciuglio, 2017), which demonstrates how children can learn to read already from the age of three, without forcing, with an alphabetical approach conducted in a playful way. The assumption is that if children have these potentialities, it is illogical not to make use of them also taking into account that anticipating reading is of particular importance in order to prevent difficulties related to dyslexia. In another research, Padovani et al. (2018), the effectiveness of a syllabic approach was verified with first-grade pupils; 93 children of the experimental group (EG) employing the syllabic method were compared with 84 of the control group (CG) using common methods; the EG shows significantly better performance in all the parameters of speed and correctness, and also for writing, although here the differences appear less systematic. To this we must add the promising results related to practices of phonological laboratories integrated into the class activities during the year (Franceschi, Savelli, & Stella, 2011).

But what happens to the practices that are widespread in schools? The institutional documents currently in force in Italy are concerned with ensuring that the adoption of textbooks is consistent with the three-year syllabus and that the choices are an expression of the "*freedom of teaching and the professional autonomy of teachers*" (Nota Ministeriale n. 3503 of 30th March 2016). The only constraint concerns the needs of students who manifest critical issues in the field of dyslexia, for which the global method is not advised (MIUR, 2011). Thus, publishing houses have full freedom to present "creative" approaches, lacking any scientific reference. This has an astonishing consequence; in the reviews carried out on the school textbooks adopted in Italian schools, there is no text that proposes a rigorous phonological programme, despite the advantages it could bring in a language as transparent as Italian. An analysis of those textbooks (Calvani & Ventriglia, 2017) has highlighted, as their predominant traits:

- complete or near-complete neglect of phonological awareness;
- predominance of global and visual techniques: children are presented with a sentence, in which closed words are integrated with images and invited to "use images to understand";
- reading environments overloaded with distracting stimulations.

Even where the textbook is presented as phono-syllabic the criteria of systematicity and progressive gradualness that a phonological approach would require are not respected.

With this work we then intended to add evidence of greater impact in support of the preferability and the sustainability of a rigorous phono-syllabic approach in line with the scientific indications mentioned above.

We aim to assess the effects of a similar approach applied on a large sample in a context of ecological validity. The benefits are evaluated according to two fundamental dimensions: better reading levels achieved by all children; a clear reduction in the number of subjects who were at risk for reading and writing difficulties at the beginning of school.

In this paper, we have investigated the following research questions:

- whether a rigorous phono-syllabic approach facilitates the learning of reading and writing in the children of the first year of primary school compared to methods that employed a marked presence of global and visual techniques;
- whether the use of a rigorous phono-syllabic approach has significant advantages in those children identified at the beginning of primary school at "risk for reading and writing difficulties".

Besides this it will be important to consider the evaluations of the teachers who participated in the experimental programme on the difficulties encountered and the climate with which it was possible to carry it out. In fact, one

of the most frequent criticisms that supporters of global or ideo-visual methods advance to alphabetical and phono-syllabic methods, concerns the fact that the latter would necessarily be abstruse, boring and demotivating.

3. METHODS AND SAMPLE

3.1. Procedure

To verify the effectiveness and sustainability of a rigorous phono-syllabic approach we set up a teaching programme (Alfabeto$_{140}$) during the 2019-20 school year. The preparation made use of materials of work and experiences conducted for many years in Italy by Luciana Ventriglia (2016), in line with the previously reported evidence.

Approximately 140 hours were estimated for the entire intervention with children enrolled in primary 1 with a time structure that approximately follows the average cycles dedicated to the teaching of reading-writing during the first year (5-6 hours of weekly activity), starting from the end of September to the end of April.

The design was quasi-experimental, with an experimental and a control sample not chosen randomly, but organised by clusters (school classes).

Seven universities (Aquila, Basilicata, Calabria, Roma Tre, Salerno, Turin and Udine), collaborated on the project. Each university indicated a school that was invited to participate. The schools that accepted were invited to select at least one experimental and one control class, eliminating classes that could be too dissimilar. For the choice of the control group (CG), the chosen teaching method was evaluated through the textbook used: it was verified that in no case the programme could be recognised as a coherent phono-syllabic method and that a marked presence of global and visual techniques was used.

The experiment was approved by the School Ethics Committee and carried out according to the Declaration of Helsinki guidelines. Schools and teachers participated with parental consent. A particular emphasis was put on the fact that all the data collected would be kept confidential. It is wort noting that none of the teachers refused to take part in the study, nor dropped out of it.

3.2. The Alfabeto140 programme

The independent variable of experimentation is therefore represented by a strictly phono-syllabic programme (Alfabeto$_{140}$) with the following features. It is:

- *phonological*: phonic, meta-phonological dimensions and grapheme-phoneme correspondence represent the focus of the programme;
- *syllabic*: once the vowels have been acquired, the consonants are presented in association with the various vowels. The open syllable (CV)[1] is recognised as the basic reference, for example, BA, BE, BI, BO, BU, before the focus on the specific phoneme "b";
- *generative*: reading activities are expanded as much as possible to the given level of phonological difficulty. Thus, having acquired the ability to read CV, reading is extended to all types of compound forms (CVCVCV...);

1 "C" stands for consonant and "V" for vowel.

- *progressive*: the fundamental principle provides that the child is never presented with parts of words, words or phrases to read before they have already learned to decode them analytically; they are never pushed to guess by chance; it follows a precise order of phonological difficulty, in accordance with the complexity of the phonotactic structure of sounds in Italy; the open syllables that are presented first have continuous consonants that are more easily identifiable, such as the nasal (m, n) and the liquid (l, r); then we move on to open syllables with consonant groups, to closed syllables also with consonant groups, and to orthographic groups that represent the greatest exception to the transparency that characterises the Italian language;
- *explicit*: the children are immediately shown what they must be able to do at the end of the unit, what types of syllables or words they will be required to recognise or read.

In more detail, the 140 hours of the programme have been divided into 6 work units, each of which is divided into work sessions with an average duration of about two hours.

Each teacher was provided with a guide in which all the activities by unit and session are described analytically; similarly, the children work through their workbook of the reading activities corresponding to the different levels of phonological complexity achieved. The experimental classes were also backed by additional work material that can be downloaded from the supporting website (voice charts, consonants, syllables for the construction of the wall syllabary) [2] (Calvani, Ventriglia, Damiani, & Zanaboni, 2022).

The session typically takes place through three main phases:

1) modelling and collective exercises. These are frontal interactions of the teacher with the whole class; the teacher visually or orally presents a model and asks children to repeat or answer questions by raising or not raising their hands, lifting or not lifting images or labels; so, for example, at the first level the teacher pronounces the phoneme "a" and the children, who have different written vowels in front of them, have to lift the right card; conversely, if the teacher raises the "a" card, the children must pronounce this vowel;
2) exercises in pairs. The same exercises are performed again between classmates, alternating between those who ask the question and those who answer;
3) enrichment. These are gestural or motor activities to consolidate the graphic representation of the letters (in line also with the Montessori perspective) (Montessori,1999). Thus, for example, the teacher invites children to reproduce a grapheme in the air with their index finger, on the ground with their foot, or with body movements. To lighten the cognitive load, also in accordance with the Guidelines for the right to study of pupils and students with SLD – Specific Learning Disorder (MIUR, 2011) the programme uses capital letters during the initial months, with a presentation of the various allographs but without dwelling on them with practice.

A metaphor guides the entire journey; the story of a wizard who teaches writing to people, showing how *"every sound has its own dress*". Next to him there is the fairy Smemorina whose role is to mitigate the anxiety of making errors; she constantly makes mistakes and urges the children to help her.

The activities have a playful character and the class is transformed into a phonological laboratory, where the teacher solicits challenges in pronouncing and writing sounds and words, even non-existent ones, but always following the order of phonological progression. In the class, every mistake is accepted with fun, and the teacher himself gets involved playing the role of the fairy Smemorina, inviting the students to correct her mistakes.

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2 A demonstration of the materials used can be found at https://lettura.sapie.it/risorse/

3.3. The sample

Twenty-three schools located in seven different regions participated, with 30 classes of the first year of primary school, for a total of 467 children for the experimental group (EG), (M_{age} = 5.95 years, SD = 0.24; M 49%; F 51%) and 21 classes of the first year of primary school for a total of 325 children for the CG (M_{age} = 5.97 years, SD = 0.23; M 52%, F 48%).

Pupils with intellectual disabilities, non-Italian-speakers, or pupils who already knew how to read were excluded from the sample.

Teachers were initially asked to note pupils who, without intellectual, physical or sensory disabilities, on the basis of the observations made in the first two weeks of school, presented some perceptive or linguistic (phonological) difficulties (reported pupils).

The composition of the sample and related details are in Table 1.

	Number of classes	Total number of pupils	Male	Female	Average age	Standard deviation (sd)	Certified or foreign students	Pupils who can already read	Reported pupils
Experimental Group (EG)	30	467	49%	51%	5.95	0.24	34	10	62
Control Group (CG)	21	325	52%	48%	5.97	0.23	6	1	27

Table 1. Composition of Experimental Group and Control Group.

There are no significant statistical differences in these two groups for gender and age ("T-Student" value t=-1.31, p=0.07 on male; t=1.29, p=0.08 on female; t=-1.17, p=0.07 on average age). The experimental classes were provided with the work tools, the guide for the teacher, the child's book, the in-depth materials and the videos of the $Alphabet_{140}$ programme. The teachers of the experimental classes also participated in initial presentation meetings, which were accompanied by four periodic meetings during the experimentation to discuss any critical issues and suggestions related to children with particular problems.

3.4. Measures

In choosing the tools for the pre and post-test evaluation we took into account the acquisition of the different phases of the reading process. Thus, we applied different tests according to the children's level of ability (Frith, 1985). Based on this, at the pre-test, we evaluated those skills, also known as prerequisites, which play an important role in learning the reading and writing abilities, such as phonological awareness and visual analysis. At the post-test evaluation, tools were administered to assess skills that should be acquired at the end of primary school, such as learning both grapheme-phoneme and phoneme-grapheme correspondences, which implies the acquisition of the alphabetic phase of the evolutionary model of reading of Uta Frith.

At the beginning of October and in the first fortnight of May, respectively, the pre- and the post-tests were applied. Two tests were used for the pre-test evaluation:

- *visual recognition of letters* (VR) (Battery PRCR-2), (Cornoldi, Miato, Molin, & Poli, 2009). This test examines the ability of Visual Analysis in children who are about to start or just started

learning graphemes and spatial orientation. Children are asked to identify the letter corresponding to a target stimulus, choosing among four possible alternatives. Some letters are rotated, making recognition more difficult. The tool consists of 12 items and the score is calculated based on the number of correct answers: 1 point is assigned for each correct answer, and 0 points for each wrong answer, omission or multiple choice. The test was standardised on a sample of 456 pupils attending pre-school (age range 58-77 months) and the first year of primary school;

- *phonological awareness* (PAIN) (Miranda & Montesano, 2021), performed on the computer, in which the child is asked to indicate, among three possible alternatives, the image that begins or ends with a certain vowel. The test consists of 20 questions. To calculate the score, one point is awarded for each correct answer. The tool has a good reliability coefficient (Cronbach's $\alpha = .85$).

Three tests were used for the post-test evaluation:

- *recognition of non-words* (LD) (Lexical Decision of Caldarola, Perini, & Cornoldi, 2012). The pupil is asked to recognise non-words within a list of words and non-words. This test provides a quick measure of the instrumental reading (decoding) ability. The test has a high correlation (.72) with a classical measure of speed of reading obtained by individual evaluation. The estimated time for the test is two minutes. The test was administered collectively to the whole class and the score was calculated by subtracting the errors (i.e. recognition of words) from the total number of non-words identified. The original test of 120 stimuli has been adapted and reduced to 30 stimuli (13 words and 17 non-words);
- *dictation of words* (DW) of increasing phonological complexity (Stella & Apolito, 2004). The test consists of 16 bisyllabic and trisyllabic words with increasing phonological complexity, aimed at investigating the development of the alphabetical phase. The test has good predictive abilities in identifying individuals at risk, in particular, for writing (Stella & Apolito, 2004; Franceschi, Savelli, & Stella, 2011). For the purposes of this research, four more words indicating the transition from the alphabetic to the orthographic stage (Frith, 1985) have been added to the existing 16 words. The test was administered collectively in class and the score was calculated awarding 1 point for each correct word and 0 points for each incorrect word. We considered incorrect both the words with errors within the graphemic structure (omissions, substitutions) and the words omitted or transcribed only in part.
- *phonological awareness* (PAOUT), a more complex variant of the PAIN test. The test consists of 12 questions. One point is awarded for each correct answer.

At the end of the programme, an exit questionnaire was administered to the teachers in the experimental group to collect the teachers' evaluation of the programme and methodology (Calvani, Damiani, Montesano, Miranda, & Ventriglia, 2021).

4. RESULTS

Before evaluating the possible effectiveness of the educational programme, it was necessary to verify that the two groups of children were balanced for the prerequisites that have a fundamental role in learning the skills of reading and writing, namely visual recognition of letters and phonological awareness. Although in both tests the scores of the CG were higher than those of EG, there were no statistically significant differences (PAIN $t = -1.75$ $p = .080$;

VR t = -.30; p=.761). The standardised average differences are less than 0.25 DS, as required by What Works Clearinghouse (2020), so the two groups can be considered statistically balanced (see Table 2).

	Number of pupils		EG	CG	t	p	Standardised average differences
	EG	CG	M (DS)	M (DS)			
Phonological awareness (PAIN)	394	244	11.24 (5.30)	11.97 (5.02)	-1.75	.080	0.14
Visual Recognition of letters (VR)	407	287	9.98 (2.95)	10.05 (2.82)	-.30	.761	0.02

Table 2. Results obtained by the Experimental Group and Control Group at the pre-test.

To evaluate the outcome at the end of the school year, the scores obtained by the EG and the CG in the exit tests were compared through the student's t- test (see Table 3).

	Number of pupils		EG	CG	t	p	Cohen's d
	EG	CG	M (DS)	M (DS)			
Phonological awareness (PAOUT)	446	255	10.52 (2.11)	10.13 (2.25)	2.25	.025	0.18
Recognition of non-words (LD)	432	286	13.12 (5.53)	12.40 (5.19)	1.77	.077	0.13
Dictation of words (DW)	432	286	17.22 (4.16)	15.17 (5.57)	5.29	.000	0.43

Table 3. Results obtained by the Experimental Group and Control Group at the post-test.

As shown in Table 3, EG performs significantly better than CG in the phonological awareness test (10.52 vs 10.13, $p = .025$; ES $d = 0.18$). Also, with regard to the recognition of non-words, a better performance is observed in the EG, even if not reaching statistical significance (Tot. correct score 13.12 vs 12.40, $p = .077$ ES $d = 0.13$). Significantly more consistent differences emerge between the two groups in the word dictation test (17.22 vs 15.17, $p = .000$; ES $d = 0.43$). To assess the effect size (ES), we employed *Cohen's d index*. As you can see in Table 3, ES in the phonological awareness test is 0.18, in the recognition of non-words it is 0.13, and in the word dictation test it is 0.43.

Applying the parameters provided by the Education Endowment Foundation (Higgins et al., 2016, p.5) the first two values translated into time should correspond to 2 months of advantage, while the third value should correspond to 5 months.

4.1. Pupils at risk for reading and writing difficulties

It is particularly interesting to consider how the experimental programme has acted towards the pupils identified as at risk for reading and writing difficulties.

To identify these students at the beginning of the path we used three criteria: the indications received from the teachers (reported pupils) and the low scores obtained at the two pre-tests (PAIN and VR) selecting as scores in the risk zone those equal to or less than -2DS, as usual in the literature (Sistema Nazionale Linee Guida dell'Istituto Superiore di Sanità - SNLG-ISS, 2011; 2022).

As one can see in the following tables, we have considered the subjects at risk identified both analytically on each of the three initial criteria, and in an overall category that includes all the subjects indicated by any of these three categories.

For all these subjects, we researched the results obtained on each of the three exit tests (PAOUT, DW and LD), evaluating how many of these remained in the risk zone.

Although the number of subjects selected in this way remains low, a consistent trend can be detected in these data; while on the one hand the average values of the output tests are always higher in the EG, on the other the percentage of children who remain below the cut-off threshold of EG is always lower than that of CG: the percentages of EG are on average 3 or 4 times lower than those of CG.

	RP	F	M	$\overline{PAOU}$	$\overline{DW}$	$\overline{LD}$	PA-OUT cut-off	F	M	%	DW cut-off	F	M	%	LD cut-off	F	M	%
EG	19	6	13	9.37	15.47	11.89	4	1	3	21 %	2	1	1	11 %	0	0	0	0%
CG	4	1	3	8.75	8.00	7.00	1	0	1	25 %	2	1	1	50 %	1	0	1	25%
Tot	23	7	16															

LEGEND:
RP: Reported Pupils;
F: Female;
M: Male;
$\overline{PAOUT}$: average score on the phonological awareness test (PAOUT);
$\overline{DW}$: average score on the dictation of words test (DW);
$\overline{LD}$: average score on the recognition of non-words test (LD);
PAOUT cut-off: pupils under the cut-off threshold (score<=6.49) on the phonological awareness test (PAOUT);
%: % on reference sample;
DW cut-off: pupils under the cut-off threshold (score<=8.06) on the dictation of words test (DW);
LD cut-off: pupils under cut-off threshold (score<=2.36) on the recognition of non-words test (LD).

Table 4. Pupils at risk reported by teachers.

	PAIN cut-off	F	M	$\overline{PAOUT}$	$\overline{DW}$	$\overline{LD}$	PA-OUT cut-off	F	M	%	DW cut-off	F	M	%	LD cut-off	F	M	%
EG	20	8	12	9.40	15.55	12.15	2	0	2	10 %	2	0	2	10 %	2	0	2	10 %
CG	5	3	2	9.20	12.20	9.60	2	0	2	40 %	2	0	2	40 %	2	0	2	40 %
Tot	25	11	14															

LEGEND:
PAIN cut-off: pupils the cut-off threshold (score<=1.34) on the phonological awareness test (PAIN);
F: Female;
M: Male;
$\overline{PAOUT}$: average score on the phonological awareness test (PAOUT);
$\overline{DW}$: average score on the dictation of words test (DW);
$\overline{LD}$: average score on the recognition of non-words test (LD);
PAOUT cut-off: pupils under the cut-off threshold (score<=6.49) on the phonological awareness test (PAOUT);
%: % on reference sample;

DW cut-off: pupils under the cut-off threshold (score<=8.06) on the dictation of words test (DW);
LD cut-off: pupils under cut-off threshold (score<=2.36) on the recognition of non-words test (LD).

Table 5. Children at risk emerged from PAIN.

	VR cut-off	F	M	$\overline{PAOU}$	$\overline{DW}$	$\overline{LD}$	PA-OUT cut-off	F	M	%	DW cut-off	F	M	%	LD cut-off	F	M	%
EG	18	7	11	9.11	16.22	11.89	2	1	1	11%	2	1	1	11%	2	1	1	11%
CG	14	4	10	7.57	11.00	9.14	4	1	3	29%	4	1	3	29%	3	1	2	21%
Tot	32	11	21															

LEGEND:
VR cut-off: Pupils under the cut-off threshold (score<=4.23) on the visual recognition of letters test (VR);
F: Female;
M: Male;
$\overline{PAOUT}$: average score on the phonological awareness test (PAOUT);
$\overline{DW}$: average score on the dictation of words test (DW);
$\overline{LD}$: average score on the recognition of non-words test (LD);
PAOUT cut-off: pupils under the cut-off threshold (score<=6.49) on the phonological awareness test (PAOUT);
%: % on reference sample;
DW cut-off: pupils under the cut-off threshold (score<=8.06) on the dictation of words test (DW);
LD cut-off: pupils under cut-off threshold (score<=2.36) on the recognition of non-words test (LD).

Table 6. Children at risk emerged from VR.

	ALL	F	M	$\overline{PAOUT}$	$\overline{DW}$	$\overline{LD}$	PA-OUT cut-off	F	M	%	DW cut-off	F	M	%	LD cut-off	F	M	%
EG	48	19	29	9.65	16.58	12.48	8	1	7	17%	3	1	2	6%	1	1	0	2%
CG	20	11	9	8.25	11.40	9.20	6	2	4	30%	6	2	4	30%	4	0	4	20%
Tot	68	30	38															

LEGEND:
ALL: Pupils fitting all criteria;
F: Female;
M: Male;
$\overline{PAOUT}$: average score on the phonological awareness test (PAOUT);
$\overline{DW}$: average score on the dictation of words test (DW);
$\overline{LD}$: average score on the recognition of non-words test (LD);
PAOUT cut-off: pupils under the cut-off threshold (score<=6.49) on the phonological awareness test (PAOUT);
%: % on reference sample;
DW cut-off: pupils under the cut-off threshold (score<=8.06) on the dictation of words test (DW);
LD cut-off: pupils under cut-off threshold (score<=2.36) on the recognition of non-words test (LD).

Table 7. Children at risk.

4.2. The teachers' evaluations

One of the most widespread criticisms of alphabetical or phono-syllabic approaches is that they are boring and demotivating. At the end of the experiment, to obtain further information on how the experience was for teachers

and children, a questionnaire including a rating scale (1–5) was addressed and completed by the experiment teachers.

Teachers were asked to evaluate the programme as a whole, its methodological guidance, its sustainability and re-applicability, the level of motivation and its effectiveness exercised on the classroom and on children with special needs (Figure 1) and, more specifically, the phono-syllabic method and its other main features: progressiveness, division in units, phonological modelling, assessment unit by unit (Figure 2).

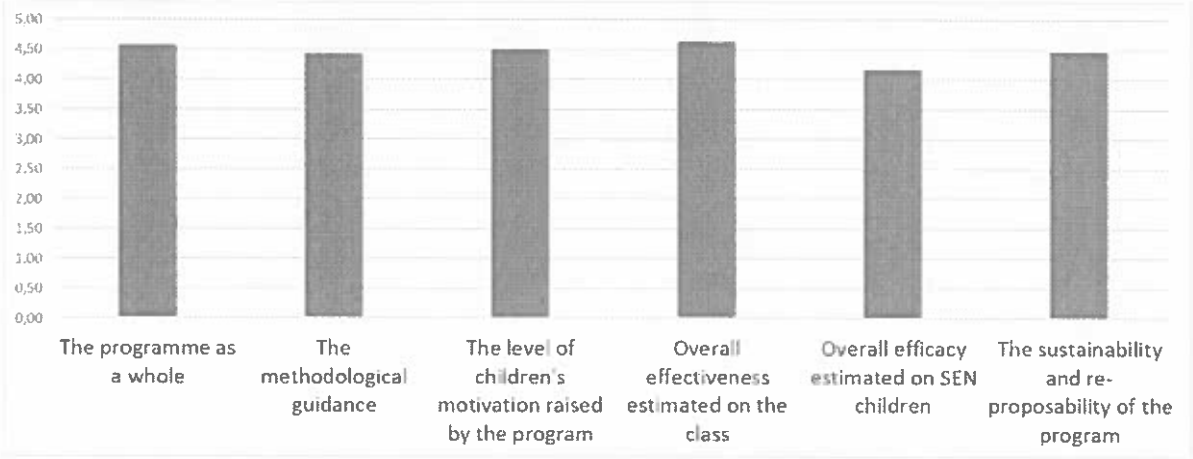

Figure 1. Teachers' evaluation of the quality of the programme.

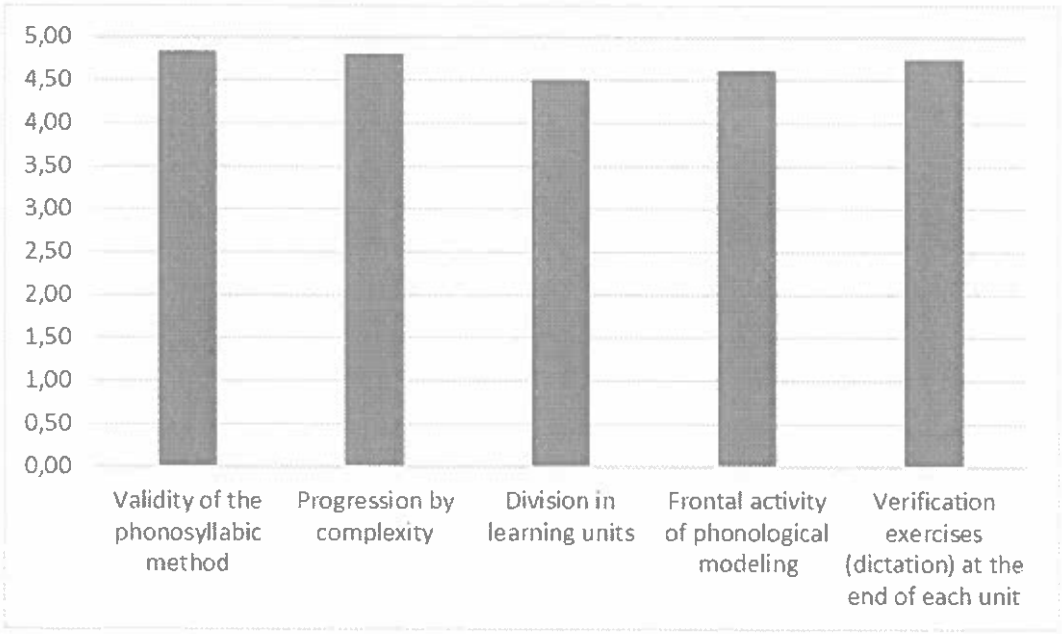

Figure 2. Teachers' evaluation of the phono-syllabic method and its specific features.

As we can see, the teacher satisfaction is generally very high, mostly with average values > 4.5. With attributions between 4.7 and 4.83, the validity of the method, the estimated effectiveness on the class, the progressiveness of the method and the assessment of the achieved objects at the bottom of the units stand out. Moreover, the teachers of the classes of the EG were asked to optionally write comments on this programme (16 comments have been collected), on the quality of the adopted method (14 comments) and on the available tools (15 comments). All these opinions were very positive, if not enthusiastic "[…] *The programme proved to be of a high methodological level... The results obtained have been excellent... great interest and motivation in the students... satisfaction from*

families... well structured... very welcoming to children ... effective and complete path... has fostered in the students a serene, playful and experiential approach to reading/writing".

5. CONCLUSIONS

According to Dehaene (2009), the domain of reading presents suitable features to find a new integrated interdisciplinary science of teaching and learning, with the confluence of contributions from cognitive psychology, neuroscience and instruction. In particular, neuroscience can provide both complementary and unique insights into learning and instruction to read and write.

The experimentation described in this work drew its origin in this framework and was carried to verify the importance of abandoning teaching practices in clear contrast with scientific evidence. A phono-syllabic progressive programme, structured and explicit, has been prepared, implemented and evaluated in a large experimental sample, comparing the results with a control group with approaches characterised by a consistent presence of global and ideo-visual methods.

In this work we have tried to answer two research questions, whether a rigorous phono-syllabic approach facilitates the learning of reading and writing in the children of the first year of primary school and whether it produces significant benefits in children at risk for reading and writing difficulties.

Concerning the first research question, our results confirm that such an approach, implemented in about 140 hours over the course of about 7 months, provides a significant advantage in phonological awareness, in the ability to distinguish words and non-words, and, above all, in writing under dictation: the students of the EG obtain superior results with an Effect Size between 0.2 and 0.43, corresponding to a temporal advantage from 2 to 5 months.

Concerning the second research question, we have identified the children at risk at the beginning both analytically from teachers reports or for the low scores obtained at the tests for word recognition or phonological awareness, and as a whole.

Our results confirm that such an approach produces significant advantages in children who, without intellectual, physical or sensory disabilities, can be considered at risk for reading and writing difficulties. Whatever the input or output assessment tool used, at the exit test, we observed a systematic percentage reduction of children at risk, approximately 3-4 times higher in the EG in comparison with the CG.

Given the large size of this sample, this experimentation provides a further extended confirmation of what the evidence-based research had already highlighted, namely that especially in transparent language, a method based on letter-sound correspondence, on syllabic decoding, and phonological awareness is undoubtedly the more effective solution for all children as well as offering particular benefits for those subjects who, without being intellectually disabled, present at the beginning of primary school various difficulties that place them in an area at risk in reading and writing.

Finally, the enthusiasm of the teachers who experimented with the programme, with evaluations almost always higher than 4.5 (on a scale from 1 to 5) on the quality of the programme, on the motivation found in the pupils, on the method and on its systematicity, provide reliable elements supporting the sustainability and transferability of this approach. We can then reject the hypothesis that alphabetical and phono-syllabic methods would be boring and demotivating, or that children would prefer graphically more attractive materials; it is more reasonable to think that the pupils increase self-efficacy and therefore motivation when they achieve progress in discovering the internal mechanics of reading.

As researchers, at this point we can only remind the decision-makers of their responsibilities. Science does not aim to dictate to education what it must do and there is certainly no single way to teach reading. However, research can delimit the framework within which it is appropriate that teaching remain, as well as indicate, in some cases, any inadequate interventions. In the case of teaching to read: "*Giving freedom of choice, where we know which is the preferable way, is a serious mistake. The school of freedom is not the one that lets choose [...] but the one that quickly teaches every child decoding – the only method that allows him to learn new words for himself*" (Dehaene, 2009, p. 382).

There are no rational justifications, other than purely commercial ones, in support of the "creative" methods and textbooks that, without any scientific foundations, continue to proliferate and exert their negative influence on school practices.

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