

A play-based program designed to engage rhythmic skills as protective factors for reading disorders

Valeria Flori^{1,2}, Letizia Mosconi², Elisa Menafrà² and Silvia Conti^{2*}

1. Scientific Institute, IRCCS E. Medea, Bosio Parini, Lecco, Italy;

2. University of Milan, Milan, Italy;

* Correspondence: e-mail@ silvia.conti1@unimi.it

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ABSTRACT

Current research on dyslexia shows that learning to read is preceded and influenced, along with other early literacy skills, by the development of phonological awareness [36, 38]. Also, rhythmic and phonological skills are often impaired in individuals with reading disorders [21, 28]. Several studies suggest that phonological awareness is effectively trained through rhythmic music trainings [13, 21].

The article presents a play-based program that allows children to engage in semi-structured rhythmic music activities, that aim to enhance the essential rhythmic skills connected to phonological awareness, conducted in the ecological environment of their house.

An observational study was conducted on a group of 4 children, aged between 4.11 and 5.7 years, who participated in the play-based training. Pre- and post-exposure evaluations were conducted to assess early literacy skills using Italian standardized tests: "Syllabic synthesis" and "Letter recognition" tests from PRCR-2 battery (Cornoldi et al., 2009), "Rhyme recognition" and "Phonetic analysis and segmentation" tests from CMF battery (Marotta et al., 2008).

All 4 children involved in the study showed individual and median improvements in all the assessed phonological awareness skills pre- and post-exposure: In particular, comparing the medians in T0 and T1 there is an improvement of 0.71 for the subtest syllabic synthesis, 1.1 for rhyme recognition, 1.35 for letter recognition and 0.29 for phonemic analysis and segmentation.

The results can be considered as a pilot to further research in order to support phonological awareness with rhythm, promote reading skills and prevent reading disorders.

INTRODUCTION

Reading plays a fundamental role in our cultural and educational systems, serving as the foundation for acquiring knowledge across disciplines. Beyond providing access to information, concepts, and ideas, reading contributes to a deeper understanding of the world by fostering the development of critical and analytical thinking, stimulating curiosity, and promoting both personal and intellectual growth [1].

The decoding of written text is a complex process, which entails the integration of linguistic and perceptual mechanisms, whose development begins at preschool age and then continues to evolve throughout the next stages of education.

The process of learning to read is also influenced by several precursors, identified by Cornoldi and colleagues who stress in particular the role of phonological awareness [2].

Phonological awareness, defined as the ability to discern, manipulate and combine the sounds of words, is recognised as critical for reading acquisition because it allows the understanding of the relationship between sounds and their corresponding letters [3, 4].

This skill, which relies on the perception of syllabic and sub-syllabic units, underpins the conversion of graphemes into phonemes, thereby allows children to face initial reading tasks [2, 5].

Phonological awareness is a multidimensional construct, involving processes of varying complexity, generally categorized into two domains: global phonological awareness, which concerns operations on syllables and analytical phonological awareness, which refers to operations on individual phonemes [3, 6].

Phonological awareness develops in close connection with language, influenced by auditory perception and attention to auditory stimuli [7]. Given the strong link with auditory perception, numerous studies have investigated the role of musical stimulations in the development of phonological skills [8, 9, 10].

The codes of music and language share various characteristics, such as a hierarchical structure based on sequences of units organized according to specific rules and the need to accurately represent auditory features such as timbre, pitch, intensity and duration [8]. In fact, music can be conceptualized as a form of language.

Recent research has also shown that the processing of music and language also takes place in overlapping neural pathways, involving brain structures in the temporal lobe and lateral frontal in both hemispheres. Musical events activate areas traditionally devoted to language, such as Broca's and Wernicke's areas and the superior temporal sulcus, suggesting a



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shared neural network for processing rhythmic and linguistic stimuli [10].

This overlap justifies the influence of rhythmic abilities on higher linguistic functions and the frequent association between rhythmic-related difficulties and language disorders [9] and learning disorders [11, 12].

Rhythm, understood as the orderly succession of acoustic phenomena over time, is closely related to phonological awareness -a prerequisite for reading- because both abilities concern the ability to perceive and reproduce specific auditory stimuli [11, 13].

The perception and the analysis of the sound rhythm depend on the simultaneous processing of multiple components, supported by specific auditory skills. The ability to synchronize with rhythm, i.e. to tune in to a rhythmic sequence, producing beats that coincide with auditory events, is related to the key reading prerequisites such as phonological awareness, short-term verbal memory and Rapid Automated Naming [10, 14].

Rhythm involves not only understanding and recognizing auditory stimuli with regular alternations, i.e. rhythmic discrimination, but also constructing cognitive frameworks for spacial, temporal and motor synchronization.

Therefore, rhythm allows synchronization since it is possible to anticipate future events, activating the motor system in a certain timing. Other rhythm-related skills are rhythm continuation (the ability to maintain a regular beat even after the stimulus ceases) and rhythm reproduction (the ability to replicate rhythmic patterns without auditory feedback) and they both are related to the development of rhythm and phonological awareness [14, 15].

It was found that individuals with dyslexia, both children and adults, show significant difficulties in anticipating such temporal events and show less precision in the synchronization activities.

This could explain the difficulties in fluent reading, which requires temporal anticipation [16].

Additional phonological awareness skills, such as rhythmic fusion, the ability to synthesize a coherent structure from multiple stimuli, and segmentation, the ability to break down complex structures into smaller components. are similarly fragile in people diagnosed with dyslexia [17, 18, 19, 20].

Several studies have explored the use of rhythm and music-based programs as preventing interventions to promote the development of phonological awareness, as a precursor to reading [21, 22, 23].

In the study by Vidal et al., children aged 3 to 4 years attending music classes showed greater gains in phonological awareness compared to peers who participated in visual arts classes, especially in segmentation and syllabic fusion tasks [5].

The study by Patscheke et al. found that only children who attended a music program -as opposed to those involved in sports activities- improved their phonological awareness, especially rhyming and seg-

mentation skills. Other studies by Degé and colleagues, showed significant improvements in phonological awareness in preschool children who attended musical or phonological programs -compared to children in sports programs [24].

Hutchins' study showed the efficacy of a year-long music program in enhancing language and pre-literacy skills in children aged 3 to 6 [14].

Moritz et al. found that children attending a Kodaly-based music pedagogy program improved their phonological awareness, with rhythmic skills correlating with future reading ability [25].

Furthermore, Linnavalli et al. observed that children involved in musical activities improved phoneme processing and language skills, compared to children who attended dance activities or no treatment [26]. Ultimately, Hande and Hegde's review confirmed that musical interventions promote the development of linguistic and cognitive skills [10].

These findings suggest that rhythm serve as protective factor which positively influences early childhood literacy skills and can therefore be the focus for preventive interventions aimed at mitigating future reading difficulties [27, 28, 29, 30, 31].

Prevention is an important resource in both educational and health fields, in order to develop protective factors that can support learning while reducing difficulties. It is in fact long been known that dyslexic functioning has negative repercussions not only on formal learning, but, depending on the school environment, also on emotional and relational health, potentially leading to externalizing behaviours or anxiety and depression [32, 33, 34, 35].

In Italy school system, children diagnosed with Specific Learning Disorders are protected by law 170/2010 "New rules on Specific Learning Disorders in school", which encourages timely interventions and ensures the right to education within an inclusive and personalised context. This law emphasizes the importance of prevention, defined as the set of interventions designed to prevent undesirable conditions from occurring or mitigating their effects [36].

This study aims therefore to take part in developing innovative, evidence-based primary prevention programs for reading disorders. It is distinguished by its ecological dimension, defined as all actions aimed at reducing risk factors associated with the emergence of a disorder within groups or communities, focusing on rhythm as a protective factor against reading difficulties.

This work describes a pilot study to evaluate the effectiveness of rhythm-based music instruments and activities specifically designed for use in a domestic context, fostering phonological awareness through playful interactions between children and parents or caregivers. The selected instruments and activities provide support phonological awareness, through informal exposure to auditory stimuli, which facilitate the development of language skills, as precur-

sors of reading.
In the context of primary prevention in Italy, the role of mediator of activities to parents can be assigned -among various professionals- to the figure of the Neurodevelopment Therapist – Terapista della Neuro e Psicomotricità dell’Età Evolutiva), healthcare professional who performs interventions of habilitation, rehabilitation and prevention in childhood disabilities or disorders, such as those of interest to this project [37].

MATERIALS AND METHODS

A pilot observational study was conducted in a sample of four typically developing children who, after expressing consent to participate in the study, were exposed to rhythmic-based music activities within the ecological setting, facilitated by their parents and caregivers.
The study included four participants, all born in 2018, with no diagnosis of primary language disorder nor other diagnoses or conditions related to phonological or rhythm or music processing difficulties.

Materials

The participants were introduced to a playful, purpose-designed material titled "Animal Band", which supports rhythmic skills associated with the enhancement of phonological awareness, using simple mu-

their rhythmic and phonological skills. They are described in Table 1.
The joyful and symbolic frame enhances motivation by leveraging play, a natural and informal mode of learning for children in their daily lives. The "Animal Band" materials consist of five activities set, within a playful-narrative frame involving a band of 12 animals. Each animal is associated with one of three selected idiophonic instruments and one specific rhythm. The selected instruments are a triangle, a shaker and a tambourine.
The activities are supported by playing cards. The cards illustrate one of the twelve animals, the associated instrument and a rhythm, that can also be played using a QR code. Additionally, a legend card is provided in the deck.
The activities are outlined in an explanatory booklet, which provides laic parents and caregivers basic theoretical knowledge on rhythmic skills, phonological awareness and their role in preventing reading difficulties. The booklet also guides adults in implementing the activities effectively.

Methods

Participants were selected according to the inclusion criteria described above. To assess the improvements in the studied skills, an evaluation of the reading prerequisites was carried out before (t0) and after (t1) the musical experience.

Table 1. Activities and objectives

Title	Activity	Objectives
1, 2, 3 bang	Children are asked to synchronize their movements to a perceived rhythm presented by a facilitator.	This activity promotes the development of synchronization skills, discrimination of rhythmic sequences from non-rhythmic sounds, and rhythmic fusion and segmentation abilities.
Guess who?	Children are asked to recognize and reproduce a rhythmic sequence.	This activity supports the development of rhythm discrimination and reproduction skills.
Hide and seek	Children are asked to identify the source of a target sound.	This activity enhances auditory attention and auditory discrimination skills.
Memory	Children are asked to match identical sounds from the QR on the cards in order to form pairs.	This activity supports the development of rhythmic discrimination skills.
Animal Band	A final game is proposed, requiring children to discriminate, synchronize, and produce rhythmic sequences of varying complexity.	This activity promotes the development of reproduction, synchronization, continuation, fusion and segmentation skills.

sical instruments in ecological the family-oriented activities between children and caregivers.
The activities, designed for the domestic setting, allow an intense exposure to rhythm stimulations, offering children numerous opportunities to train

Each family received a presentation letter, providing information on the study’s objectives, required commitments, access to material, input evaluation protocol and data processing procedures.
Inclusion criteria were the following:



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- Children exposed to Italian as a single language;
 - Children participating in all the tests;
 - Presence of at least one caregiver motivated to participate actively in the project according to the indicated modalities and to guarantee the presence during the sessions of test evaluation;
- Exclusion criteria were the following:
- Children diagnosed with primary language disorder or other diagnoses related to phonological or rhythmic-musical processing difficulties;
 - Children with significant sensory difficulties (especially visual and auditory) that could interfere with the proposed tests and activities;
 - Children involved in other preventive projects at the same time.

The children included in the study were underwent an initial evaluation protocol (assessment at t0). The evaluation was carried out with one individual session for each child, in a psychological clinic, lasting approximately 25 minutes.

The early literacy skills assessment protocol used includes the following tests:

- Letters Recognition Test, from the Prove di Prerequisito per la Diagnosi delle Difficoltà di Lettura e Scrittura PRCR-2 [38];
- Phonetic Analysis and Segmentation Test from the Prove di Prerequisito per la Diagnosi delle Difficoltà di Lettura e Scrittura PRCR-2 [38];
- Rhyme Recognition Test from the Test per le Competenze Meta-Fonologiche CMF [39];
- Syllabic Synthesis Test from the Test per le Competenze Meta-Fonologiche CMF [39].

These tests were chosen among Italian tests, in order to align with the Get Ready to Read! - Revised (GRTR-R), by Whitehurst (40), which has been identified as the gold standard screening tool for identifying risk factors of reading difficulties in children aged 3 to 5 years (Table 2). The review that allowed to identify the Italian tests aligning with the GRTR-R was completed in 2023.

Table 2. Assessment tests

Test	Authors	Similarity to GRTR-R subtest	Activity
“Riconoscimento di lettere” i.e. Letters recognition Test from Prove di Prerequisito per la Diagnosi delle Difficoltà di Lettura e Scrittura PRCR-2	Cornoldi et al., 2009	Subtest 6	This test requires the visual association of letters arranged in different orientations. It includes 12 items and evaluates the errors made.
“Analisi e segmentazione fonemica” i.e. Phonemic Analysis and Segmentation Test from Prove di Prerequisito per la Diagnosi delle Difficoltà di Lettura e Scrittura PRCR-2	Cornoldi et al., 2009	Subtest 7	It includes 3 subtests: the first requires identifying the last phoneme of heard words (10 words); the second requires identifying the first phoneme (10 words); and the third requires the segmentation of words (9 words). One point is assigned for each part of the word correctly identified. The total score takes into account all three subtests.
“Riconoscimento di rime” i.e. Rhyming Recognition Test from “Competenze Meta-Fonologiche CMF”	Marotta et al., 2008	Subtest 14	This test requires identifying, among three heard words, the one that rhymes with a given target element (15 words). The test uses visual images for support. The correct words are evaluated.
“Sintesi sillabica” i.e. Syllabic Synthesis Test from “Competenze Meta-Fonologiche CMF”	Marotta et al., 2008	Subtest 15	This test requires the fusion of heard syllables (15 words), and the correct responses are evaluated.



Procedure

After the assessment tests, each family was then provided with the educational and play materials, and parents were asked to play with their child for a period of 6 weeks, at least 2 times per week, for a minimum duration of 10 minutes per session. Parents were recommended to try at least once all the proposed activities (reference Table 1), with particular emphasis on those that their child enjoyed most. The 6-weeks period was defined in relation to the study by Martinez and colleagues who described it as effective for the design purposes and objectives (41). At the end of the exposure period (t1), the four children were re-evaluated using the same tests and methods that were proposed initially (t0 assessment), in order to detect any changes in their early literacy skills.

RESULTS

Below are the results collected from the sample of children involved in the study. The comparison of the data collected at t0 and t1 allows to describe the effects of exposure to our rhythmic program “Animal Band”. The qualitative comparison between the data collected in T0 and in T1 showed a positive variation of the skills tested. However, it is considered necessary to interpret these results with caution: It cannot be excluded that this variation may have been

partly influenced by uncontrolled factors such as individual maturation or exposure to environmental factors facilitating the development of phonological awareness. The program, consisting in play within the domestic context, aims to support the development of phonological awareness in children during their last year of preschool, acting as a facilitator for the development of precursors to reading skills. The results are presented in the following tables (Tables 3, 4, 5 and 6) related to the performance of each child involved (n=4 subjects). For details regarding the assessment tests, please refer to the Methods section. Table 3 provides the results of Child A, who, at the time of assessment, was 4 years and 11 months old. Child A’s t0 tests show an overall emerging profile of early literacy skills. In particular, immaturity is noted in the Letters Recognition, with numerous spatial orientation error, as well as difficulties in the Rhyme Recognition. At t1, a positive evolution of all pre-literacy skills is observed, particularly in those domains that are highlighted as more fragile during the initial assessment phase. The positive development is also revealed in the Phonemic Analysis and Segmentation test, although this progress is less pronounced. Table 4 provides the results of Child B’s, who, at the time of assessment, was 5 years old at the time of assessment.

Table 3. Results of Child A.

Test Name	T0 (Z score)	T1 (Z score)	Δ (Z score)
Sintesi sillabica <i>Syllabic Synthesis</i>	-1.04	0.4	1.44
Ricognizione di rime <i>Rhyming Recognition</i>	-1.97	-0.08	1.89
Riconoscimento di lettere <i>Letters Recognition</i>	-1.74	0.06	1.8
Analisi e segmentazione fonemica <i>Phonemic Analysis and Segmentation</i>	-1.26	-0.81	0.45

Table 4. Results of Child B.

Test Name	T0 (Z score)	T1 (Z score)	Δ (Z score)
Sintesi sillabica <i>Syllabic Synthesis</i>	-0.07	0.41	0.48
Ricognizione di rime <i>Rhyming Recognition</i>	-2.61	0.23	2.84
Riconoscimento di lettere <i>Letters Recognition</i>	-0.84	0.06	0.9
Analisi e segmentazione fonemica <i>Phonemic Analysis and Segmentation</i>	-1.58	-0.62	0.96



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At t0, the assessment reveals an emerging profile of early literacy skills development. Specifically, immaturity is evident in Rhyming Recognition and in Phonemic Analysis and Segmentation tests, especially in the identification of the final phoneme in target words. At T1 there is a positive evolution across all skills, however the Phonemic Segmentation difficulty persists. Qualitative analysis highlights emerging Syllabic Segmentation skills.

Table 5 provides the results of Child C, who was 5 years and 6 months old at the time of assessment. At t0, the assessment indicates good early literacy skills with only slight immaturity in the Letters Recognition test. The final assessment appears consistent with the initial one, but a noticeable improvement in the Letters Recognition.

Table 6 shows the results of Child D, who was 5 years and 7 months old at the time of assessment. At t0, the assessment shows a highly uneven profile

of early literacy with good skills in Rhyming Recognition and Phonemic Analysis and Segmentation and immaturity in Letters Recognition, with numerous spatial orientation errors. At t1 a general positive evolution is observed across of all the studied skills, with a stronger improvement in those identified as immature at t0.

DISCUSSION

Reflecting on the overall sample of children included in the study, the initial assessment at t0 reveals that 3 participants showed difficulties in Letters Recognition (Riconoscimento di lettere), due to the presence of numerous errors in spatial orientation and a tendency for letter reversal, as well as immaturity in the Phonetic Analysis and Segmentation (Analisi e Segmentazione fonetica). This is illustrated in Figure 1, which compares the performance of the entire sample before and after exposure to the “Animal Band” program.

Table 5. Results of Child C.

Test Name	T0 (Z score)	T1 (Z score)	Δ (Z score)
Sintesi sillabica Syllabic Synthesis	0.41	0.41	0
Ricognizione di rime Rhyming Recognition	0.86	0.86	0
Riconoscimento di lettere Letters Recognition	-0.84	0.51	1.35
Analisi e segmentazione fonemica Phonemic Analysis and Segmentation	1.32	1.10	-0.22

Table 6. Results of Child D.

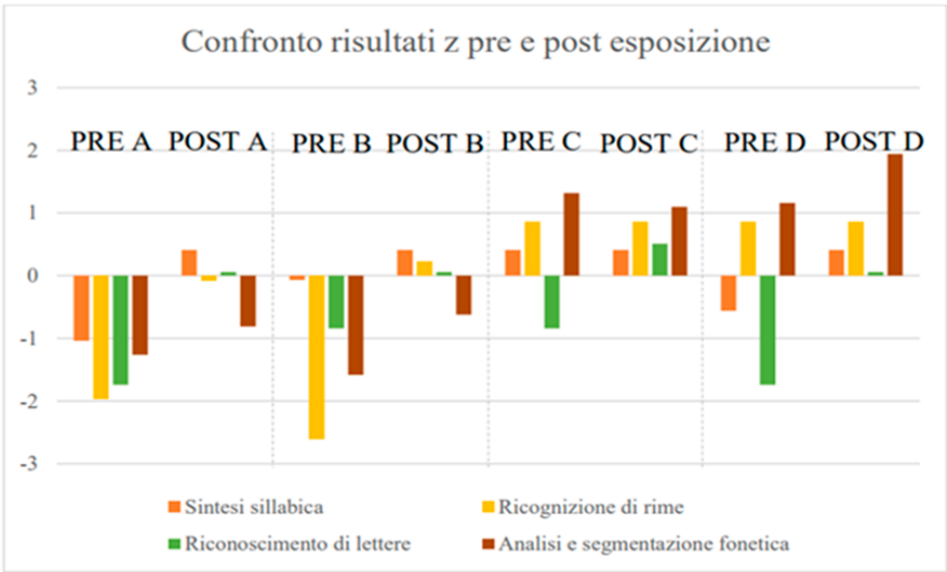
Test Name	T0 (Z score)	T1 (Z score)	Δ (Z score)
Sintesi sillabica Syllabic Synthesis	-0.56	0.41	0.97
Ricognizione di rime Rhyming Recognition	0.86	0.86	0
Riconoscimento di lettere Letters Recognition	-1.74	0.06	1.8
Analisi e segmentazione fonemica Phonemic Analysis and Segmentation	1.16	1.94	0.78



The graphical representation below (Figure 1) of the comparison between pre- and post-exposure results demonstrates an overall improvement in all evaluated items. The only exception is the Phonetic Analysis and Segmentation test (Analisi e Segmentazione fonetica): Child C, exhibited a slight regression post-intervention in this test.

All findings seem to confirm what has already been highlighted in the literature: exposure to rhythm-based music activities supports the development of phonological awareness. Phonological awareness is confirmed as a malleable ability through play experiences, in informal contexts such as the domestic environment. This pi-

Figure 1. Pre and post-intervention individual comparison (Child A, B, C, D).



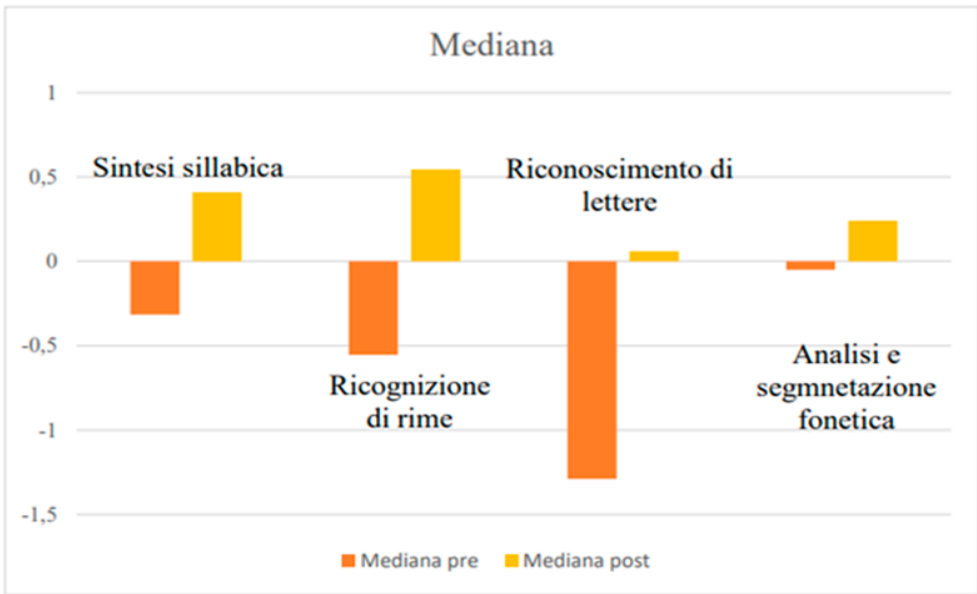
All children demonstrate a positive evolution in the skills under investigation; the profiles identified as only emerging at t0 were found, in nearly all subjects, acquired at t1. This finding is corroborated by aggregate results, as shown in Figure 2, which illustrates the median performance of the sample before and after exposure to the program.

lot results validate the effectiveness of the “Animal Band” program and underscore the importance of early primary prevention of reading disorders [32, 33, 34, 35].

Limitations and future perspectives

This study has certain limitations, that must be addressed. Regarding the discussion about effective-

Figure 2. Pre and post-intervention median comparison (mediana).



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ness, the small sample size limits the generalizability of the results. The selection of a small sample may increase the internal variability of the sample, making it very heterogeneous and therefore difficult to control; it can also cause excessive homogeneity which does not represent the characteristics of the population. The poor representativeness of the sample requires a purely qualitative analysis of the results and encourages further investigations with larger samples to verify the actual possibility of generalising the results to the whole population. Furthermore, the pilot study did not include a control group, which represents a key limitation.

As a future perspective, the program "Animal Band" could be tested on a larger sample of children, within an observational, randomized and controlled prospective study. Longitudinal analysis over time of these participants, as well as those who will be recruited in future studies, would enable to evaluate the program's effects as a real factor of protective factor for reading skills.

Additionally, in the validating process of the program, it would be important to assess rhythmic skills alongside early literacy abilities in order to provide a more comprehensive understanding of its impact.

CONCLUSIONS

In conclusion, despite the limitations outlined above,

this study represents a pilot investigation into the evolution of early literacy skills within an ecological domestic context, through a playful program that exposes children to rhythmic music activities. The observations reported thus describe an interesting improvement of phonological awareness skills but do not allow to establish a causal link, supported by statistical significance, between the use of the material and the improvements found. A qualitative description of the observed evolution is given, encouraging a future extension of the study carried out.

The data collected from observing the children before and after the intervention indicate a positive evolution of the targeted skills. Both the children and their families have expressed interest in the program, which was easily implemented across different home-based settings.

We therefore assert that a play-based rhythmic stimulation program can be a relevant tool to support the development of phonological awareness, which is already recognized as a fundamental precursor to reading skills.

This underlines the importance of early intervention, that involves both educational contexts and family networks, through appropriately designed programs. This study also reinforces the critical role of rehabilitative health professions for the development of effective preventive programs.

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