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Review Article

Effectiveness of phonological awareness stimulation in preschoolers – A systematic review

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ABSTRACT

Phonological awareness is a strong predictor of reading and writing skills development. Several programs have been developed and tested for the stimulation of phonological awareness, but the degree of variation among them makes it difficult to compare the different methods. A synthesis of the literature on phonological awareness stimulation programs is needed to examine the effectiveness of PA programs while considering the variability that exists between the methodologies used. This systematic review aimed to 1) synthesize the literature on PA stimulation programs in typically developing children; 2) examine the effectiveness of PA programs; 3) critically appraise the methodology of PA stimulation programs. Central, Medline, Pubmed, Scopus, and Web of Knowledge were used to conduct an extensive literature search. A total of 10 articles met the eligibility criteria and were included in the present study. Results showed that, in general, the phonological awareness stimulation programs carried out in the analyzed research were effective. However, the quality of the methodology varied significantly across studies, showing in some cases a lack of detail in the inclusion criteria, limited training of the professionals who carried out the PA programs, an inconsistency in parent involvement, and a lack of follow-up. Guidelines for future research are discussed to enhance the methodological quality of this line of research and reduce the risk of bias.

Keywords:
Phonological awareness programs; Systematic review; Preschool

Efectividad de la estimulación de la conciencia fonológica en preescolar: una revisión sistemática

RESUMEN

La conciencia fonológica es un predictor fuerte del aprendizaje de la lectura y la escritura. Se han desarrollado y probado programas para su estimulación, en los que se evidencia una variedad de métodos que dificulta la comparación de resultados. Se plantea una revisión con los siguientes objetivos 1) sintetizar la literatura sobre estudios que investigan programas de estimulación de la conciencia fonológica en niños con desarrollo típico; 2) examinar la eficacia de dichos programas; 3) evaluar críticamente su metodología Para esta investigación bibliográfica se utilizaron las siguientes bases de datos: Central, Medline, Pubmed, Scopus y Web of Knowledge. Diez artículos cumplieron con los criterios de elegibilidad establecidos y fueron incluidos en el presente estudio. En general, los resultados mostraron la efectividad de los programas de estimulación de conciencia fonológica utilizados. Sin embargo, la calidad metodológica entre los estudios varió; esto incluyó la falta de criterios de inclusión detallados, capacitación limitada de los profesionales que llevaron a cabo los programas de AF, consideración inconsistente de la participación de los padres y falta de seguimiento. Se discuten algunas pautas para futuras investigaciones con el objetivo de mejorar la calidad metodológica de los estudios y reducir el riesgo de sesgo.

Palabras clave:
Programas de conciencia fonológica; Revisión sistemática; Preescolares

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INTRODUCTION

Phonological awareness (PA) is defined as the ability to identify and manipulate, in a conscious manner, any phonological unit (Castles & Coltheart, 2004; Ehri, 1989; Freitas et al., 2007). There are certain agreements regarding the existence of levels of PA, based on the type of sound that is analyzed. Alves et al. (2010) and Caravolas & Bruck (1993) propose the following levels: (1) syllabic awareness (the ability to identify and manipulate the syllables of a word), (2) intrasyllabic awareness (the ability to identify and manipulate elements that internally form the syllable) and (3) segment/phonemic awareness (the ability to analyze the phonemes that constitute the word). On their part, Freitas et al. (2007) and Tunmer et al. (1983) also consider word awareness (the ability to identify words in a sentence) as a level. For each of the existing levels of PA it is possible to perform several tasks, such as segmentation, reconstruction, categorization, manipulation, and identification (Castelo, 2012).

It is known that the development of PA starts at the preschool age (Freitas et al., 2007). Accordingly, most of the studies on PA have been conducted on preschool-aged children (Carroll et al., 2003; Castles & Coltheart, 2004; Ehri, 1989; Hulme et al., 2002; Pfost et al., 2019; Rack et al., 1994; Share, 2004; Tibi & Kirby, 2018; Wagner & Torgesen, 1987). Furthermore, it is well known that PA is an important predictor of reading. For instance, before the introduction of the alphabetic principle, it is important to develop the awareness that words are constructed by smaller units (i.e., phonemes) as well as to recognize that oral sounds can be associated with letters. The understanding of what phonemes are and how to manipulate them represents the foundation for early literacy (Carroll et al., 2003; Castles & Coltheart, 2004; Ehri, 1989; Liberman et al., 1990; Rack et al., 1994; Share, 2004; Wagner & Torgesen, 1987). Thus, children who have the ability to manipulate and reflect on phonemes will find it easier to learn to read and write (Alves et al., 2010). In this sense, the stimulation of PA in preschoolers could facilitate their later recognition of words and association of sounds and letters, making it easier for children to develop their reading and writing skills.

Different Intervention programs have been developed with the goal of stimulating PA in preschool-aged children, which show positive results (e.g., Lundberg et al., 2012; Segers & Verhoeven, 2005; Yeung et al., 2013). Overall, these studies proved the efficacy of these programs, evidenced in the development of PA at a syllabic, intrasyllabic, and phonemic level Moreover, they demonstrated that early PA development has significant positive effects on early literacy and on learning to read and write. All these studies were applied to a large sample size over a broad period, where participants were evaluated pre and post-intervention using different PA assessment methods. However, they differed in the inclusion and exclusion criteria applied, making it difficult to compare the effects of each PA program. Therefore, it becomes important to count on a synthesis of the literature on PA stimulation programs, to examine the effectiveness of PA programs while at the same time considering variability between the methodologies used across studies.

In this context, the present study intends to 1) synthesize the existing literature on PA stimulation programs carried out on typically developing children; 2) examine the effectiveness of said PA programs; and 3) critically appraise the methodology of the PA stimulation programs.

METHODS

This systematic review was planned and conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Search strategy

An extensive literature search was conducted using five scientific databases: Cochrane Controlled Register of Trials (CENTRAL), Medline, Pubmed, Scopus, and Web of Knowledge, with the most recent search completed in February 2020. The search was limited to studies published in English between 2005 and 2019. The following search terms were used: preschool AND typical development AND (intervention OR training OR stimulation OR stimulation program) AND (phonological awareness OR phonemic awareness OR syllabic awareness).

Inclusion criteria

The following criteria were used to include a study in this review:

1) The study had a Randomized control trials (RCT) design.
2) The study was based only on a PA stimulation program.
3) The study was conducted in children 3 to 6 years of age with typical language development.
4) The study had an outcome measure of PA (e.g., syllabic, intrasyllabic and phoneme awareness tasks).
5) Studies targeting pre-literacy skills of letter-sound knowledge and alphabet knowledge were also included.

Exclusion criteria

The following criteria were used to include a study in this review:

1) The study had a study design other than an RCT (e.g., quasi-experimental, qualitative research case studies, clinical notes, scientific communications).
2) The study was not based solely on a PA stimulation program (i.e., included the stimulation of other skills such as morphology and semantics).
3) The study included children with atypical development (e.g., autism, intellectual disability, hearing loss, neurological lesion) in their sample.
4) The study did not have an outcome measure for PA.
5) The study was written in other languages than English.
6) Did not provide a clear description and characterization of the program and its implementation.

Data collection

The data that were extracted from each of the selected studies included: 1) author and year of publication, 2) the participants' age, 3) a description of the intervention, and 4) outcome measure used.

Selection of the studies

All the references obtained from the five databases were inserted into Mendeley (desktop version 1.19.4). Duplicated references were identified and removed. Subsequently, an analysis of the articles' titles and abstracts was performed, in order to select the ones which seemed most relevant, considering the aforementioned inclusion criteria. This task was carried out by both authors of this review. Studies whose titles and abstracts did not include a PA stimulation program were excluded. Where there was a divergence of opinions, a consensus was reached between the authors. After the initial selection, a thorough reading of the full texts was carried out. Those that met all the established eligibility criteria were included in the final sample.

Assessment of the quality of the studies

A quality measurement scale was implemented— The Standard Quality Assessment criteria for evaluating primary research papers from a variety of fields (Kmet checklist; Kmet et al., 2004). Data relating to methodological quality was extracted following the Kmet checklist. The Kmet checklist consists of 14 items that assess the sampling strategy, characteristics of the participants, sample size calculations, sample collection methods, description and justification of methods of analysis, reporting of result, controls for confounding variables, and whether the conclusions reflect the results obtained. Each item is scored using a 3-point scale (0 = no, 1 = partial, 2 = yes), thus providing a systematic and quantifiable measure of the quality of the study (Kmet et al., 2004). Finally, an overall percentage of quality can be calculated and a category for the methodological quality is assigned. According to Kmet et al. (2004), a score higher than 80% is considered to represent high quality, a score of 70 to 79% is considered good quality, 50 to 69% fair quality, and a score lower than 50% means the quality of the methodology is low.

Data extraction and quality appraisal were performed following the same procedures and independently by two reviewers. Where a difference of opinion appeared, a consensus was reached between both evaluators. Moreover, the risk of bias was significantly reduced since the reviewers had no affiliation with the authors.

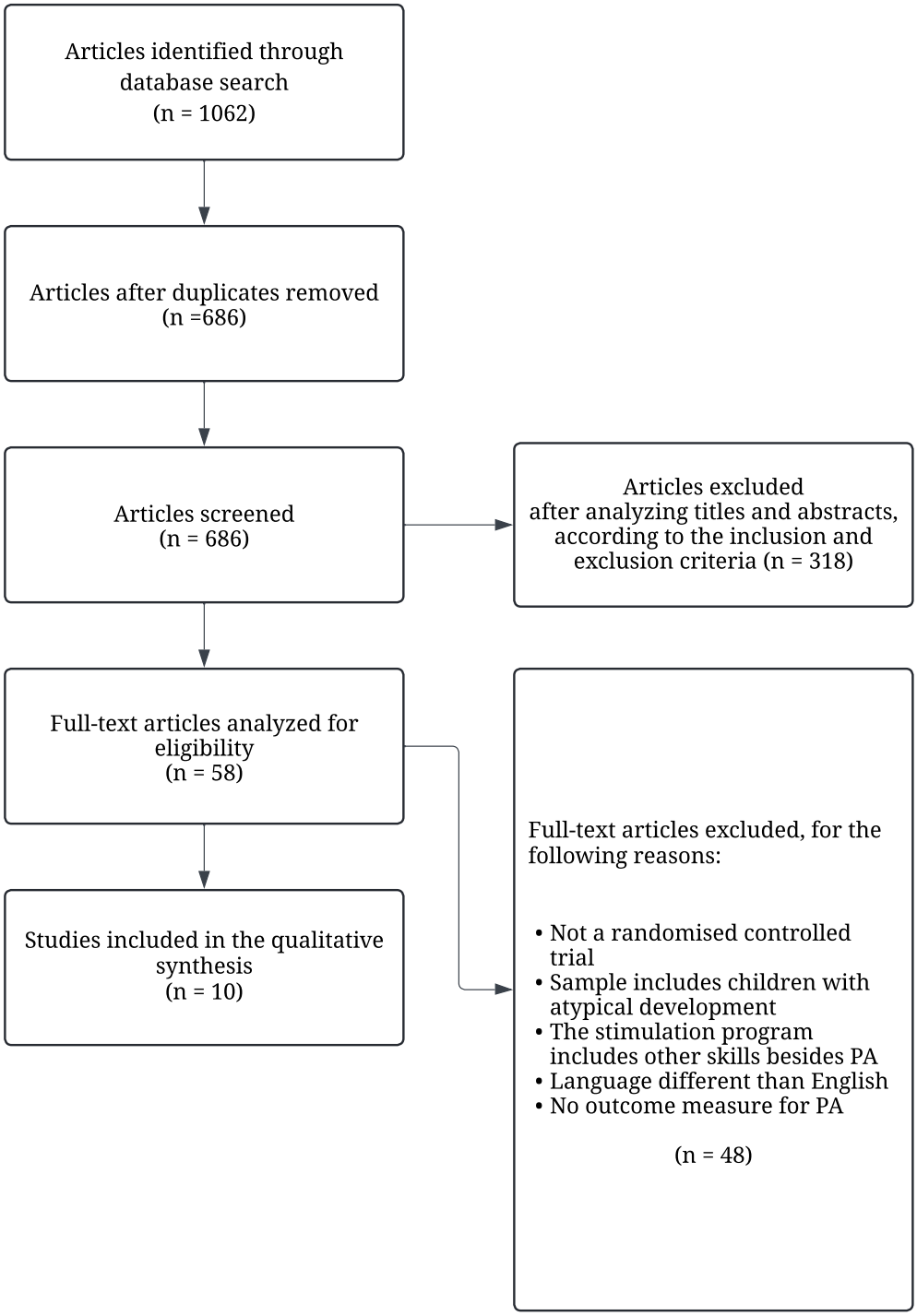
Data synthesis

After selecting the studies, the extracted data were summarized. A qualitative analysis was applied, as it was considered the most appropriate method to address the research question, while at the same time taking into consideration the heterogeneity of study designs and outcome measures.

RESULTS

The initial database search resulted in 1,062 articles. From those, 686 duplicates were removed, resulting in a total of 376 studies. After analyzing titles and abstracts according to the inclusion and exclusion criteria, the selection was reduced to a total of 58 studies. Subsequently, the full texts were analyzed in greater depth, resulting in 48 articles being excluded due to the following reasons: (1) the study not being a randomized controlled trial, (2) the sample included children with typical and atypical development, without specifying if the data were analyzed separately, (3) the program included the stimulation of skills other than PA, such as morphological and semantic skills, (4) the study did not include an outcome measure of PA, and (5) it was written in a language other than English. The final selection for this review included a total of 10 studies, as shown in Figure 1.

Figure 1. Flow diagram for the article selection process.



Characteristics of the studies

Participants

The 10 selected studies included a total of 4,881 preschool-aged children. Ages ranged between 4.2 years and 5.9 years. For studies that reported the participants' age (n = 8), the mean age was 5.3 years. For studies that reported the standard deviation for age (n = 6), the mean standard deviation was 2.4 months. However, the eligibility criteria for participation varied across the included studies. For example, some studies reported more detailed inclusion criteria (e.g., correctly answering a certain number of questions) while others did not describe eligibility criteria in depth.

Control groups

The children in some of the control groups participated in activities other than PA (e.g., semantic categorization, sports, words and grammar, cognitive abilities, language skills, and word meanings; n = 5), some were exposed to the same activities but in a different physical format (pen and paper tasks versus online; n = 1), while others maintained their usual activities (e.g., typical preschool intervention practice; n = 4).

Outcome measures

Phonological awareness measures varied greatly across studies. One study collected data related to word awareness; six assessed syllable, rhyme, and phoneme awareness; and three studies collected data related to word, syllable, rhyme and phoneme awareness. Additional outcome measures included non-verbal intelligence (n = 2), memory (n = 1), numeracy (n = 1), letter identification (n = 8), letter-sound knowledge (n = 1), reading (n = 5), and oral comprehension (n = 2). More details about each study's outcome measure(s) are described in Table 1.

Intervention characteristics

Ten different intervention programs were reported across the 10 studies. The programs included phonological tasks for different levels: word (n = 4), syllable (n = 8), rhyme (n = 7), and phoneme (n = 10). Two of the studies targeted PA at all levels (word, syllabic, intrasyllabic, and phonemic). Most programs were carried out in person and used physical materials such as paper, cards, pictures, and books (n = 7); the remaining programs (n = 3) were carried out in a digital format and required the use of computers and headphones. In some of the studies, PA tasks were complemented with alphabet knowledge tasks (n = 5), letter-sound knowledge tasks (n = 1), and comprehension tasks (n = 1). See Table 2 for further details of the characteristics of the interventions.

Professionals responsible for the assessment and training

In all studies, the programs were child-directed interventions and were conducted in a group setting.

PA programs were administered in collaboration with teachers (n = 5), parents (n = 1), tutors with no teaching experience (n = 1), and trained research assistants (n = 1). In two studies, the professionals responsible for the intervention were not identified.

In only four of the studies, the professionals were trained prior to the application of the stimulation programs, to subsequently perform the assessments and implementation of the program.

Duration and setting/mode of delivery

Interventions varied in frequency (i.e., the number of times the intervention was provided per day or per week) and total intervention duration (i.e., the time over which the intervention was performed). The shortest intervention was conducted over five weeks, with 20 minutes per session (Goffredo et al., 2016). The longest intervention implemented two-hour sessions per week, for 5 months, with a total of 50 hours (Korat et al., 2017). The rest of the interventions varied between five to 20 weeks, with a session duration of between 10 minutes and two hours. The intervention with the lowest intensity required 20 minutes of intervention per week. The most intense intervention involved 20 minutes, four to five times a week.

Main findings

The statistical analysis varied across studies, however, the findings regarding the effectiveness of PA stimulation programs were fairly consistent. Seven of the studies found significant improvement in performance in the experimental group, compared to the control group. The remaining studies (n = 3) described improvements in rhyme, syllable, and phoneme awareness tasks after the PA stimulation program in the experimental group, but there was not a statistically significant difference between the experimental group and the control group.

Two of the studies had a follow-up to analyze the long-term impact of PA stimulation programs on the development of reading and writing skills. One of them assessed the children's mastery of the alphabetic principle after six months of receiving reading and writing instruction in grade 1, using a pseudo-word spelling test. However, there were no significant differences in performance between experimental (e.g., children who received the PA […]

Table 1. Characteristics of the included studies.

Reference, Location	Program/Target Skills	Participant groups (N)	Age (Mean ± SD)	Inclusion/Exclusion Criteria	Outcome Measure	Follow-up	Main Findings
(Bodé & Content, 2011), Luxembourg	Phonological Training Program adapted to Luxembourgish	EG: 150 CG: 157	5.8 years	**Inclusion Criteria:** when studying the effects of the general training for the whole kindergarten group, only children whose dominant language was not Luxembourgish were included. As for the study of the effects of training on specific reading and writing difficulties, only children speaking Luxembourgish were included. **Exclusion Criteria:** not specified.	**Non-verbal intelligence** (pretest measure): colored Progressive Matrices Test. **Verbal short-term memory** (pretest and post-test measures): modified version of the Digit Span Task. **Active vocabulary** (pretest and post-test measures): German active vocabulary test, adapted to Luxembourgish. **Phonological awareness** (pretest and post-test measures): rhyme, syllable and phoneme awareness tasks. **Letter identification** (post-test measure)	In first grade, children's mastery of the alphabetic principle was assessed through a pseudo-word spelling test after six months of reading and writing instruction.	Significant improvement in both groups. No significant differences between groups. Follow-up: EG and CG do not differ significantly for any of the tests.
(Cardoso-Martins et al., 2011), Brazil	Phonological Awareness Instruction	EG: 10 CG: 10	4.7 years ± 3.7 months	**Inclusion criteria:** children who did not know the names of any target letters **Exclusion Criteria:** not specified	**Letter name knowledge (**pretest and post-test measures) **Letter sound knowledge** (pretest and post-test measures) **Reading words** (pretest and post-test measures) **Rhyme detection** (pretest and post-test measures) **Alliteration detection** (pretest and post-test measures) **Receptive vocabulary** (pretest and post-test measures)	Not reported	No significant difference between groups in any of the pretests. Significant differences between EG and CG in phonological awareness, letter name knowledge, and letter sound knowledge post-test measures (higher scores found in EG).

(Degé et al., 2011), Germany	Music program for Phonological Awareness	EG1 (Music program): 13 EG2 (Phonological skills program): 14 CG (Sports training): 14	5.9 years	**Exclusion criteria:** lower scores in pretest measures	**Phonological Awareness:** four subtests of the Bielefelder Screening (Pretest and posttest measures) **Intelligence:** Culture fair test (pretest measure)	Not reported	No differences between the groups in pretest measures. Significant differences between EG and CG in post-test measures.
(Ecalle et al., 2015), France	Evidence-based literacy practices	EG: 2067 CG: 1502	5.9 years ± 0.32 months	Not reported	**Letter knowledge (**pretest and post-test measures) **Phonological skills** (pretest and post-test measures) **Vocabulary** (pretest and post-test measures) **Oral Comprehension** (pretest and post-test measures) **Word and pseudo-word reading** (post-test measures)	Not reported	Significant differences between groups in letter knowledge, phonological skills, oral comprehension, and pseudo-word reading in post-test measures (higher scores in EG). No significant differences between groups in vocabulary and word reading in post-test measures (higher scores in EG).
(Ferraz et al., 2015), Portugal	Phonological Awareness Program	EG: 132 CG: 124	Not reported	Not reported	**Phonological Awareness Evaluation Test:** syllabic, intrasyllabic and phonemic awareness tasks (pretest and post-test measures)	In fourth grade, children were assessed through Portuguese National Assessment Tests.	No significant differences between groups in pretest measures. Significant differences between groups in post-test measures (higher scores in EG). Follow-up: Significant differences between EG and CG in the math test; No significant differences between groups in the Portuguese test.
(Goffredo et al., 2016), Italy	Platform *En Plein*, for the practice of phonological skills	EG: 8 CG: 8	Not reported	Not reported	**Italian Phonological Awareness Battery for Kindergarten:** discrimination of minimal pairs of words and pseudo-words;	Not reported	Normalized scores in phonological awareness tasks pretest.

					syllabic awareness tasks and rhyme tasks (pretest and post-test measures)		Differences between groups in phonological awareness tasks post-test measures (higher scores in EG).
(Kelly et al., 2017), Australia	*Cracking the Code* program	EG: 60 CG: 60	4.2 years ± 3.6 months	Not reported	**Clinical Evaluation of Language Fundamentals – P2:** sentence structure, word structure and expressive vocabulary tasks (pretest measures) **Early Repetition Battery** (pretest measures) **Cracking the Code Phonological Awareness:** syllable, onset-rime and phoneme subtests (pretest and post-test measures) **Alphabet knowledge** (pretest and post-test measures) **Non-word reading and spelling** (pretest and post-test measures)	Not reported	No significant differences between groups pretest measures. Significant differences between groups in phonological awareness, alphabet knowledge, and non-word reading and spelling measures at post-test.
(Korat et al., 2017), Israel	Computer-based early literacy program	EG: 134 CG: 100	5.4 years ± 2.25 months	**Inclusion Criteria:** answering correctly a minimum of 10 out of 17 questions in the Riddles subtest of the Kaufman Assessment Battery for Children. No diagnosis of a learning disability **Exclusion Criteria:** Not specified	**Phonological awareness:** syllabic, intrasyllabic and phoneme awareness tasks (pretest and post-test measures) **Print knowledge:** print letter recognition, letter-sound connection and print knowledge, and picture matching tasks (pretest and post-test measures) **Early reading** (pretest and post-test measures) **Numeracy** (pretest and post-test measures)	Not reported	No significant differences between groups pretest measures. Significant differences for group and time. Post-test outcomes were higher than pretest. The EG had scored higher than the CG. Significant differences in phonological awareness, print knowledge, and numeracy skills in post-test measures. EG improved significantly more than the CG.

(Ron Nelson et al., 2010), USA	*Stepping Stones to Literacy,* an early literacy intervention program focused on phonological awareness	EG: 41 CG: 47	4.76 years ± 4.28 months	**Inclusion Criteria:** not specified **Exclusion Criteria:** children experiencing significant learning and/or behavioral difficulties	**Receptive language:** Peabody Picture Vocabulary Test-IIIA (Pretest measure) **Print awareness:** Section A from Test of Preschool Early Literacy - Print Knowledge subtest (pretest and post-test measures) **Alphabetic knowledge:** Sections B and C from Test of Preschool Early Literacy - Print Knowledge subtest (pretest and post-test measures) **Phonological awareness** Test of Preschool Early Literacy - Phonological Awareness subtest - syllable and phoneme awareness tasks (pretest and post-test measures) **Definitional vocabulary** Preschool Early Literacy - Definitional Vocabulary subtest (pretest and post-test measures)	Not reported	Significant differences between groups in print awareness measure pretest (higher scores in EG). Significant differences between groups in alphabetic knowledge and phonological awareness post-test measures.
(Vanbecelaere et al., 2019), Belgium	*Reading Game*: adaptive and non-adaptive educational games	EG1 (Non-adaptive condition): 64 EG2 (Adaptive condition): 62 CG:65	5.88 years ± 0.37 months	Not reported	**Phonological Awareness:** auditory blending skills and auditory memory skills (pretest and post-test measures) **Letter knowledge** (pretest and post-test measures) **Reading fluency** (post-test measures)	Not reported	No differences between the groups in pretest measures. No differences between the EG1 and EG2 in post-test measures - significant learning gains were found immediately following the completion of training in all conditions.

EG= Experimental Group; CG= Control Group

Table 2. Characteristics of the phonological awareness intervention.

Reference	Levels of Phonological awareness included in the program	Procedure	Professionals responsible for the assessment and training	Duration and Setting/Mode of delivery	Tailoring/ Modifications
(Bodé & Content, 2011)	Syllable Rhyme Phoneme	**Three periods:** pretest, training, posttest **Prior to the study:** 1-hour information session was organized to introduce the teachers of the EG to the theoretical background of the study (aims of phonological training and links to the acquisition of reading and writing skills) and to the structure of the program. **Training:** EG teacher's started phonological training program; CG followed the regular kindergarten program. **End of the training period:** Filling out a questionnaire about application of the training program by teachers.	**Pretest and post-test assessment:** Well-trained second year students from the Luxembourgish Center for Teacher Training and Educational Research **Training program:** Teachers	Daily 10 min sessions for 20 weeks	Not reported
(Cardoso-Martins et al., 2011)	Rhyme Phoneme	**Three periods:** pretest, training, posttest **Training:** children were taught the names of letters that correspond to the beginning sound and letters that correspond to the middle sound. In addition, EG children received training in phonological awareness, whereas CG children received training in semantic categorization. After training, children were taught the sounds of the letters whose names they learned during training.	Not reported	28 sessions, each approximately 20 min, 4 to 5 times a week	Not reported
(Degé et al., 2011)	Word Phoneme	**Three periods:** pretest, training, posttest **Prior to the study:** Demographic questionnaire for the parents **Training:** Sessions were held in groups of five to seven children, in a quiet, spacious room at the kindergarten. The music group received training in music program developed by the authors; the phonological awareness group received "Hören, lauschen, lernen Sprachspiele für Kinder im Vorschulalter". The sports group received several physical exercises.	Trained research assistants	10 min daily sessions, 20 weeks	Not reported
(Ecalle et al., 2015)	Rhyme Syllable Phoneme	**Three periods:** pretest, training, posttest **Prior to the study:** teachers received a booklet containing all the instructions for the assessments. They were instructed by educational advisors.	Teachers	January to June Session duration: 30 min	Not reported

		Training: children in the EG received stimulation on code-focused processes (alphabetic code and phonological awareness training) and stimulation on meaning-focused processes (comprehension training)		**Alphabetic code training**: 18 hours **Phonological awareness training**: 18 hours **Oral comprehension training**: 9 hours	
(Ferraz et al., 2015)	Word Syllable Phoneme	**Three periods:** pretest, training, posttest **Training:** EG children received phonological awareness training. Children were divided into small groups of three to four. Each session included instructions on the procedures to be used in each of the training games. Some of these training sessions were supported by visual aids (picture cards) that were properly identified.	Examiners (not specified)	8 sessions, 1 per week, 30 min	Not reported
(Goffredo et al., 2016)	Syllable Rhyme Phoneme	**Three periods:** pretest, training, posttest **Training: a training program that was integrated into** the teaching material; the EG practiced phonological skills using *El Plein* in a personal computer, supported by the teacher.	Teachers	One 20 minutes session per week, 5 weeks	Not reported
(Kelly et al., 2017)	Syllable Onset-rime Phoneme	**Three periods:** pretest, training, posttest **Training:** EG and CG participants from each class were grouped into three groups (of four to seven children each); the *Cracking the Code* program was applied to the children in the EG. The Alphabet Knowledge component of the *Cracking the Code* program was also implemented. The *Words, Grammar and Fun* program was applied to the CG.	**Clinical Evaluation of Language Fundamentals - P2 and Early Repetition Battery** (pretest assessments): Primary researcher and speech-language pathologists **Other pretest assessments and all posttest assessments:** speech-language pathologists **Training program:** Trained education staff members (university-trained teachers and teaching assistants)	**Cracking the Code program:** Two 40 minute sessions per week, 16 weeks **Alphabet knowledge component:** two 15 minute sessions per week (at a separate time to the phonological awareness program)	Not reported

(Korat et al., 2017)	Word Syllable Rhyme Phoneme	**Three periods:** pretest, training, posttest **Prior to the study: the parents responded a b**ackground questionnaire. The instructors received all the lesson plans for each program (experimental and control) and were taught how to follow the plan precisely. **Training:** Children were divided into small groups of approximately 20, with an accompanying instructor for each group. Children in the EG received a computer program that focused on phonological awareness and print knowledge development; CG children received a computer program that focused on general cognitive skills and verbal knowledge. The training (for both groups) took place in the computer rooms of the absorptions centers. Each child worked individually on a computer alongside her/his parent, and they both received the instructors' help as needed. The sessions had a similar structure starting with a general explanation followed by practice with the computer.	**Pretest and posttest assessments:** Instructors (BA degree students) and researcher **Training:** Parents, with instructor's help when needed	One 2h session per week, 5 months (total of 50 hours)	Modifications to the Phonological Awareness Test (Lapidot, Wohl, and Tobol (1995)) used in pretest and posttest measures: shortened each section and added five sections that would more carefully examine the relationship between phonological awareness and numeracy. The computer program used in the EG was modified to focus on phonological awareness, letter knowledge, and emergent print knowledge.
(Ron Nelson et al., 2010)	Word Syllable Rhyme Phoneme	**Three periods:** pretest, training, posttest **Prior to the study:** two questionnaires were applied about literacy environment, at home and in the classroom. Training tutors implement the instructional components of the experimental and control conditions correctly. **Training:** During sessions, small groups of EG children were guided by a paraeducator through a set of instructional activities designed to promote children's phonological awareness and alphabet knowledge. Additional instructional	**Pretest and posttest assessments:** Testers trained and supervised by research staff **Training program:** Tutors with no previous teaching experience	Daily 20 min sessions, 5 days per week, over 10 weeks	Modified form of Interactive Book Reading used in the CG's intervention.

		activities were used to promote children's listening comprehension skills and understanding of the meanings of sentences/short stories. CG children were instructed using pictures and guiding prompts to introduce, engage and motivate, encourage explanations, and support independent use of word meanings.			
(Vanbecelaere et al., 2019)	Syllable Phoneme	**Three periods:** pretest, training, posttest **Training:** The researcher came to the classroom to distribute the tablets and headphones for each intervention (EG1 and EG2). Non-adaptive (EG1) and adaptive (EG2) program contained identical tasks and the same order of levels. The CG children received paper-and-pen tasks, which were developed by the researchers.	**Training program:** Teachers	Five 30 min sessions, over 5 weeks	Not reported

Table 3. Methodological quality of the included studies.

Reference	Intervention	Control	Randomization	Blinding	Methodological Quality
(Bodé & Content, 2011)	Phonological Training Program adapted to Luxembourgish	Regular kindergarten program	Randomization reported but procedure not described.	Blinding of evaluators reported. No blinding of participants reported.	Strong quality: 82.14%
(Cardoso-Martins et al., 2011)	Phonological Awareness Instruction	Semantic categorization training	Randomization reported but procedure not described.	No blinding of evaluators or participants reported.	Fair quality: 67.86%
(Degé et al., 2011)	Music program for Phonological Awareness	Sports training	Randomization reported but procedure not described.	No blinding of evaluators or participants reported.	Fair quality: 60.71%
(Ecalle et al., 2015)	Evidence-based literacy practices	Conventional classroom teaching	Randomization reported but procedure not described.	No blinding of evaluators or participants reported.	Good quality: 78.57%
(Ferraz et al., 2015)	Phonological Awareness Program	Treatment as usual	Randomization reported but procedure not described.	Blinding of evaluators reported. No blinding of participants reported.	Fair quality: 67.86%
(Goffredo et al., 2016)	Platform *En Plein*, for the practice of phonological skills	Treatment as usual	Randomization reported but procedure not described.	No blinding of evaluators or participants reported.	Fair quality: 60.71%
(Kelly et al., 2017)	*Cracking the Code* program	Words, Grammar, and Fun Program	Randomization reported but procedure not described.	Blinding of evaluators reported. No blinding of participants reported.	Strong quality: 82.14%
(Korat et al., 2017)	Computer-based early literacy program	Computer-based program focused on general cognitive abilities and language skills	Randomization reported but procedure not described.	Blinding of evaluators reported. No blinding of participants reported.	Strong quality: 89.29%
(Ron Nelson et al., 2010)	*Stepping Stones to Literacy,* a phonological awareness intervention program focused on early literacy	Modified form of Interactive Book Reading	Randomization reported but procedure not described.	Blinding of evaluators reported. No blinding of participants reported.	Strong quality: 82.14%
(Vanbecelaere et al., 2019)	*Reading Game*: adaptive and non-adaptive educational games	Pen-and-paper tasks as in the experimental conditions	Randomization reported but procedure not described.	Blinding of participants reported. No blinding of evaluators reported.	Fair quality: 64.29%

Table 4. Kmet Appraisal Checklist.

	Kelly et al. (2017)	Vanbecelaere et al. (2019)	Ron Nelson et al. (2010)	Ecalle et al. (2015)	Cardoso-Martins et al. (2011)	Korat et al. (2017)	Bodé & Content (2011)	Ferraz et al. (2015)	Goffredo et al. (2016)	Degé et al. (2011)
1. Question / objective sufficiently described?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Study design evident and appropriate?	P	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Method of subject/comparison group selection or source of information/input variables described and appropriate?	Y	P	Y	Y	Y	Y	Y	Y	Y	Y
4. Subject (and comparison group, if applicable) characteristics sufficiently described?	P	P	P	P	P	Y	P	P	Y	P
5. If random allocation to treatment was possible, was it described?	P	P	P	P	P	P	P	P	P	P
6. If interventional and blinding of investigators was possible, was it reported?	Y	N	Y	N	N	Y	Y	N	N	N
7. If interventional and blinding of subjects was possible, was it reported?	N	Y	N	N	N	N	N	N	N	N
8. Outcome and (if applicable) exposure measure(s) well defined and robust to measurement / misclassification bias? means of assessment reported?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
9. Sample size appropriate?	Y	P	P	Y	P	Y	Y	Y	P	P
10. Analytic methods described/justified and appropriate?	Y	P	Y	Y	P	Y	P	P	P	P
11. Some estimate of variance is reported for the main results?	Y	N	Y	Y	P	Y	Y	N	N	N
12. Controlled for confounding?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
13. Results reported in sufficient detail?	Y	P	Y	Y	Y	Y	Y	Y	N	P
14. Conclusions supported by the results?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

[…] program in preschool) and control groups (e.g., children who did not receive the PA program in preschool). The other examined the children's performance in Grade 4 through a national assessment test. Results showed significant differences between the experimental and control group in math; no significant differences were found between groups in the Portuguese test. See Table 1 for further details of the main findings in each study.

Quality assessment of the studies

Using the Kmet checklist, four studies were rated as having "strong" methodological quality, and one study was rated as "good". The remaining five studies were rated as having "fair" methodological quality for the following reasons: subject characteristics were not sufficiently described; random allocation to intervention was not described; the sample size was not appropriate; analytic methods were not described/justified or appropriate; no estimate of variance reported for the main results; and insufficient details in reported results. A description of the methodological quality and Kmet ratings is provided in Table 3.

Risk of bias

All studies reported a random distribution of participants in groups, however, no study reported how participants were allocated to each group (i.e., experimental, control), resulting in a lack of clarity regarding the presence of selection bias. Nearly all studies (n = 9) were at risk of bias due to challenges in blinding the participants; only one study reported blinding of participants to the intervention group. Regarding blinding of the evaluators, half of the included studies (n = 5) reported that the evaluators were blind to the aims of the study. The remaining studies (n = 5) were deemed at risk of detection bias due to unclear reports of blinding for child-directed assessments (see Table 4).

According to the Kmet checklist's authors (Kmet et al., 2004), a sample is considered adequate if it:

> Seems reasonable with respect to the outcome under study and the study design. When statistically significant results are achieved for major outcomes, appropriate sample size can usually be assumed, unless large standard errors (SE > ½ effect size) and/or problems with multiple testing are evident (Kmet et al., 2004, p. 17).

The sample size was deemed adequate for five studies, as standard errors were not greater than half of its intervention effect. The adequacy of the sample size could not be confirmed for the remaining five studies, as standard errors were not reported.

DISCUSSION

The aim of the present review was to 1) synthesize the literature on PA stimulation programs in typically developing preschool children; 2) examine the effectiveness of PA programs; and 3) critically appraise the methodology of PA stimulation programs. To meet the aforementioned objectives, a systematic review was carried out on the existing literature that studies PA programs for preschool children with typical language development, examining the effectiveness of the PA programs. A total of 10 studies met the inclusion criteria. Overall, the results demonstrated the effectiveness of stimulation programs in the development of phonological awareness. Although some studies (n = 3) did not show statistically significant differences between the experimental groups and the control groups, improvements in the post-test outcome measures of the experimental group were clear. The absence of significant differences may be explained by the type of analysis carried out (e.g., some of the studies only compared the groups' mean scores) or by the characteristics of the program (e.g., duration, activities, application context). Despite positive findings after the application of PA stimulation programs in typically developing preschool children, our review identified inconsistencies in the methodology that may have impacted the overall results.

The description of participant characteristics is important for determining their eligibility (Kmet et al., 2004). However, inclusion and exclusion criteria were not described across all of the studies included in this review. Five of the studies included in this review did not describe these criteria in detail, creating a greater risk of bias.

Six studies included in this review did not carry out training for the delivery of PA stimulation programs. Implementing preparatory training is essential for consistency among the professionals delivering the programs, ultimately reducing the risk of bias. If professionals are not sufficiently trained, they will not have appropriate knowledge about the program and are at risk of making mistakes during its application, thus affecting the results.

It was also noted that only one study described the use of a standardized test for PA. The use of standardized tests is beneficial for evaluation consistency, as the assessment is carried out systematically. Consequently, failing to report the training of assessors on evaluation methods (e.g., outcome measures), may increase the likelihood of inconsistency among evaluations, contributing to bias in outcome measures.

In addition to the inconsistencies identified in the methodology, this review also identified key areas requiring further investigation, such as parental involvement, the long-term impact of PA programs on the development of reading and writing, and the use of technology for PA programs. All PA stimulation programs included in this review were carried out at school, which can be considered a place that enhances the effectiveness of the program since children spend most of the day there (Brazendale et al., 2017). In this sense, parental involvement was very low as only one study included parents in the application of the program. However, this factor must be considered in the design of the study. Including the parents in the application of the program can be a strategy for the generalization of skills, since it provides knowledge of the skills targeted to these interlocutors and allows the continuation of stimulation in other contexts (Almeida, 2004; Dunst et al., 1988). Therefore, adjusting the balance between the participation of teachers and parents could increase the effectiveness of the stimulation programs. Nevertheless, there is a lack of research in the area of parent-mediated PA stimulations that allows for stronger conclusions to be reached.

Phonological awareness is composed of different levels, based on the division of their sound constituents (Alves et al., 2010; Caravolas & Bruck, 1993). However, there are few studies included in this review (n = 2) that include activities aimed at all levels of PA. In this sense, more research is needed that addresses stimulation of all the levels of PA (e.g., syllabic awareness, intrasyllabic awareness, segment/phonemic awareness, and word awareness).

In addition to the need for further research on the effects of PA programs on each PA level, more research is needed to examine the long-term benefits of stimulation programs; follow-up data were reported in only two studies included in this review. With PA being a strong and important predictor of literacy development (Carroll et al., 2003; Castles & Coltheart, 2004; Ehri, 1989; Liberman et al., 1990; Rack et al., 1994; Share, 2004; Wagner & Torgesen, 1987), there is a need for researchers to track the effects of interventions over time, in order to evaluate their impact on the development of reading and writing.

Finally, in this literature review, only three studies assessed digital programs. However, the current use of computers, smartphones, tablets, and other devices by young children has significantly increased in the past years (Furió et al., 2013). Furthermore, there is evidence that the use of digital games is an effective option for enhancing learning since they seem to increase the interest of children in the activities (Jesus et al., 2015; Papastergiou, 2009; Sá et al., 2019, 2022). In this sense, it is necessary to develop more innovative PA stimulation programs, including activities that are more dynamic and motivating.

This literature review presents some limitations that should be acknowledged. Studies written in languages other than English, quasi-experimental design studies, and single-case experimental designs were excluded from the review. Thus, future research should include studies with a lower risk of bias (e.g., clearer inclusion and exclusion criteria, blinding of participants, blinding of evaluators).

CONCLUSION

The present review carried out a synthesis of the literature on PA stimulation programs in typically developing preschool children, while examining the effectiveness of these programs and critically appraising their methodology. Studies were included that approached the stimulation of this skill and the analysis confirmed the effects of stimulating phonological awareness. However, in some of the included studies, the inclusion and exclusion criteria were not clearly defined. Similarly, the training of professionals that conduct the assessment and training was not considered in all the reviewed studies. It is recommended that in future research the eligibility criteria and the training of professionals are described in more detail.

PA stimulation programs are generally effective for preschool children with typical development. However, further research is needed to investigate the long-term impact of PA programs on the development of reading and writing. Additionally, research on the role of parents in supporting the generalization of PA skills is also needed. Lastly, advancements in technology provide good possibilities for the delivery of PA programs; however, whether digital PA programs are superior to traditional methods (pen/paper) requires further exploration.

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REFERENCES

Almeida, I. C. de. (2004). Intervenção precoce: Focada na criança ou centrada na família e na comunidade? *Análise Psicológica*, *22*(1), 65–72. https://doi.org/10.14417/ap.130

Alves, D., Castro, A. L. A. dos S. F. de, & Correia, S. (2010). Consciência Fonológica—Dados sobre consciência fonémica, intrassilábica e silábica. En A. Maria Brito, F. Silva, J. Veloso, & A. Fiéis (Eds.), *Textos Seleccionados do XXV Encontro Nacional da APL* (pp. 169–184). Associação Portuguesa de Linguística. https://novaresearch.unl.pt/en/publications/consci%C3%AAncia-fonol%C3%B3gica-dados-sobre-consci%C3%AAncia-fon%C3%A9mica-intrassil

Bodé, S., & Content, A. (2011). Phonological awareness in kindergarten: A field study in Luxembourgish schools. *European Journal of Psychology of Education*, *26*(1), 109–128. https://doi.org/10.1007/s10212-010-0039-0

Brazendale, K., Beets, M. W., Weaver, R. G., Pate, R. R., Turner-McGrievy, G. M., Kaczynski, A. T., Chandler, J. L., Bohnert, A., & von Hippel, P. T. (2017). Understanding differences between summer vs. school obesogenic behaviors of children: The structured days hypothesis. *The International Journal of Behavioral Nutrition and Physical Activity*, *14*(100), 1–14. https://doi.org/10.1186/s12966-017-0555-2

Caravolas, M., & Bruck, M. (1993). The Effect of Oral and Written Language Input on Children's Phonological Awareness: A Cross-Linguistic Study. *Journal of Experimental Child Psychology*, *55*(1), 1–30. https://doi.org/10.1006/jecp.1993.1001

Cardoso-Martins, C., Mesquita, T. C. L., & Ehri, L. (2011). Letter names and phonological awareness help children to learn letter-sound relations. *Journal of Experimental Child Psychology*, *109*(1), 25–38. https://doi.org/10.1016/j.jecp.2010.12.006

Carroll, J., Snowling, M., Stevenson, J., & Hulme, C. (2003). The Development of Phonological Awareness in Preschool Children. *Developmental Psychology*, *39*(5), 913–923. https://doi.org/10.1037/0012-1649.39.5.913

Castelo, A. (2012). *Competência metafonológica e sistema não consonântico no português europeu:descrição, implicações e aplicações para o ensino do português como língua materna* [Tesis Doctoral, Universidade de Lisboa]. https://repositorio.ul.pt/handle/10451/7454

Castles, A., & Coltheart, M. (2004). Is there a causal link from phonological awareness to success in learning to read? *Cognition*, *91*(1), 77–111. https://doi.org/10.1016/s0010-0277(03)00164-1

Degé, F., Schwarzer, G., Dege, F., & Schwarzer, G. (2011). The effect of a music program on phonological awareness in preschoolers. *Frontiers in Psychology*, *2*(JUN). https://doi.org/10.3389/fpsyg.2011.00124

Dunst, C. J., Trivette, C. M., & Deal, A. G. (1988). *Enabling and empowering families: Principles and guidelines for practice* (pp. xiv, 219). Brookline Books.

Ecalle, J., Labat, H., Le Cam, M., Rocher, T., Cros, L., & Magnan, A. (2015). Evidence-based practices to stimulate emergent literacy skills in kindergarten in France: A large-scale study. *Teaching and Teacher Education*, *50*, 102–113. https://doi.org/10.1016/j.tate.2015.05.002

Ehri, L. C. (1989). The development of spelling knowledge and its role in reading acquisition and reading disability. *Journal of Learning Disabilities*, *22*(6), 356–365. https://doi.org/10.1177/002221948902200606

Ferraz, I., Pocinho, M., Pereira, A., & Pimenta, A. (2015). Phonological Awareness Program: A longitudinal study from Preschool to 4th Grade. En B. Donahue, C and Mamede, M and Marin (Ed.), *9th International Conference: Literacies and Effective Learning and Teaching for All* (Vol. 16). https://doi.org/10.1051/shsconf/20151601002

Freitas, M. J., Alves, D., & Costa, T. (2007). *O Conhecimento da Língua:* Ministério da Educação - Direcção-Geral de Inovação e de Desenvolvimento Curricular. https://area.dge.mec.pt/gramatica/O_conhecimento_da_lingua_desenv_consciencia_fonologica.pdf.pdf

Furió, D., González-Gancedo, S., Juan, M.-C., Seguí, I., & Rando, N. (2013). Evaluation of learning outcomes using an educational iPhone game vs. Traditional game. *Computers & Education*, *64*, 1–23. https://doi.org/10.1016/j.compedu.2012.12.001

Goffredo, M., Bernabucci, I., Lucarelli, C., Conforto, S., Schmid, M., Nera, M. M., Lopez, L., D'Alessio, T., & Grasselli, B. (2016). Evaluation of a motion-based platform for practicing phonological awareness of preschool children. *Journal of Educational Computing Research*, *54*(5), 595–618. https://doi.org/10.1177/0735633115626881

Hulme, C., Hatcher, P., Nation, K., Brown, A., Adams, J., & Stuart, G. (2002). Phoneme Awareness Is a Better Predictor of Early Reading Skill Than Onset-Rime Awareness. *Journal of experimental child psychology*, *82*, 2–28. https://doi.org/10.1006/jecp.2002.2670

Jesus, L., Santos, J., Martinez, J., Lousada, M., & Pape, D. (2015). *The Table to Tablet (T2T) Therapy Software Development Approach*. *2*, 57–60. https://doi.org/10.1109/CISTI.2015.7170549

Kelly, C., Leitão, S., Smith-Lock, K., & Heritage, B. (2017). The effectiveness of a classroom-based phonological awareness program for 4–5-year-olds. *International Journal of Speech-Language Pathology*, *21*(1), 101–113. https://doi.org/10.1080/17549507.2017.1400589

Kmet, L. M., Cook, L. S., & Lee, R. C. (2004). *Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields*. Heritage Foundation for Medical Research. https://doi.org/10.7939/R37M04F16

Korat, O., Gitait, A., Deitcher, D. B., & Mevarech, Z. (2017). Early literacy programme as support for immigrant children and astransfer to early numeracy. *Early Child Development and Care*, *187*(3–4), 672–689. https://doi.org/10.1080/03004430.2016.1273221

Liberman, I. Y., Shankweiler, D., & Liberman, A. M. (1990). The Alphabetic Principle and Learning To Read. *Haskins Laboratories Status Report on Speech Research*, 1–13. https://eric.ed.gov/?id=ED427291

Lundberg, I., Larsman, P., & Strid, A. (2012). Development of phonological awareness during the preschool year: The influence of gender and socio-economic status. *Reading and Writing*, *25*(2), 305–320. https://doi.org/10.1007/s11145-010-9269-4

Papastergiou, M. (2009). Digital Game-Based Learning in High School Computer Science Education: Impact on Educational Effectiveness and Student Motivation. *Computers & Education*, *52*(1), 1–12. https://doi.org/10.1016/j.compedu.2008.06.004

Pfost, M., Blatter, K., Artelt, C., Stanat, P., & Schneider, W. (2019). Effects of training phonological awareness on children's reading skills. *Journal of Applied Developmental Psychology*, *65*, 1–12. https://doi.org/10.1016/j.appdev.2019.101067

Rack, J., Hulme, C., Snowling, M., & Wightman, J. (1994). The role of phonology in young children learning to read words: The direct-mapping hypothesis. *Journal of Experimental Child Psychology*, *57*(1), 42–71. https://doi.org/10.1006/jecp.1994.1003

Ron Nelson, J., Sanders, E. A., & Gonzalez, J. (2010). The efficacy of supplemental early literacy instruction by community-based tutors for preschoolers enrolled in head start. *Journal of Research on Educational Effectiveness*, *3*(1), 1–25. https://doi.org/10.1080/19345740903381031

Sá, M., Miranda, J., Capelas, S., Valente, R., Figueiredo, J., Machado, B., Ferreira, T., & Lousada, M. (2019). Development of the Phonological Awareness Stimulation Programme (PECF)—Digital version. *2019 14th Iberian Conference on Information Systems and Technologies (CISTI)*, 1–6. https://doi.org/10.23919/CISTI.2019.8760963

Sá, M., Sa-Couto, P., & Lousada, M. (2022). Phonological awareness digital program: A randomized controlled study. *Revista de Investigación En Logopedia*, *12*(1), e77402–e77402. https://doi.org/10.5209/rlog.77402

Segers, E., & Verhoeven, L. (2005). Long-term effects of computer training of phonological awareness in kindergarten. *Journal of Computer Assisted Learning*, *21*(1), 17–27. https://doi.org/10.1111/j.1365-2729.2005.00107.x

Share, D. L. (2004). Knowing letter names and learning letter sounds: A causal connection. *Journal of Experimental Child Psychology*, *88*(3), 213–233. https://doi.org/10.1016/j.jecp.2004.03.005

Tibi, S., & Kirby, J. R. (2018). Investigating phonological awareness and naming speed as predictors of reading in Arabic. *Scientific Studies of Reading*, *22*(1), 70–84. https://doi.org/10.1080/10888438.2017.1340948

Tunmer, W. E., Bowey, J. A., & Grieve, R. (1983). The development of young children's awareness of the word as a unit of spoken language. *Journal of Psycholinguistic Research*, *12*(6), 567–594. https://doi.org/10.1007/BF01067963

Vanbecelaere, S., Van den Berghe, K., Cornillie, F., Sasanguie, D., Reynvoet, B., & Depaepe, F. (2019). The effectiveness of adaptive versus non-adaptive learning with digital educational games. *Journal of Computer Assisted Learning*. https://doi.org/10.1111/jcal.12416

Wagner, R., & Torgesen, J. (1987). *The nature of phonological processing and its causal role in the acquisition of reading skills.* https://doi.org/10.1037/0033-2909.101.2.192

Yeung, S. S. S., Siegel, L. S., & Chan, C. K. K. (2013). Effects of a phonological awareness program on English reading and spelling among Hong Kong Chinese ESL children. *Reading and Writing*, *26*(5), 681–704. https://doi.org/10.1007/s11145-012-9383-6