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Early literacy interventions: effects of invented writing and phonological awareness on reading and writing

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ABSTRACT

The development of reading in literate contexts depends largely on the early strengthening of specific linguistic skills that act as precursors to written language. Among these, phonological awareness and invented writing have been shown to have a differential impact on reading acquisition, particularly in transparent languages such as Spanish. This study aimed to compare the effects of three intervention methods on five-year-old Spanish-speaking children: computer-mediated phonological awareness, invented writing in small groups, and a combined intervention. A quasi-experimental design with pre- and post-test measurements was used, in addition to a follow-up assessment six months later. The interventions were applied over eight weeks and evaluated using pre- and post-tests, as well as a follow-up measurement at six months. Although no significant differences were observed between groups, all participants improved their reading skills, including reading new words. However, persistent difficulties in reading pseudowords suggest incomplete consolidation of the phonological pathway. These findings provide empirical evidence on the effectiveness and sustainability of early interventions in initial literacy.

Keywords: early literacy, invented writing, phonological awareness, reading, preschool.

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1. Introduction

The acquisition of written language is based on a set of linguistic skills that precede formal reading and writing instruction. According to the National Institute for Literacy (NIL) (2008), skills such as knowledge of the alphabet and phonological awareness are important predictors of future written language proficiency. Furthermore, early interventions targeting these skills can improve overall literacy development.

Most studies on this topic have been conducted with English-speaking samples, a language that differs significantly from Spanish in its relationship with the alphabetic code (Balbi et al., 2018). Therefore, it is important to have research on Spanish-speaking samples that explore which prior skills are most important and whether intervention in these skills yields positive results in subsequent reading performance.

Although phonological awareness (PA) skills have been considered important precursors to reading for years (Defior et al., 2008), we did not find consistent results in this regard. This study found a positive correlation between phonemic awareness (PhA), reading and writing from the age of 6 onwards. However, this skill explains a low percentage of the variance and begins to be predictive when explicit code teaching begins.

Zugarramurdi et al. (2022) conducted a longitudinal study with a sample of non-reading Spanish-speaking children from the third year of pre-school to the first year of primary school. The aim was to analyze the unique contribution of pre-reading PA, sound knowledge and letter naming to subsequent reading skills. It was found that PA had a floor effect and did not contribute uniquely to the prediction of reading acquisition, unlike other skills such as letter knowledge, rapid naming (RN) or short-term memory (STM). This pattern has been confirmed in other longitudinal and quasi-experimental studies in Spanish (Casillas and Goikoetxea, 2007).

On the other hand, there are discrepancies regarding the relative importance of metalinguistic skills in learning to read. Although PhA has always been considered the most important skill for reading readiness, syllabic awareness has been shown to play an important mediating role in word reading (Pérez-Pereira et al., 2020). In a meta-analysis of 47 studies, Míguez-Álvarez et al. (2022) found that the strongest relationship with subsequent reading competence is with syllabic and intrasyllabic awareness.

Other linguistic skills that have been shown to have a decisive influence on subsequent reading acquisition are, in addition to PA, RN (Aguilar-Villagrán et al., 2010; González-Valenzuela et al., 2016; González-Valenzuela et al., 2023; McWeeny et al., 2022; Luque et al., 2016; Suárez-Coalla et al., 2013; Tolchinsky et al., 2012), knowledge of the names and sounds of letters (Martínez and Goikoetxea, 2020), short-term verbal memory (STVM) (Atkinson and Martin, 2022), and invented writing (IW) (Pollo et al., 2007; Read, 1971). The latter is one of the most powerful predictors of subsequent reading competence in both opaque languages (Hand et al., 2024; Sénéchal et al., 2023) and transparent languages (Albuquerque and Martins, 2022; Bigozzi et al., 2023; Pinto et al., 2017). Furthermore, recent studies confirm that IW not only predicts reading, but also has effects on spelling development and phonological awareness (McNeill et al., 2023; Ouellette and Sénéchal, 2017).

IW is the way children write before conventional writing instruction, actively exploring the representation of word sounds and opening a window to their grapheme-phoneme knowledge. This understanding of the alphabetical code has undergone an evolution that has been reflected by various authors (Pollo et al., 2007). In a meta-analysis conducted by Sénéchal et al. (2023) on seven studies and a sample of more than 1,500 participants, a consistent and robust correlation of 0.6 was found between IW measures at ages 5 and 6 and reading proficiency measures at age 7. IW predicts reading competence even up to the 4th year of primary school (Treiman et al., 2019).

As for studies on the effectiveness of intervention in pre-reading skills, although research on early intervention in PA in Spanish shows advantages in subsequent reading learning, these studies combine PA intervention with intervention in another skill (González-Seijas et al., 2017; Gutiérrez, 2018; Porta et al., 2021) or work with samples that have already been exposed to formal code teaching (Gutiérrez-Fresneda and Díez-Mediavilla, 2017). Furthermore, the results are contradictory regarding which component of PA is most effective in the intervention. While Gutiérrez (2018) points out that PhA is the most important element in learning to read, other studies in transparent languages, such as that by Majorano et al. (2023) with Italian children, point to syllabic awareness as a decisive component for subsequent reading acquisition.

Regarding IW interventions, Ouellette and Sénèchal (2008) conducted a 4-week intervention with 5-year-old participants. The IW intervention improved PA, spelling awareness, and reading learning ability, while the PA intervention only improved PA scores. This result is repeated in other studies by these authors (Ouellete et al., 2013) and in studies with samples from other nationalities, such as Portuguese (Albuquerque and Martins, 2021), Italian (Pinto et al., 2018), Norwegian (Hofslundsengen et al., 2016), Danish (Møller et al., 2022), and French (Pulido and Morin, 2018). More recently, studies such as that by Schrodt et al. (2024) have highlighted how spontaneous writing and early feedback impact subsequent reading throughout primary school. However, we found no research on the effectiveness of intervention in early intervention in Spanish samples.

Therefore, this study investigates the effectiveness of IW intervention in Spanish compared to PA intervention. For the PA intervention, we will use pre-reading skills sessions from the Glifing method (García et al., 2016), a computer-mediated intervention platform that can be used in groups. The IW intervention will be carried out in small groups within the classroom.

The main objective of this study was to evaluate and compare the effects of two intervention methods —invented writing and phonological awareness— on early reading and writing learning, before the formal start of written code teaching. In addition, an additional experimental condition combining both techniques was implemented.

In addition, the following specific objectives were set: (1) to evaluate the evolution of knowledge of the name and/or sound of letters, IW and PA after the intervention; (2) to compare the relative effectiveness of each method in the development of reading and writing skills; (3) to analyze the stability of the effects six months after the intervention.

This approach was structured around the following research questions: (1) What effects do interventions in PA, IW, and their combination have on the development of reading and writing skills in five-year-old children? (2) Do these effects persist six months after the end of the interventions? (3) Are there significant differences between the three types of intervention in terms of reading and writing performance?

2. Method

To meet the objectives set, a quasi-experimental study was designed using naturally formed classroom groups without random assignment, which were evaluated at three points in time: before the intervention, at the end of the intervention, and six months later.

2.1. Participants

Fifty-two subjects from three Year 3 nursery classes at a state school in the province of Toledo participated in this study. An informed consent document was prepared for the families. This project was approved by the Social Sciences Research Ethics Committee of the University of Castilla-La Mancha and by the Regional Government's Department of Education.

Students with neurodevelopmental disorders, absenteeism, or a mother tongue other than Spanish were excluded from the sample. The groups were randomly assigned to the intervention condition. In group A, only the Glifing intervention was implemented; in group C, only IW was implemented; and in group B, both interventions were combined. Table 1 shows the sociodemographic features by group. In the follow-up measurements, the sample was reduced to 48 subjects, as one participant from group A, two from group B, and one from group C were not at the center on the days when the tests were administered.

Table 1
Features of participants. Own elaboration

Groups	N	Girls	Boys	Average age (in months)
Grupo A	15	6	9	67,3
Grupo B	19	8	11	65,9
Grupo C	18	7	11	68,1
TOTAL	52	21	31	67,1

Gender: X^2= 0.041, p= 0.980 Age: F= 1.659, p = 0.2

2.2. Instruments

2.2.1. Pre- and post-intervention assessment

The assessment included various tasks designed to measure key skills related to reading and writing. Some of these were taken from previously validated instruments: tests of syllabic awareness, phonemic awareness, and knowledge of the name and/or sound of letters were taken from the Reading Precursors Test (PreLec) (Suro and Leal, 2013), while the tasks of naming speed and short-term verbal memory come from the PROLEXIA protocol (Cuetos et al., 2020). Both tests have psychometric properties suitable for use with children. In the case of PreLec, reliability has been assessed using Cronbach's alpha coefficient, reaching values above 0.8 in most subtests, reflecting acceptable internal consistency (Suro and Leal, 2013). For its part, the PROLEXIA protocol has shown high levels of reliability (α between 0.85 and 0.95) and evidence of content and construct validity, supporting its usefulness for the early detection of reading difficulties in children aged 4 to 6 years (Cuetos et al., 2020). The assessment of invented writing was carried out using a rubric developed by the research team. The tasks administered are described below:

- *Word reading:* Ten high-frequency, two-syllable words with a direct syllabic structure were displayed and had to be read aloud. One point was awarded for each word read correctly. The maximum score was 10 and the minimum was 0.
- *Syllabic awareness*: Subjects were asked to remove the syllable indicated from a given word and say the resulting word. The maximum score was 5 and the minimum was 0.
- *Phonemic awareness*: The subject had to delete a phoneme from the indicated word. The maximum score was 5 and the minimum was 0.

- *Knowledge of the name and/or sound of letters*: A sheet was prepared with the 27 letters of the alphabet and 3 digraphs, LL, CH and RR. The letters were arranged in alphabetical order in columns from left to right, while the subjects had to read them in rows, from left to right. The maximum score was 30 and the minimum was 0.
- *Speed of naming (SAN)*: Two tasks were proposed, one involving naming colors and the other naming objects. In both tasks, the time taken to name the stimuli was recorded in seconds.
- *Short-term memory*: A digit recall task was presented consisting of series of numbers that increase in length and must be repeated after the evaluator says them aloud. The maximum score is 10 and the minimum is 0.
- *Invented writing (IW)*: To assess IW, we asked participants to write their own name. Then, six disyllabic words were dictated, accompanied by an image to eliminate memory problems. The assessment was carried out using a rubric developed by the research team with scores from 0 to 10. Three independent assessors rated the productions, and inter-rater agreement was calculated using Cohen's Kappa index, which reached a value of 0.95.

2.2.2. PA intervention

Glifing is a web platform that offers activities designed to develop reading skills: the "Palmasil" package (focused on syllabic segmentation), "Phonological Awareness" (focused on rhyming), "Do they sound the same?" (aimed at working on syllabic segmentation and phonographic discrimination) and Phonogames (on the ordering and omission of syllables).

2.2.3. Intervention with invented writing

To implement the intervention in IW, heterogeneous groups of 6 children were formed based on the results obtained in the pretest. The IW sessions were guided by a member of the research team. The aim of the intervention was for the children to discuss how to write a series of words until they reached a consensus. As the sessions progressed, they were also asked to write noun phrases and simple sentences in a narrative context, to give more meaning to their productions and increase the children's motivation.

During the first eight sessions, they were shown four images of animals (one at a time) and had to decide which letters to use and in what order to write their names. Once a consensus was reached, the adult wrote the word correctly and said, "A child from another school told me that this is how it is spelled" (following the procedure described by Martins et al., 2017). After this, they were invited to reflect again on how they had spelled the word. In session 9, movable letters were introduced to encourage group work. In session 10, they were asked to write a list of their names and the name of their team on an envelope in which they would keep their work. In session 11, they were asked to make a list of the titles of stories they knew. In session 12, a story was read to them, and they were asked to write a list of the characters. The last four sessions were devoted to writing their own story.

2.2.4. Combined PA and IW intervention

The combined intervention included eight intervention sessions with Glifing (four with Palmasil, three with Phonological Awareness, and one with Phonogames) and eight with IW (sessions 3, 9, 10, 11, 13, 14, 15, and 16 of the IW intervention).

2.3. Procedure

The pretest was administered individually and took approximately 15–20 minutes. Subsequently, we carried out an 8-week intervention, twice a week in 25-minute sessions. In the group that underwent a combined Glifing-IW intervention, each intervention was alternated each week. Six months after the intervention, a follow-up test was conducted, consisting of reading 20 words and 20 pseudowords, as well as writing the 20 words used in the reading test.

Non-parametric tests were used for statistical analysis, given the distribution characteristics of the variables. The Kruskal-Wallis and Wilcoxon tests and Games-Howell post-hoc analysis were applied. Non-parametric factorial analyses were also performed using the nparLD package in the R statistical environment (version 4.0.2) to examine group effects, time effects, and interactions. Descriptive analyses and additional tests were performed using SPSS (version 26).

3. Results

Table 2 shows the means and standard deviations of all measures in the three groups before the intervention.

In the Shapiro-Wilk test, all groups showed values less than 0.05, except CONLET in group 1 ($p = 0.330$), RANCOLTI in group 3 ($p = 0.297$), RANOBJTI in group 1 ($p = 0.068$), RANOBJTI in group 2 ($p = 0.150$), and DIGITOS in group 2 ($p = 0.190$).

The homogeneity of variances was assessed using Levene's test. The results indicated significant heterogeneity of variances for the variables LECPAL ($p < 0.001$), CONSIL ($p \leq 0.012$), and CONFON based on the mean ($p = 0.021$) and trimmed mean ($p = 0.048$). No significant heterogeneity was observed in the variables CONLET ($p \geq 0.128$), RANCOLTI ($p \geq 0.794$), and RANOB-JTI ($p \geq 0.576$).

The results for DIGITOS also showed significant heterogeneity (p = 0.010). Due to the characteristics of the data, we opted to use non-parametric tests.

To check the initial homogeneity of the groups, we performed the Kruskal-Wallis test. All variables were found to be homogeneous, except for CONSIL (H = 8.87, p = 0.012) and CONLET (H = 16.45, p < 0.001).

Post-hoc analyses were performed using the Games Howell test. Differences in CONSIL were found between Group A (Mdn=0) and Group B (Mdn = 1), 95% CI [0.13, 2.10], p < 0.05. Similarly, the CONLET variable was higher in Group B (Mdn=28) than in Group A (Mdn = 15) 95% CI [2.90, 12.54], p = 0.001, and C (Mdn = 17.5) 95% CI [2.85, 14.46], p = 0.003.

Table 3 shows the descriptive statistics for the post-test measurements.

Table 2

Pre-intervention measures in the three groups. Own elaboration

		Mean	Median	SD	Minimum	Maximum	Skewness	Kurtosis
	1	2,2	0	3,27	0	10	1,66	1,98
LECPAL	**2**	4,21	1	4,61	0	10	0,28	-1,97
	3	1,44	0	2,99	0	9	1,89	2,22
	1	0,2	0	0,77	0	3	3,87	15
CONSIL	**2**	1,32	1	1,49	0	4	0,84	-0,62
	3	0,94	0,5	1,34	0	5	1,89	3,92
	1	0,2	0	0,41	0	1	1,67	0,89
CONFON	**2**	0,74	0	1,52	0	5	2,08	3,28
	3	0,94	0	1,43	0	5	1,72	2,64
	1	17,4	15	7,57	5	29	0,23	-1,11
CONLET	**2**	26,05	28	5,51	8	30	-2,24	5,88
	3	18,33	17,5	6,38	6	30	-0,03	-0,21
	1	51.94	47.06	14.71	35.75	94.02	1.831	4,08
RANCOLTI	**2**	48,85	44,3	15,02	28,22	80,02	0,92	0,04
	3	47,76	45,54	11,22	32	68	0,2	-1,22
	1	59,29	56,58	17,85	29,45	105,11	1,16	2,35
RANOBJTI	**2**	54,39	51	15,34	34,63	88,35	0,72	-0,34
	3	52,43	51,5	13,68	37	96	1,83	5,51
	1	3	3	0,65	2	4	0	-0,17
DIGITOS	**2**	3,42	4	1,5	0	7	0,06	1,46
	3	3,33	3	0,84	2	5	-0,07	-0,47
	1	6,28	5,33	2,34	3,5	10	0,48	-1,49
IW	2	6,69	6,66	3,11	1	10	-0,25	-1,51
	3	5,99	5,33	2,01	1,5	10	0	0,37

LECPAL: Word reading; CONSIL: Syllabic awareness; CONFON: Phonological awareness; CONLET: Letter knowledge; RAN-COL: Time in RAN colors; RANOBJ: Time in RAN objects; DIGITOS: Digit memory; IW: Invented writing.

Table 3
Post-intervention measures in the three groups. Own elaboration

		Mean	Median	SD	Minimum	Maximum	Skewness	Kurtosis
RLECPAL	**1**	4,4	3	3,92	0	10	0,23	-1,64
	2	5,79	7	4,18	0	10	-0,38	-1,56
	3	3,78	3	3,76	0	10	0,41	-1,52
RCONSIL	**1**	0,4	0	0,82	0	3	2,54	7,06
	2	1,58	1	1,77	0	5	0,58	-1,18
	3	1,17	1	1,38	0	5	1,31	1,99
RCONFON	**1**	0,47	0	0,74	0	2	1,33	0,47
	2	1,47	0	2,01	0	5	0,91	-0,87
	3	1,28	1	1,40	0	5	1,15	1,30
RCONLET	**1**	21,53	22	6,32	8	30	-0,49	-0,35
	2	26,84	29	4,54	14	30	-1,65	2,35
	3	20,89	23	7,80	0	29	-1,35	1,75
RRANCOLTI	**1**	49,41	43	24,05	32	130	2,99	10,17
	2	49,82	47,78	17,32	28	90	1,07	0,65
	3	44,90	43,5	10,88	32	75	1,20	2,03
RRANOBJ	**1**	59,88	57	18,21	40	106	1,33	1,69
	2	57,64	52	28,68	34	149	2,12	5,24
	3	55,61	53,5	16,67	34	94	0,97	0,37
DIGITOS	**1**	2,93	3	1,03	2	6	1,94	5,26
	2	3,21	3	1,27	2	6	0,82	-0,40
	3	3,33	3	1,53	2	7	1,34	0,95
IWPOST	**1**	7,9	9,5	2,26	4	10	-0,42	-1,64
	2	7,89	9,66	2,77	0	10	-1,49	2,24
	3	6,85	6,75	2,57	3,5	10	0,02	-1,80

LECPAL: Word reading; CONSIL: Syllabic awareness; CONFON: Phonological awareness; CONLET: Letter knowledge; RANCOL: Time in RAN colors; RANOBJ: Time in RAN objects; DIGITOS: Digit memory; IW: Invented writing.

For variables that did not show differences between groups in the pre-test, non-parametric factorial analyses were performed to determine the effect of the type of training on the variables analyzed. For this purpose, the "nparLD" package in R (R Core Team, 2019) was used, which allows factorial analyses based on ranks to be performed, even in the case of unknown distribution or outliers (Noguchi et al., 2012). The Relative Treatment Effect (RTE) was used as a measure of effect. According to the criteria of Vargha and Delaney (2000), RTE values greater than 0.71 or less than 0.29 are considered to have a high effect; RTE values between 0.71 and 0.64 or between 0.29 and 0.36 are considered to have a medium effect; and RTE values between 0.56 and 0.63 or between 0.37 and 0.44 are considered to have a low effect. Post-hoc tests were performed using the same nparLD package. The results of this analysis are shown in Table 4. In this table, we can see that there is a statistically significant time effect on the RLECPAL and IW variables, such that in both variables the participants improved their scores after the respective interventions (all ps < 0.011), except for group 3 in the IW variable, whose post-hoc test was not significant (p = 0.343).

The evolution of the scores measured in these variables can be seen in Figure 1, which allows us to visualize the improvements achieved in the different intervention groups over time.

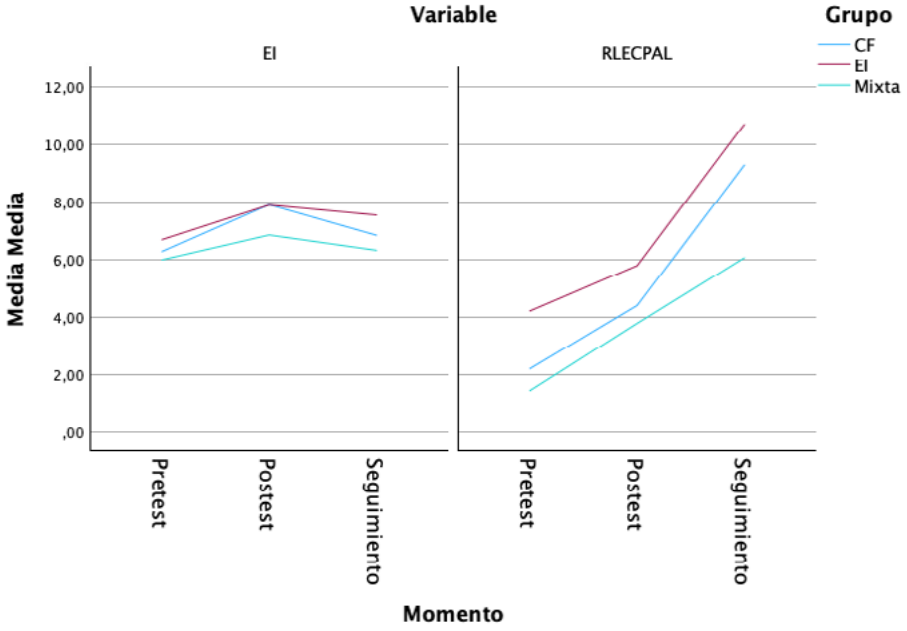

Figure 1. *Mean scores on the RLECPAL and IW variables in the pre-test, post-test and follow-up, by intervention group.*

For the variables that showed significant differences between groups in the pre-test evaluation (CONSIL and CONLET), the percentage change was used as a dependent variable to evaluate the effect of training in the three groups. This percentage represents the extent to which a final score changes compared to an initial score. It is calculated as follows: (Post-test score – Pre-test score) / Pre-test score). In the case of the CONSIL variable, given that a high percentage of participants scored 0 in the pre-test phase, an epsilon value (0.01) was included in the formula to calculate the percentage change. Thus, for this variable, the formula used was: (Post-test score – Pre-test score) / (Pre-test score + 0.01). Once the percentage change variables were obtained, a Kruskal Wallis test was performed to measure the effect of the group (independent variable) on the percentage change (dependent variable). The results found statistically significant differences in the percentage change of the CONLET variable (H = 10.39, p = 0.006), but not in the CONSIL variable (H = 5.33, p = 0.070). Thus, post-hoc analyses were performed for the CONLET variable using the Bonferroni test. The results showed that differences were found in CONLET between Group 1 (Mdn=0.33) and Group 2 (Mdn=0) and between Group 2 (Mdn=0) and Group 3 (Mdn=0.18). Despite these results, we must bear in mind that knowledge of letters in Group 2 remains higher than in Groups 1 and 3 in the post-test, which we can attribute to a ceiling effect in CONLET in that group.

Table 5 below presents the descriptive statistics for the follow-up measures in the three groups.

Table 4
Results of the NparLD analysis. Own elaboration

	RLECPAL	RCONFON	RRANCOLTI	RRANOBJ	DIGITOS	IW
Group effect						
F (p-value)	3,62 (0,164)	2,28 (0,106)	0,09 (0,918)	1,30 (0,272)	0,30 (0,728)	1,67 (0,434)
RTE:						
Group 1	0,51	0,41	0,52	0,59	0,46	0,51
Group 2	0,57	0,51	0,50	0,45	0,53	0,55
Group 3	0,42	0,56	0,48	0,48	0,50	0,44
Time effect						
F (p-value)	**23,19 (<0,001)**	3,84 (0,051)	2,07 (0,150)	0,14 (0,706)	2,43 (0,119)	**19,34 (<0,001)**
RTE:						
Pre-test	**0,42**	0,45	0,53	0,51	0,53	**0,44**
Post-test	**0,58**	0,54	0,47	0,50	0,47	**0,57**
Group x time interaction						
F (p-value)	0,18 (0,915)	0,31 (0,859)	1,27 (0,282)	0,84 (0,424)	0,26 (0,757)	4,21 (0,122)
RTE:						
G1 x pre-test	0,43	0,38	0,58	0,63	0,48	0,41
G1 x post-test	0,58	0,45	0,46	0,55	0,44	0,61
G2 x pre-test	0,50	0,45	0,49	0,46	0,55	0,48
G2 x post-test	0,65	0,57	0,51	0,45	0,50	0,63
G3 x pre-test	0,33	0,52	0,51	0,46	0,55	0,41
G3 x post-test	0,51	0,59	0,46	0,50	0,46	0,46

Tabla 5
Estadísticos descriptivos de las medidas de seguimiento. Elaboración propia

GROUP		Reading Words	Reading Pseudowords	IW
A	**Mean**	9,28	9,07	6,84
	Median	6	7	7,62
	N	14	14	14
	DT	8,33	7,65	2,38
B	**Mean**	10,70	8,65	7,54
	Median	8	4	8,25
	N	17	17	17
	DT	8,29	7,9	2,35
C	**Mean**	6,06	4,70	6,32
	Median	4	1	6,90
	N	17	17	17
	DT	6,33	6,04	2,39
Total	**Mean**	8,64	7,37	6,98
	Median	7	4	7,67
	N	48	48	48
	DT	7,76	7,34	2,47

The application of the IW rubric in the follow-up yielded an $\alpha = 0.982$. We used the Wilcoxon test to check for differences between the number of correctly read words and pseudowords. According to the results, the subjects in the sample correctly read more words (Mdn = 7; Range = 20) than pseudowords (Mdn = 4; Range = 20), Z = 3.684, p < 0.001, gHedges = 0.167.

To determine progress in word reading ability, given that subjects read 10 words in the pretest and posttest and 20 words in the follow-up, we calculated the success rates at each point in time for each subject and applied the Friedman test. Table 6 shows the means and SDs of the reading success rates in the pretest, posttest, and follow-up tests.

Table 6

Descriptions of reading success at the three measurement points. Own elaboration

Group		Reading success pretest	Post-test reading success	Reading success at follow-up
1	Mean	23,57	47,14	46,42
	DT	33,42	38,7	41,66
2	Mean	40,58	60	53,52
	DT	46,02	43,73	41,44
3	Mean	15,29	36,47	30,20
	DT	30,64	38,39	31,64
Total	Mean	26,66	47,91	43,23
	DT	38,33	40,84	38,83

We found significant differences with respect to the time frame, $\chi 2(2) = 22.86$, p < 0.001, W= 0.201. The success rate in the pretest (average range = 1.52) was lower than in the posttest (average range = 2.29, p = 0.001) and in the follow-up (average range = 2.19), p < 0.001, with no significant differences found between the posttest and the follow-up.

To check for inter-subject differences, we carried out a Kruskall-Wallis test with each of the success measures comparing the three groups, finding no significant differences between the groups in any of the measures.

4. Discussion

The main objective of this study was to compare the effects of three interventions, one focused on working with IW, another on PA, and a combination of both, as well as to verify the maintenance of their effects.

Our results indicate that the three interventions worked in a very similar way. A notable finding is that none of our interventions produced an improvement in PA, which remained at a very low level in both the pre-test and post-test, unlike in studies with English-speaking samples (Ehri, 2014; Ouellette et al., 2013; Sénéchal et al., 2012) and Portuguese (Martins and Silva, 2006). This is consistent with the study by Zugarramurdi et al. (2022), which shows that the floor effect in PA measures is common in Spanish-speaking samples at the age of 5. For its part, the intervention in IW has not had a major effect on word reading, which has improved equally in all groups in the post-test and has been maintained in the follow-up measures.

Another variable that has experienced significant growth is knowledge of letter names, which has increased especially in the two groups that started with lower measures, A and C.

In terms of improvement in IW complexity, all groups improved significantly, except, curiously, the group that received IW intervention, in contrast to some studies (Sénéchal et al., 2012; Tangel and Blachman, 1992; Puranik and Lonigan, 2012). Other studies, however, are consistent with this result, as they find no significant advances in conceptual knowledge of the code with IW-based interventions (Levin and Aram, 2013; Rieben et al., 2005; Silva and Martins, 2003; Ouellette and Sénéchal, 2008). Recently, Ouellette and Sénéchal (2017) found that invented writing has a stronger relationship with spelling and phonological awareness than with immediate reading progress, which may explain our results. The results of Pinto et al. (2018) show that IW-based intervention has greater effects on variables such as letter knowledge and spelling awareness than on IW itself. However, in the group that received exclusive IW intervention, significant progress was observed: the IW mean increased from 5.90 to 6.80, indicating a shift from writing not guided by speech sounds to writing influenced by syllables or phonemes. This change, which is particularly relevant in a group with low initial scores, suggests the need for more in-depth qualitative analysis in future research.

In relation to the follow-up results, word reading measures show an improvement in the post-test that is maintained 6 months later, so we can conclude that the interventions have been effective and their effects are sustained over time.

It should be noted that the words read by the subjects in the follow-up measurement were new words with respect to the pre- and post-intervention measurements. Few studies find that interventions have effects on reading new words, and these studies tend to be conducted on samples with transparent languages (Hofslundsengen et al., 2016; Martins et al., 2013; Ziegler and Goswami, 2005). Cardoso-Martins et al. (2023), in a longitudinal study, also report that the impact of certain early skills such as writing and spelling knowledge can extend to reading unfamiliar words.

Finally, reading words and pseudowords yields significant differences, which contradicts the study by Hofslundsengen et al. (2016). It should be noted that our sample presents scores that border on the floor effect in phonological awareness tasks in both the pretest and posttest, as is the case in other studies in Spanish (Carrillo, 1994; Zuga-rramurdi et al., 2022). Despite this, the subjects maintain their frequency of success in reading words, which may be due to improvements in other skills, such as knowledge of letter names or practice in decoding skills, without this translating into superior metalinguistic ability. Everything indicates that in transparent languages it is easier to read words without a noticeable increase in PA.

In short, the results show that PA intervention is as effective as IW intervention. However, our interventions differ in several respects from those described in previous studies. The PA intervention was computer-mediated and focused on syllabic and intrasyllabic awareness tasks. Regarding the EI intervention, in addition to asking children to write words and giving them feedback, we introduced invented writing in more meaningful contexts, in which they had to write their own story. In this regard, feedback on writing activities has been shown to be key to promoting phonological awareness and sound-spelling mapping (Levin and Aram, 2013; Puranik and Lonigan, 2012). According to Ehri (2014), these types of processes contribute to the early establishment of connections between phonemes and graphemes. Schrodt et al. (2024) also point out that IW promotes functional literacy, especially when integrated into authentic communicative contexts such as story writing. In the first sessions, we offered product-based feedback ("some children wrote it this way"), but as the intervention progressed, we went beyond writing isolated words.

Even so, beyond the particular characteristics of each intervention, this study has several limitations that must be carefully considered. First, it is important to mention that, at the start of the research, the groups were not homogeneous. This could have introduced initial disparities that may have influenced some of the results observed.

Secondly, simpler PA measures should be considered to check whether there are any effects of the intervention on this measure, avoiding the floor effect (Pinto et al., 2017). However, Sénéchal et al. (2012) found an improvement in writing in an IW intervention with children with low PA, so it should be considered whether these results are due to this competence behaving differently in Spanish, as pointed out by Zugarramurdi et al (2022).

In conclusion, this study shows that the interventions applied significantly improved reading and writing skills, highlighting the importance of early teaching methods focused on these skills. Future research should further explore the impact of phonological awareness and the synergies between reading and writing in transparent languages, as well as the influence of the teaching methods used in schools on the learning of written language and the development of pupils' skills.

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