Revista de Psicodidáctica 29 (2024) 69–77

Revista de Psicodidáctica

www.elsevier.es/psicod

Original

Effect of an early intervention program for oral and written language on the reasoning ability of students at risk of learning disabilities

Isaías Martín-Ruiz* and Maria-José González-Valenzuela

Departamento de Psicología Evolutiva y de la Educación, Facultad de Psicología y Logopedia, Universidad de Málaga, C/Doctor Ortiz Ramos, nº 12 (Ampliación Campus de Teatinos), 29071 Málaga, Spain

ARTICLE INFO

Article history:
Received 16 May 2023
Accepted 22 September 2023
Available online 9 October 2023

Keywords:
Learning disabilities
Reasoning
Reading
Writing
Early intervention

ABSTRACT

The relationship of certain cognitive processes with oral and written language is frequently studied, however, there is not enough research that tries to clarify the directionality of these relationships, especially in students with learning difficulties. The aim of this study is to analyze the effect of an early intervention program for oral and written language on reasoning in pupils at risk of presenting learning disabilities. The program aims to prioritize and systematize the teaching of oral and written language through the ordinary school curriculum, through five instructional components: alphabetic principle, awareness phonology, reading and writing fluency, vocabulary, and text comprehension. A total of 53 girls and boys at risk of presenting learning difficulties have participated, from four to six years of age. A mixed and longitudinal research design with repeated measures has been followed, with four phases of evaluation and three of intervention, two groups of pupils (instructed vs. not instructed) and three study variables (reasoning, classification and seriation). The evaluation of these variables has been through test of classification and seriation, with adequate validity and reliability. The instructed group has obtained better scores in reasoning, classification and seriation than the non-instructed group throughout the application of the program. The efficacy of early, systematic and planned intervention of oral and written language is highlighted as a way to improve certain cognitive abilities in subjects at risk of learning difficulties.

Efecto de un programa de intervención temprana del lenguaje oral y escrito en la capacidad de razonamiento de alumnado en riesgo de dificultades en el aprendizaje

Palabras claves:
Dificultades en el aprendizaje
Razonamiento
Lectura
Escritura
Intervención temprana

RESUMEN

La relación de determinados procesos cognitivos con el lenguaje oral y escrito es frecuentemente estudiada, sin embargo, no hay suficientes investigaciones que traten de esclarecer la direccionalidad de estas relaciones, sobre todo en estudiantes con dificultades en el aprendizaje. El objetivo de este estudio es analizar el efecto de un programa de intervención temprana del lenguaje oral y escrito en la capacidad de razonamiento en escolares en riesgo de presentar dificultades en el aprendizaje. El programa tiene como objetivo priorizar y sistematizar la enseñanza del lenguaje oral y escrito a través del curriculum escolar ordinario, mediante cinco componentes instruccionales: principio alfabético, consciencia fonológica, fluidez lectoescritora, vocabulario y comprensión textual. Han participado 53 niñas y niños en riesgo de presentar dificultades en el aprendizaje, desde los cuatro a los seis años. Se ha llevado a cabo un diseño de investigación de tipo mixto y longitudinal de medidas repetidas, con cuatro fases de evaluación y tres de intervención, dos grupos de participantes (instruido vs no instruido) y tres variables de estudio (razonamiento, clasificación y seriación). La evaluación de estas variables ha sido mediante pruebas

DOI of original article: https://doi.org/10.1016/j.psicod.2023.09.002
* Corresponding author.
E-mail addresses: ismar@uma.es (I. Martín-Ruiz), valenzu@uma.es (M.-J. González-Valenzuela).

https://doi.org/10.1016/j.psicoe.2023.10.001

tipificadas de clasificación y seriación, con una adecuada validez y fiabilidad. El grupo instruido ha obtenido mejores puntuaciones en razonamiento, clasificación y seriación que el grupo no instruido a lo largo de la aplicación del programa. Se destaca la eficacia de la intervención temprana, sistemática y planificada del lenguaje oral y escrito como modo de mejorar determinadas capacidades cognitivas en alumnado en riesgo de dificultades en el aprendizaje.

Introduction

In recent decades, numerous studies have attempted to identify certain cognitive processes that support school learning from an early age (Mackenzie & Hemmings, 2014; Partanen et al., 2019; Zhang et al., 2017). However, there is not enough research seeking to clarify the directionality of some of these relationships. The relationship of certain cognitive processes with oral and written language is studied frequently. Specifically, it has been shown that training in attention, perception, verbal memory and reasoning, among others, at an early age facilitates the learning of written language and improves the prevention of disabilities (Best et al., 2011; Fletcher et al., 2019). Scionti et al. (2020) carry out a meta-analysis of the impact of intervention on cognitive processes and find that the most widely studied and relevant ones are attention, working memory (visuospatial and verbal) and reasoning, with intervention showing positive and significant results in the case of reading, although the effect size is small at an early age (3-6 years old) (Scionti et al., 2020). Other research indicates that the effect may be greater in later stages (6 to 12 years old) (Kassai et al., 2019; Takacs & Kassai, 2019). Gathercole et al. (2019) find that interventions at an early age have positive short- and long-term benefits, as schoolchildren use cognitive strategies worked on from the beginning of their learning and incorporate them into their repertoire of skills. In addition, Cortese et al. (2015) find that programmes are more effective in pupils at risk of disabilities than in schoolchildren with normative development. Some neurobiological studies suggest that these findings on cognitive intervention at early ages have a positive effect on brain function, as well as on the structures of the prefrontal cortex, which facilitates myelination processes and the stimulation of synaptic connections, producing a physical change in the cerebral cortex (Best et al., 2011; Diamond, 2013).

There is also scientific evidence that oral and written language have a direct and positive effect on the development of certain cognitive processes (Horowitz-Kraus & Hutton, 2018; Jablonski, 2017; Kochhann et al., 2018). Research shows that early literacy learning modifies brain structure and the connections between different areas of the brain. Neuroimaging studies have indicated that the ventral and dorsal circuits related to literacy (Benítez-Burraco, 2007; Shaywitz & Shaywitz, 2008) are interrelated with circuits of verbal comprehension (Boukrina & Graves, 2013; Taylor et al., 2013), sharing resources with high-level cognitive processes. In addition, other areas of the prefrontal cortex related to cognitive functions have been found to develop and experience greater activation with literacy tasks (Dehaene, 2013; Horowitz-Kraus & Hutton, 2018; Shaywitz & Shaywitz, 2008). Other authors who also analyse the role of language in cognitive abilities, from early ages to older ages, find that at different points of literacy, changes occur according to the moment of learning; in the early stages, changes are manifested in perception and attention, and later in cognitive reasoning and flexibility (Jablonski, 2017).

However, few studies analyse this influence of language on certain cognitive abilities (working memory, reasoning and perception, among others) in children at risk of having learning disabilities, and some do not find any such influence (Kim & Pallante, 2012; Welsh et al., 2010), although it would be expected according to the neurological dysfunctions (anatomical and physiological) that characterise them (González-Valenzuela & Martín-Ruiz, 2021). Along these lines, some psycho-gerontological research attempts to relate the effects of reading and writing with the conservation and improvement of cognitive functions in healthy older adults (Beber & Chaves, 2016; Cotrena et al., 2016; Jacobsen et al., 2017; Kochhann et al., 2018; Pawlowski et al., 2012). It has been found that people with reading and writing routines achieve better scores in certain cognitive abilities (attention, memory, perception, etc.) and, in particular, in working memory and reasoning. Other studies have indicated that written language instruction has a positive effect on the maintenance and preservation of higher cognitive abilities in adults with neurodegenerative diseases (Baker et al., 2019; DeVries et al., 2019; Diamond, 2013; Isella et al., 2019; Longden et al., 2016; Ripamonti et al., 2017). These studies have found that reading in groups of adults with Alzheimer's has a positive effect on the improvement and conservation of cognitive abilities analysed (Baker et al., 2019; DeVries et al., 2019) and prevents cognitive impairment in combination or in isolation with psychotropic drugs (Kochhann et al., 2018; Longden et al., 2016). In short, it seems that language favours the development of cognitive abilities (Schneider & Dixon, 2009) and can be a good tool to prevent and slow down cognitive decline in adulthood (Cotrena et al., 2016).

It would appear that the relationship between oral and written language and the development of cognitive abilities can be bidirectional. On the one hand, some reviewed studies have indicated that intervention in certain cognitive abilities improves written language at different ages and more so in non-normative samples. On the other hand, other studies indicate that the development of oral and written language favours certain cognitive abilities in the illiterate adult population and that the learning of written code is a primary prevention tool for the slowing down of cognitive impairment, with very few studies carried out with children at risk of learning disabilities in childhood. With these results, an improvement in cognitive abilities in children with school learning disabilities can be expected through oral and written language intervention.

Therefore, the objective of this work is to analyse the effect of an early intervention programme in oral and written language on the reasoning, classification and seriation abilities of pupils at risk of learning disabilities at ages four to six. Specifically, the hypothesis of the study suggests that schoolchildren in the instructed group who receive early, systematic and planned instruction in oral and written language obtain higher scores in the cognitive abilities analysed than pupils in the non-instructed group.

Method

Participants

The study population comprised pupils in second year of the second cycle of Early Childhood Education (four years of age) in the province of Malaga (Spain), belonging to schools from middle sociocultural areas, Spanish-speaking, with a normative intellectual level, with no physical, mental or sensory handicaps. They have not received any special education and show poor performance

in oral and written language, according to the psychopedagogical reports compiled by psychologists at the schools to which they belong. Schools were selected by means of stratified random sampling, from all the schools in the city distinguished by socio-cultural areas (high, medium, low). Five were selected from among twelve state-run and subsidised-private schools belonging to an average socio-cultural area, where 2.14% of the adult population is illiterate, below the average in Andalusia (Instituto de Estadística, 2023).

The research encompassed 53 pupils at risk of learning disabilities, selected from a sample of 204 pupils belonging to the schools indicated. Two groups were created: an Instructed Group (IG) and a Non-Instructed Group (Non-IG). The IG consisted of 31 pupils (14 boys and 17 girls) at risk of learning disabilities, who were four years of age at the start of the research ($M = 4.3$ and $SD = 0.5$). The Non-IG consisted of 22 schoolchildren (12 boys and 10 girls) at risk of learning disabilities, who were four years of age at the start of the research ($M = 4.7$ and $SD = 0.6$). The groups did not show statistically significant differences in the number of boys and girls in each group, $\chi^2(1, 51) = 309.00$ and $p = .505$.

Participants from both groups were selected based on the results of the evaluation carried out on their academic performance, reading, writing and oral language. The disabilities presented by the pupils in both groups were evaluated using the Academic Performance Evaluation Test (TERA) questionnaire, used by the teachers for the evaluation of academic performance (Moya et al., 2010), with Reading Performance (RP) and Writing Performance (WP) tests applied for the evaluation of reading and writing performance in Spanish, respectively (González & Delgado, 2006; González et al., 2012) and the Navarra Oral Language Test -PLON- (Aguinaga et al., 1989) for the evaluation of oral language development. In both groups, only those participants who obtained a score below the twentieth percentile in all the tests, a criterion used in other studies for the diagnosis of students with learning disabilities (Fletcher et al., 2019; González-Valenzuela & Martín Ruiz, 2020) were taken into account. No statistically significant differences were initially found between the means of the two groups (Table 1) for academic performance, reading, writing and oral language: $F(1, 51) = 0{,}659$ and $p = .422$; $F(1, 51) = 1{,}206$ and $p = .279$; $F(1, 51) = 2{,}147$ and $p = .152$; and $F(1.51) = 2{,}532$ and $p = .136$, respectively.

Instruments

The *capacity for reasoning* (REAS) has been defined as the ability to establish significant relationships between visual stimuli, identify categories of objects and order elements belonging to the same category, depending on their attributes. Evaluation was carried out by means of two sub-tests from the *Evalúa-0 battery* (García Vidal & González Manjón, 2000): the *Classification test* and the *Seriation test*. The total score was defined as the sum of the scores obtained in both tests, with a maximum of 66 points. The reported reliability of the test ($n = 942$) was excellent by means of ($\alpha = .92$) (García Vidal & González Manjón, 2000). The internal consistency obtained in the research ($n = 53$) was acceptable, using Cronbach's alpha ($\alpha = .70$) and McDonald's Omega ($\Omega = .75$). Both the average variance extracted (AVE = .60) and the composite reliability (FC = .72) of this test indicated a good factorial fit of the items.

The *capacity to classify* (CLAS) has been defined as the ability of the subject to induce categories from visual stimuli and detect which elements of a group do not belong to the same category as the others. Evaluation was carried out using two tasks (Garcia Vidal & González Manjón, 2000). The first task was to detect a drawing that does not belong to the same lexical category as the others, with a total of five response options (for example: apple, pear, hamburger, eggs and bottle; bottle would be the one that would have to be crossed out). The second task was to select a simple geometric figure (square, triangle, circle, etc.) from six possible answer options. The test contained 18 items in total, with nine items in each task. Correction was performed according to the random correction formula, expressed in Equation 1, where the numbers of right and wrong answers obtained in the tasks were considered, and omissions were not penalised. The maximum score was 18 points. The average number of correct answers obtained was between ten and fourteen points ($M = 12.17$ and $SD = 2.21$). The test ($n = 950$) reported good reliability ($\alpha = .85$) (García Vidal & González Manjón, 2000). The internal consistency obtained in the research ($n = 53$) was acceptable, using Cronbach's alpha ($\alpha = .65$) and McDonald's Omega ($\Omega = .70$). Both the average variance extracted (AVE = .58) and the composite reliability (FC = .69) indicated a good factorial fit of the scale items.

$$PD_{CLAS} = \left[\left(\sum A_1 - \frac{E_1}{4}\right) + \left(\sum A_2 - \frac{E_2}{5}\right)\right] \quad (1)$$

The *capacity of seriation* (SE) has been defined as the ability of the subject to order sets of elements that differ from one another in terms of a given attribute. Evaluation was carried out using three tasks with four items each. The items in the first task consisted of ordering drawings according to size criteria, from largest to smallest. The second task consisted of ordering drawings with a different number of elements according to the quantity, from highest to lowest. Finally, the third task consisted of ordering drawings according to a given criterion (length, age, weight and height).

The test contained 12 items and four items to sort per task. Correction was performed according to the random correction formula, expressed in Equation 2, where the numbers of right and wrong answers obtained in the tasks were considered, and omissions were not penalised. The maximum score was 48 points. The average number of correct answers obtained was between thirty and forty-three points ($M = 36.12$ and $SD = 6.99$). The test ($n = 940$) presented excellent reliability ($\alpha = .93$) (García Vidal & González Manjón, 2000). The internal consistency obtained in the research ($n = 53$) was acceptable, using Cronbach's alpha ($\alpha = .73$) and McDonald's Omega ($\Omega = .79$). Both the average variance extracted (AVE = .61) and the composite reliability (FC = .70) indicated a good factorial fit of the scale items.

$$PD_{SE} = \left[\left(A_1 - \frac{E_1}{3}\right) + \left(A_2 - \frac{E_2}{3}\right) + \left(A_3 - \frac{E_3}{3}\right)\right] \quad (2)$$

Procedure

The research complies with ethical requirements according to the approval granted by the Ethics Committee for Experimentation at the Universidad de Málaga (CEUMA) and the authorisation provided by the management teams of the participating schools. After the parents signed the required informed consent, psychologists from the participating schools were interviewed in order to obtain the data from the psychopedagogical reports and select the study sample. Subsequently, pupils at risk of learning disabilities were selected, through the administration of the aforementioned tests, at the beginning of the school year (September). The evaluations of the study variables and the interventions were then carried out alternately. The participants were evaluated by three Psychology graduates, previously trained in the administration and correction of these psychological evaluation tests. Evaluations were carried out with each child individually using a blind testing approach and during school hours. The first measurement of the study variables (pretest) was carried out during the first quarter of the school year (October), when the pupils were in the second year of Early Childhood Education. The other three post-tests were carried out after each intervention phase (June). The intervention phases were carried out between October and May of the three corresponding school years, when the children were in the second and third years

Table 1
Descriptive statistics of the groups in the participant selection variables

Variable	Group	*N*	*M*	*SD*	η^2
Reading	IG	31	1.04	1.87	
	Non-IG	22	1.73	1.42	
	Total	53	1.24	1.76	.03
Writing	IG	31	3.78	3.71	
	Non-IG	22	1.91	3.14	
	Total	53	3.24	3.62	.05
Academic performance	IG	31	2.74	1.93	
	Non-IG	22	3.36	2.61	
	Total	53	2.92	2.13	.01
Oral language	IG	31	4.04	1.50	
	Non-IG	22	3.55	1.91	
	Total	53	3.79	1.74	.03

Note. IG = Instructed Group; Non-IG = Non-Instructed Group.

of Early Years Education and the first year of Primary Education, respectively.

The Non-IG did not take part in the intervention programme. This group received instruction in oral and written language, regulated by the compulsory official curricular objectives established in Decrees 105 and 107 (CECJA, 1992) for Early Childhood Education and Primary Education, respectively. In Early Childhood Education (four and five years of age), the contents developed in classrooms throughout the academic year relating to oral language refer to listening to stories, songs and oral storytelling. At this school level, written language is only approached through the knowledge of some very frequent words (CECJA, 1992). In Primary Education (six years of age), oral language is developed with the same tasks as in the previous year and begins with the teaching of written language, through instructional components related to visual processing, such as visual and spatial discrimination, psychomotricity, laterality and body schema (CECJA, 1992). The contents were developed by the teachers in each ordinary classroom to which the children belonged and were not prioritised or structured at any educational level. The amount of classroom time dedicated each day to oral and written language instruction varied in each school year and could not be controlled. A total of four teachers took part. Participants in the IG received structured and systematic instruction in oral language and reading and writing, through the Prevention of Disabilities in Learning Literacy Programme (PREDALE) (González-Valenzuela & Martín Ruiz, 2020, 2023). The programme jointly considered as instructional components the alphabetical principle, phonological awareness, literacy fluency, vocabulary and text comprehension, components recommended by the National Reading Panel (NRP, 2000).

The overall objective of the PREDALE programme is to promote reading (accuracy and comprehension) and writing (accuracy and expression), integrating it with oral language activities between four and six years of age. The contents of the programme are structured according to the five components indicated above (González-Valenzuela, 2017; González-Valenzuela & Martín-Ruiz, 2023). The alphabetical principle is taught through phonemic articulation activities and the discrimination of all graphemes of the alphabet and the reading, copying and dictation of all letters (vowels and consonants), and spelling rules. Phonological awareness (syllable and phoneme knowledge) is developed through the identification, counting, addition, omission and substitution of syllables and phonemes, identification of rhymes, recognition of the vowel structure of words, linking words according to the final syllable, forming words with single letters, guessing words by spelling, and spelling. Reading and writing fluency is achieved through reading, copying and dictation of words, sentences and texts of different length, intonation and prosody. Vocabulary is promoted through activities that involve defining and associating images and words, finding antonyms and synonyms, categorisation of concepts, finding the odd image out, constructing and solving crossword puzzles and word searches, using the dictionary, ordering images and/or words to construct sentences of different lengths, ordering sentences to build a story, and identifying and converting masculine/feminine, plural/singular, and affirmative/interrogative words. Finally, text comprehension encompasses tasks of reading comprehension and written expression, such as identifying and organising the main ideas present in texts of different length and complexity; changing or guessing the end of a written text; deciding on a title or predicting the end of a text, producing short messages or texts from images, words or sentences; spontaneous written expression and writing short stories individually and in groups, self-questioning about what they have not understood and self-correcting, and correcting the writing of classmates (González-Valenzuela & Martín Ruiz, 2020, 2023). These contents were sequenced over three academic years according to the level of cognitive complexity implied by the tasks used (González-Valenzuela, 2017; González-Valenzuela & Martín-Ruíz, 2023). The activities were carried out daily, combining individual and group activities at the beginning of the school day, through different subjects. The programme was implemented for two and a half hours every day for approximately twenty weeks in each school year. It was implemented by six teachers in their ordinary classrooms. The teachers had been trained to apply the programme through seminars and workshops to update and revise their knowledge of reading and writing instruction. The procedures were also tested by means of modelling to implement them in the classroom. In the follow-up sessions, the teachers received feedback through direct observation in the classroom and individual and/or group interviews with the authors, in order to analyse their experiences, solve any difficulties encountered and comment on and assess the achievements. The agreement index for the observations carried out on the performances of the teachers by two observers, during 30 randomly chosen class sessions, showed a good degree of agreement between evaluators (.87). This process allowed us to control the validity and reliability of teacher interventions.

Design and data analysis

The research design used was quasi-experimental and mixed with intersubject (two groups of participants) and intrasubject (three study variables) factors, a longitudinal study with repeated measures (four measurements in each variable) and three intervention phases. Three study variables (reasoning, classification, and seriation) and two groups of participants (Instructed Group and Non-Instructed Group) were considered. Statistical analyses were performed in several phases. Firstly, the descriptive statistics for CLAS, SE, and REAS were calculated, and a GLM Repeated Measures Analysis of Variance (Ato &Vallejo, 2015) was performed.

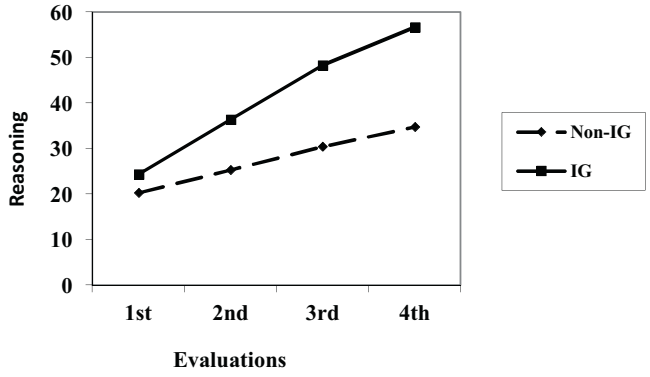

Figure 1. Mean REAS scores per evaluation according to groups.

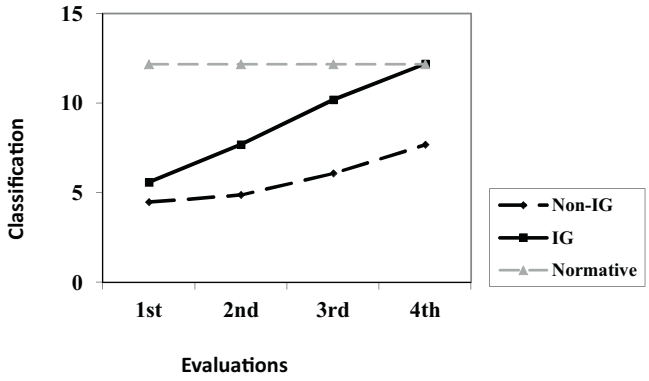

Figure 2. Mean CLAS scores per evaluation according to groups.

After verifying the parametric assumptions of sphericity and homoskedasticity of the variances, using the Mauchly and Levene tests, respectively, a repeated measures analysis of variance (ANOVA) for a single factor was performed, according to the objectives of the study. With this type of approach, hypothesis testing was analysed: firstly, those referring to the interaction between group and evaluation to verify the effect of the intervention, and if significant, between groups (Instructed Group and Non-Instructed Group) and, finally, the intrasubject factor in each group (1st, 2nd, 3rd and 4th evaluation). The statistical power of the analyses (1-β), was calculated, considering positive values greater than .80, along with the effect size (using the η^2 test), considered small, moderate or strong, η^2 = |.10|, η^2 = |.30|, η^2 = |.50| or greater, respectively, according to Cohen's (1992) criteria.

We also analysed the adjusted post-hoc comparisons between groups and intrasubjects, using the Bonferroni method, based on Student's *t* distribution, which shows the specific differences between evaluations between groups in each evaluation and the specific differences between evaluations (intrasubject), respectively. This method controls the error rate by dividing the significance level (α) by the number of comparisons (*k*) performed. Each comparison was evaluated using a significance level $\alpha_c = \alpha/k$ (Ato & Vallejo, 2015). Finally, the effect size was calculated for the comparison of means, using Cohen's *d* (1992), considered small, moderate or large, *d* = |0.20|, *d* = |0.50|, *d* = |0.80| or greater, calculated using the G*Power statistics programme (Faul et al., 2009). Data analysis was carried out using the statistics software programme SPSS 28 (IBM Corp. Released, 2021).

Results

Results in reasoning

The descriptive statistics of REAS obtained by the two groups of participants in the four evaluations indicate an increase in the mean scores in the second, third and fourth evaluations compared to the initial evaluation (pretest), both in the IG and in the Non-IG. However, the scores for REAS in the IG were higher than those presented by the Non-IG (Figure 1 and Table 2).

The analysis of differences was conducted by means of a repeated measures ANOVA. We verified the assumptions of sphericity (χ^2 = 8,159 and *p* > .05) and homoskedasticity in all measurements: *F*(1, 50) = 3.51 and *p* = .07, *F*(1, 50) = 0.51 and *p* = .47, *F*(1, 50) = 3.76 and *p* = .06, *F*(1, 50) = 2.98 and *p* = .09. Firstly, the results of the interaction between group and evaluation in REAS indicate that the differences were statistically significant, *F*(3, 150) = 19.82 and *p* < .001] between the instructed group and the non-instructed group in the different evaluations, with excellent power (1-β = 1.00) and a moderate effect size (η^2 = .28).

Secondly, cross-group analyses indicate that there were statistically significant differences in REAS between the two groups, with *F* (1.50) = 99.297 and *p* < .001, a high adequacy of hypothesis testing, excellent power (1-β = 1), and a strong effect size, with η^2 = .66. The differences between the IG and the Non-IG in the first evaluation were not statistically significant (Table 2). However, the differences between the groups were statistically significant in the second, third and fourth evaluation, in favour of the IG, with a large effect size. In addition, the differences between the groups from the second evaluation onwards were greater when the programme had been running for longer.

Finally, the results of the intrasubject factor indicated statistically significant differences between the evaluations in REAS, *F*(3, 150) = 132.81 and *p* < .001 in both groups, with excellent power in hypothesis testing (1-β = 1) and a strong effect size (η^2 = .73). Table 3 shows the contrasts of each group between the different evaluations, as well as the effect size. The IG showed statistically significant differences between all evaluations, with scores increasing progressively in each intervention period, and a large effect size. However, the Non-IG did not show statistically significant differences between all evaluations, except between the first and third (four-five years old), the first and fourth (four-six years old) and the second and fourth (four and six years old), with a large effect size.

Results in classification

The descriptive statistics for CLAS obtained by the two groups of participants in the four evaluations show an increase in the mean scores in the second, third and fourth evaluations compared to the initial evaluation (pretest), both in the IG and in the Non-IG. However, the scores for CLAS in the IG were higher than those presented by the Non-IG (Figure 2 and Table 2).

The analysis of differences was conducted by means of a repeated measures ANOVA. In this case, the assumption of sphericity (χ^2 = 14,089 and *p* < .05), which is corrected by means of the Huynh-Feldt epsilon (ε = .89), was not fulfilled. However, the assumption of homoskedasticity was verified in all measurements: *F*(1, 50) = 0.16 and *p* = .68, *F*(1, 50) = 2.33 and *p* = .13, *F*(1, 50) = 0.46 and *p* = .499, *F*(1, 50) = 2.26 and *p* = .13. Firstly, the results of the interaction between group and evaluation in CLAS show that the differences were statistically significant, *F*(2.67, 133.52) = 5.42 and *p* < .001 between the instructed group and the non-instructed group in the different evaluations, with excellent power (1-β = 91) and a small effect size (η^2 = .10). Secondly, cross-group analyses indicate that differences were statistically significant in CLAS between the two groups, with *F*(1, 50) = 71.98 and *p* < .001, a high adequacy of hypothesis testing, excellent power 1-β = 1), and a strong effect size, with η^2 = .59. The differences between the IG and the Non-

Table 2
Comparisons between groups in each evaluation in reasoning, classification and seriation

Evaluation	M_{IG}	*SD*	M_{Non-IG}	*SD*	$M_{(IG-Non-IG)}$	*p*	*d*
REAS							
1	24.32	5.58	20.36	9.44	3.96	.064	0.10
2	36.47	8.39	25.41	7.01	11.06	.000	0.83
3	48.38	7.57	30.49	5.99	17.88	.000	0.90
4	56.75	5.64	34.85	8.65	21.89	.000	0.95
CLAS							
1	5.64	2.57	4.55	2.80	1.09	.150	0.05
2	7.71	2.40	4.93	2.41	2.77	.000	0.70
2	10.21	2.24	6.12	2.45	4.09	.000	0.75
4	12.29	2.19	7.71	2.55	4.57	.000	0.78
SE							
1	19.10	6.31	15.81	8.07	3.29	.102	0.25
2	28.73	7.43	20.47	6.43	8.26	.000	0.80
3	38.05	6.35	24.37	5.82	13.68	.000	0.84
4	44.49	5.30	27.14	7.20	17.36	.000	0.90

Note. REAS = Reasoning; CLAS = Classification; SE = Seriation; IG = Instructed Group; Non-IG = Non-Instructed Group.
$^{*}p < .05$. $^{**}p < .00$.

Table 3
Comparisons between evaluations in each group in reasoning, classification and seriation

Group	Eval (I)	Eval (J)	$M_{(I-J)}$	*p*	*d*
REAS					
IG	1	2	12.15	.000	0.85
		3	24.06	.000	0.92
		4	32.43	.000	0.96
	2	3	11.91	.000	0.84
		4	20.28	.000	0.91
	3	4	8.37	.000	0.81
Non-IG	1	2	5.04	.114	0.16
		3	10.13	.000	0.82
		4	14.49	.000	0.83
	2	3	5.09	.065	0.17
		4	9.45	.000	0.83
	3	4	4.36	.060	0.13
CLAS					
IG	1	2	2.06	.038	0.35
		3	4.56	.000	0.48
		4	6.64	.000	0.60
	2	3	2.49	.000	0.38
		4	4.57	.000	0.48
	3	4	2.07	.004	0.35
Non-IG	1	2	0.38	1.00	0.02
		3	1.57	.265	0.04
		4	3.16	.000	0.23
	2	3	1.18	.265	0.04
		4	2.78	.002	0.21
	3	4	1.59	.128	0.05
SE					
IG	1	2	9.62	.000	0.61
		3	18.95	.000	0.72
		4	25.39	.000	0.75
	2	3	9.32	.000	0.82
		4	15.76	.000	0.93
	3	4	6.44	.000	0.60
Non-IG	1	2	4.65	.105	0.25
		3	8.55	.000	0.43
		4	11.32	.000	0.83
	2	3	3.90	.211	0.09
		4	6.66	.004	0.62
	3	4	2.76	.370	0.05

Note. REAS = Reasoning; CLAS = Classification; SE = Seriation; IG = Instructed Group; Non-IG = Non-Instructed Group.

IG in the first evaluation were not statistically significant (Table 2). However, the differences between the groups were statistically significant in the second, third and fourth evaluation, in favour of the IG, with a medium effect size. In addition, the differences between the groups from the second evaluation onwards became greater the longer the programme had been running. Finally, the results of the intrasubject factor indicated statistically significant differences between the evaluations in CLAS, $F(2.67, 133.52) = 41.32$ and $p < .001$ in both groups, with excellent power in hypothesis testing ($1\text{-}\beta = 1$) and a moderate effect size ($\eta^2 = .45$). Table 3 shows the contrasts of each group between the different evaluations, with statistically significant differences in the IG between all of them and a small and medium effect size. In this group, the scores increased progressively in each intervention period. However, the Non-IG group did not show statistically significant differences between all the evaluations, except between the first and fourth (four-six years

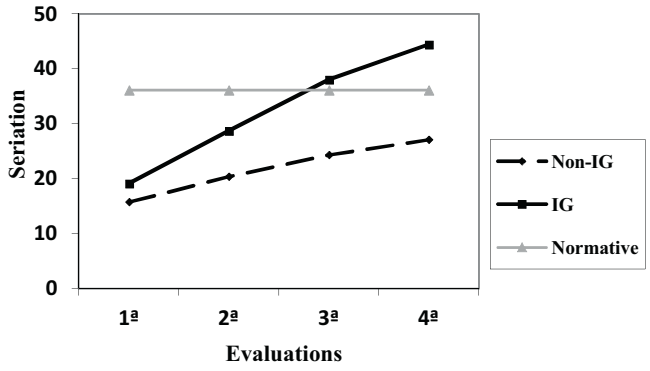

Figure 3. Mean SE scores per evaluation according to group.

old) and the second and fourth (four and six years old), with a small effect size.

Results in seriation

The descriptive statistics for SE obtained by the two groups of participants in the four evaluations show an increase in the mean scores in the second, third and fourth evaluations compared to the initial evaluation (pretest), both in the IG and the Non-IG. However, the IG scores were higher than those reported by the Non-IG from the second evaluation onwards (Figure 3 and Table 2).

The analysis of differences was conducted by means of a repeated measures ANOVA. We verified the assumptions of sphericity ($\chi^2 = 5.1$ and $p > .05$) and homogeneity of variances in all the different evaluations: $F(1, 51) = 0.91$ and $p = .34$, $F(1, 51) = 0.28$ and $p = .59$, $F(1, 51) = 1.72$ and $p = .19$, $F(1, 51) = 2.62$ and $p = .11$. Firstly, the results of the interaction between group and evaluation show that the differences in SE were statistically significant, $F(3.153, 150) = 14.53$ and $p < .001$ with optimal power ($1-\beta = 1$) and a moderate effect size ($\eta^2 = .22$). Secondly, cross-group analyses indicate that differences were statistically significant in SE between the two groups, with $F(1.51) = 78052$ and $p < .001$, excellent power ($1-\beta = 1$), and a strong effect size, with ($\eta^2 = .61$). Contrasts between the means of the groups indicate that the differences were statistically significant between the IG and the Non-IG in the second, third and fourth evaluation, in favour of the IG (Table 2), with a large effect size. The differences in scores increased the longer the programme ran, confirming the effectiveness of the intervention programme. Finally, the results of the intrasubject factor indicated statistically significant differences between the evaluations in SE, $F(3, 3.153) = 97.85$ and $p < .001$ in both groups, with excellent power in hypothesis testing ($1-\beta = 1$) and a strong effect size ($\eta^2 = .65$). The IG obtained statistically significant differences between all the evaluations, increasing the scores progressively with the intervention periods, with a medium and large effect size (Table 3). However, the Non-IG did not show statistically significant differences between the different evaluations, except between the first and third (four-five years old), the first and fourth (four-six years old) and the second and fourth (four and six years old), with a large effect size.

Discussion

The objective of this work is to analyse the effect of an early intervention programme based on oral and written language on the reasoning, classification and seriation abilities of pupils at risk of learning disabilities at an early age (four to six). Specifically, the hypothesis of the study suggests that participants in the IG who receive early, systematic and planned instruction in oral and written language obtain higher scores in the cognitive abilities analysed than pupils in the Non-IG.

The results indicate, in the first place, that both the IG and the Non-IG progress in the cognitive variables studied (reasoning, classification and seriation) throughout Early Childhood Education and early Primary Education, with the scores of the IG being significantly better. In addition, the differences between the two groups increase as the intervention periods progress, being greater in the last year of the programme. That is to say, pupils at risk of presenting learning disabilities who are instructed through the intervention programme in oral and written language achieve between the ages of four and six better scores in reasoning, classification and seriation than those who are not instructed through the intervention programme.

Secondly, the results show that the IG showed statistically significant differences in reasoning, classification and seriation in all evaluations, increasing scores gradually from four to six years of age. In contrast, the Non-IG did not show a significant increase in scores in all study variables, and when one was observed, it was usually between the first and the last years. That is, the group of children at risk of having learning disabilities that have been instructed through the early intervention programme in oral and written language progressively improved their cognitive abilities of reasoning, classification and seriation from four to six years of age, while pupils at risk of presenting learning disabilities who were not instructed through the intervention programme presented a slower and non-significant improvement in the cognitive abilities studied. These results indicate that Spanish-speaking children at risk of learning disabilities improve their cognitive abilities of reasoning, classification and seriation, between four and six years of age, if they receive systematic and prioritised instruction in oral and written language from an early age. This study shows the influence of oral and written language on certain cognitive abilities, in line with other research (Dehaene, 2013; Horowitz-Kraus & Hutton, 2018; Jablonski, 2017; Scionti et al., 2020; Shaywitz & Shaywitz, 2008). Systematic instruction in oral and written language promotes activity in the prefrontal cortex areas and the development of high-level cognitive processes at early and more advanced ages (Diamond, 2013; Jablonski, 2017; Kassai et al. 2019; Scionti et al., 2020; Shaywitz & Shaywitz, 2008). In addition, these brain changes are more relevant in pupils at risk of learning disabilities, since a reading intervention programme of only three months produces increases in frontal brain activity in school children with reading disabilities (Partanen et al., 2019). Therefore, it seems that literacy learning tasks, based on the development of oral language, stimulate the functional activity of brain areas involved in the functioning of high-level cognitive processes, such as reasoning, even in pupils at risk of learning disabilities (Fletcher et al., 2019; MacKenzie & Hemmings, 2014; Zhang et al., 2017).

These findings are also in line, on the one hand, with studies conducted with illiterate adults that highlight the importance of direct and systematic written language instruction to improve cognitive abilities (Horowitz-Kraus & Hutton, 2018; James et al., 2016). Research indicates that changes in brain structures in illiterate adults are observed following intervention in literacy. And, on the other hand, they also coincide with research that highlights the fundamental role of oral and written language as a tool for the conservation of mental functions in neurodegenerative diseases (Baker et al., 2019; DeVries et al., 2019; Diamond, 2013; Isella et al., 2019; Longden et al., 2016; Ripamonti et al., 2017) and in the slowing down of age-related neurodegenerative processes (Beber & Chaves, 2016; Cotrena et al., 2016; Jacobsen et al., 2017; Kochhann et al., 2018; Pawlowski et al., 2012).

Therefore, the results of this study emphasise the role of oral and written language in the capacity for reasoning, classification and seriation of pupils at risk of presenting learning disabilities.

In this sense, planned and systematic intervention in oral and written language is effective for the development of certain cognitive abilities, through the instructional components compiled by the PREDALE early intervention programme (González & Martín, 2020, 2023), which takes into account the recommendations of the National Reading Panel (NRP, 2000), specifically, the learning of literacy and the development of oral language, with the aim of increasing academic performance and decreasing numbers of students with learning disabilities (González-Valenzuela & Martín-Ruiz, 2020, 2023). That is, intervention in oral and written language from an early age in schoolchildren at risk of learning disabilities improves certain basic psychological processes, where these students usually present problems (Fletcher et al., 2019; González-Valenzuela & Martín, 2021) and, in turn, prevents the development of disabilities, particularly in reading and writing. Therefore, the directionality of the relationship between certain cognitive abilities and oral and written language could be said to be bidirectional in schoolchildren with learning disabilities (Cortese et al., 2015, Fletcher et al., 2019; Shaywitz & Shaywitz, 2008) and in normative students (Best et al., 2011; Boukrina & Graves, 2013; Horowitz-Kraus & Hutton, 2018; Jablonski, 2017; Kassai et al., 2019; Scionti et al., 2020; Takacs & Kassai, 2019).

It is also worth noting some limitations of this study, such as the size of the sample, because the research population is smaller, since they are specifically pupils at risk of presenting learning disabilities and not normative students. In future studies, it would be important to analyse whether the results found are maintained at older ages, and to apply other types of statistical analysis to explore the relationships between oral and written language and cognitive abilities considered or others that have been taken into account in other studies, such as perception, memory or attention. This way, greater robustness could be given to the results found in this study. However, the educational implications of this study are relevant, since the results obtained indicate the importance of prioritised, systematic and planned oral and written language teaching, as a way to improve certain cognitive abilities of normative students and those at risk of presenting learning disabilities.

In short, the results of this study highlight the relevance of prioritising systematic intervention in oral and written language in improving some cognitive abilities of pupils at risk of presenting difficulties in learning, from early childhood education onwards. Oral and written language, therefore, can be a relevant tool for preventing these difficulties, improving reading and writing performance, but also for the development of some cognitive abilities, such as those analysed in this study and that are necessary for school learning.

Funding

This research was funded by the SEJ 521 “Learning Disabilities and Developmental Alterations” research group as part of Andalusia’s Research Plan (Junta de Andalucía).

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