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Variables that Predict the Potential Efficacy of Early Intervention in Reading in Down Syndrome

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A B S T R A C T

It is known that alterations in Down syndrome (DS) occur at cognitive and language levels that affect the acquisition of reading and academic skills. The aim of this study is to know which neuropsychological variables predict the potential efficacy of early intervention in reading in this population with a program traditionally used with this population. Thirty-eight children of around 5 years of age with DS who were immersed in an early childhood care program participated in the study, 20 of them were immersed in a reading program. Significant differences were found at neurocognitive and linguistic level, especially in the experimental group at neurocognitive level, with achievements in reading and writing at early ages. In addition to this, two variables were found to predict reading acquisition. As conclusion, the effectiveness of the reading program and its benefits at neuropsychological and psycholinguistic levels in the development of this group of children with DS at an early age was revealed.

Las variables que predicen la eficacia potencial de la intervención temprana en la lectura en el síndrome de Down

Palabras clave:
Evaluación
Programa de intervención
Preescolar
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Lectura temprana

R E S U M E N

Se sabe que en el síndrome de Down (SD) se producen alteraciones a nivel cognitivo y del lenguaje que afectan la adquisición de habilidades académicas y de lectura. El objetivo de este trabajo ha sido conocer qué variables neuropsicológicas predicen la eficacia potencial de la intervención temprana en la lectura en esta población con un programa que se usa tradicionalmente con la misma. En el estudio participaron 38 niños con SD de alrededor de 5 años que estaban inmersos en un programa de cuidado de la primera infancia, de los cuales 20 estaban inmersos en un programa de lectura. Como resultados, se observan diferencias significativas a nivel neurocognitivo y lingüístico, especialmente en el primero en el grupo experimental, con logros en lectura y escritura a edades tempranas. Además, hay dos variables que predicen la adquisición de la lectura. En conclusión, se comprueba la efectividad del programa de lectura y sus beneficios a nivel neuropsicológico y psicolingüístico en el desarrollo de este grupo de niños con SD a una edad temprana.

Many children with DS have great potential to learn to read, although there is great variability in the reading levels that are finally reached (Kay-Raining Bird & Chapman, 2011). Problems have been observed in both automation and reading comprehension (Naes et al., 2012; Roch & Jarrold, 2012), issues that can be explained by interindividual differences in this population's deficits (cognitive, language, etc.), along with differences in access to formal instruction (Naess et al., 2012).

It is now accepted that the majority of children with DS achieve an adequate level of reading (Flórez et al., 2015; Roch & Jarrold, 2012). However, a great variability in reading and reading-related skills for this population has been reported. While some individuals only reach elementary levels of reading, others reach higher levels of reading and comprehension automation (Roch et al., 2011). This wide variability in reading performance may, at least in part, be explained by individual differences in language skills, general cognitive level, or verbal memory (Levorato et al.,2011; Roch & Levorato, 2010). In addition, differences in their reading level can be explained by the degree of exposure to formal reading instruction. In this regard, students with DS who are integrated into general classes tend to

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show greater achievements in literacy than those relegated to special education programs (Bochner et al., 2001).

It can be said that most individuals with DS have cognitive impairments, ranging from mild to moderate (Valencia & Robles-Bello, 2017; Marchal et al., 2016). The cognitive profile observed in DS is typically uneven: DS, for example, has severe effects on language development, particularly in expressive language (Galeote et al., 2018). Typical correlates of reading ability in this population are general cognitive function (Sloper et al., 1990), expressive and receptive language skills (Lorenz et al., 1985), phonological awareness (Baylis & Snowling, 2012; Lemons & Fuchs, 2010), and hearing loss (Laws & Gunn, 2002).

In addition, performance on short-term verbal auditory memory tasks is often significantly affected. An individual's lexical capacities are typically higher than those in the morphosyntactic domain, with better general performance in comprehension than in production and lexical comprehension that is higher than syntactical decoding. Poor phonological awareness is often present in this population, that is, their ability to identify/recognize/produce explicit speech sounds (Jarrold et al., 1999). This has been observed in DS populations speaking English, Spanish, and Italian (Galeote et al., 2018). Further, while it has been shown that phonological awareness is one of the most important factors for the acquisition of reading in children with typical development (Roch & Jarrold, 2012; Schnorr, 2011), this also seems to be a weak point in the language development of this group.

On the other hand, providing visual representations of verbal information seems to benefit children with DS (Jarrold et al., 2006). Relative strength in visual memory and verbal memory weaknesses are associated with the phenotype, suggesting that initial reading instruction could be improved by increasing visual support, thereby decreasing the verbal work memory load through practice and intensive repetition (Calero et al., 2010; Menghini et al., 2011).

Therefore, we want to verify which factors, of those included in a neuropsychological assessment of preschool children with DS, can predict their early acquisition in reading. This objective can be operationalized into a series of specific aims, such as (a) checking the potential efficacy of early intervention in reading in DS children and (b) establishing which assessment variables predict their reading acquisition.

Method

Sample

The sample of the present study consists of 38 children with DS (specifically, with trisomy 21), of whom 22 were boys and 16 were girls (M = 5.2 years, SD = 1.05); 20 were in the experimental group and 18 in the control group (Table 1). All the children were enrolled in regular public centers since they were 3 years old. None had any additional health problems or suspicion of dual pathology (e.g., possible additional diagnosis of autism) according to reports from the Early Childhood Development Center (ECDC), where they were treated from birth. In Spain, all newborns identified by the pediatrician are referred to the Early Childhood Development Center (ECDC) closest to their home by national health protocol (Robles-Bello & Sánchez-Teruel, 2013; Robles-Bello et al., 2018).

Therefore, the criterion for assigning each method was that no reading method was initiated, so in the experimental group a reading method was initiated and in the control group it was initiated 9 months later.

The children in the experimental group (EG) came from Down syndrome association centers and ECDC in Jaén, Ciudad Real, Córdoba, and Andújar. Children in the control group (CG) were from two centers in Linares and one in Úbeda.

Early child care programs are drawn up at all the centers. Centers were then asked for permission to conduct this study, permission that was also sought from families. In all the centers, except for two in Linares and one in Úbeda, the pretest situation is evaluated first and immediately afterwards the interventions which are carried out for between four to five years. The training program application (Troncoso & del Cerro, 2005) takes place once a week for one year and includes coordinating and working in conjunction with schools and families. All these children belong to the experimental group.

However, although the centers in Linares and Úbeda are evaluated at the pretest level, intervention is not carried out there because these centers usually start this method a little later, around the age of five. The situation regarding age is used to create a control or waiting group, as they will eventually receive treatment nine months later. Finally, all the children are reassessed in a posttest situation. The control group will be evaluated first in order not to delay the start of their own reading training program.

This work was approved by the bioethics committee of the University of Jaén (code: DIC.18/0.PRY).

Table 1. Sociodemographic Characteristics of Children with Down Syndrome

	Total *n*	Experimental Group	Control Group
Gender (*n*)			
Female	16	9	8
Male	22	12	10
Mean age (*SD*)	5.2 (1.05)	5 (1.2)	4.4 (1.9)
Total	38	20	18

Measures

Weschsler Intelligence Scale for Preschool and Primary School (WPPSI; Spanish adaptation, *Escala de Inteligencia de Wechsler* - WPPSI-IV, for pre-school and primary education; Weschsler, 2014) is a battery consisting of several subtest measures of qualitative and quantitative aspects of general intelligence. WPPSI, like WISC, is divided into two parts: verbal and manipulative. The subtests that assess verbal intelligence are: Information, Vocabulary, Arithmetic, Similarities, Comprehension, and Sentences (complementary). The subtests that evaluate manipulative intelligence are: House of the Animals, Incomplete Figures, Labyrinths, Geometric Drawing, and Squares. Its administration is individual and is normed for children 2.6 to 7.7 years old. Test administration usually takes 60 to 90 minutes. Test reliability varies, depending on the subtest and the age group; for 5 to 5.5 year-old children reliability coefficients range from .93 (verbal and manipulative CI) to .95 (total CI scale).

Childhood Neuropsychological Maturity Questionnaire (CUMANIN; Portellano et al., 2002) is an individually administered test for the evaluation of children aged 3 to 6 years (36 months to 78 months). Test taking varies (generally from 30 to 50 minutes). CUMANIN contains main scales (psychomotricity, articulatory language, comprehensive language, expressive language, spatial structuring, visuoperception, iconic memory, and rhythm) and auxiliary scales (attention, verbal fluency, reading, writing, and laterality). The level of reliability alpha varies depending on the scale: .71 (psychomotor), .92 (articulatory language), .73 (expressive language), .72 (comprehensive language), .81 (spatial structuring), .91 (visoperception), .57 (iconic memory), and .72 (rhythm).

Navarra-Revised Oral Language Test (PLON-R; Aguinaga et al., 2004) is an individual administration test for rapid identification or screening of oral language development. It is normed for 3 to 6 year-old children. Test taking is variable, ranging from 10 to 12 minutes. PLON-R consists of several linguistic levels: phonological, morphological, syntactic, lexical, semantic, and communicative use. The reliability coefficients in 5 year-old children are: .91 (phonology), .43 (morphology-syntax), .87 (form), .54 (content), .13 (use), and .76 (total PLON-R).

Procedure

The use of Troncoso and del Cerro's (2005) reading method is widely disseminated and accepted among the group of children with DS who attend associations that serve this group and ECDC centers. For this reason, the first thing we check is that this reading method was used in these centers within their work program.

The number of evaluation sessions was between 3 and 4 sessions for each participant (pre- and post-evaluation) with a variable duration depending on the test administered, ranging from 15 to 90 minutes. It was administered individually and in different sessions in a balanced way: first WPPSI, followed by CUMANIN, and finally PLON-R.

The evaluation sessions in both groups were conducted by the first two researchers of this study, with biweekly follow-up sessions, for the intervention program, with the psychologists who administered the training program in each center on a regular basis, and monthly with the families by video call.

Intervention program. The program for teaching reading and writing in Down syndrome (Troncoso & del Cerro, 2005) is a method of reading and writing for students with DS. It is a comprehensive and analytical method that describes the sequence to be followed, and the errors to be avoided, in the teaching-learning process of reading and writing. It consists of multiple examples and illustrations in an attempt to help parents and professionals during this process. The method is structured and explained, taking into account the ideal situation (i.e., that of a 3 to 5 year-old child who has participated in an early care program in which he/she has progressed adequately in his/her perceptive and manipulative faculties). However, if the student is older, the activities and materials appropriate to their level of maturity and skills will be derived. The program is divided into three stages of teaching and learning (for both reading and writing), each of which has its respective specific objectives and related materials.

The intervention phase is applied only to the experimental group. Initially a pre-workout evaluation is performed. Alongside these evaluation sessions it is noted, with interviews with the teaching psychologists who attend to these children, that the methodology of this intervention program is being followed. Two aspects are checked with them. On the one hand, that it is important to work the motivation of the child as well, since it is much easier to get their attention on a simple word and rich in content than on a sign in principle unintelligible. On the other hand, all children, who are cared for in ECDC centers, are undergoing an educational process and training their perceptual and discriminatory abilities. Before starting reading, they have been training attention, perception, and discrimination (skills to associate, select, classify, name, and generalize) and manual dexterity, as directed by the method. This whole process takes about three months from the end of 2017.

In January 2018 the intervention began, continuing throughout the year, with the exception of August. The reading method comprises three different stages with specific objectives and provides its own materials for each of them. At the same time, the three stages are interrelated and sometimes objectives must be reached simultaneously. This is mainly because the conditions of understanding, fluency, and motivation must be kept and consolidated at any time in the process. It is not necessary to complete all the goals of one stage before starting to work on the next.

The first stage is global perception, recognition of written words, and understanding their meaning. The important thing at this stage is for the student to understand what reading is, that is, how you access meanings and messages through graphic symbols. This stage starts with isolated words and soon phrases are presented. This recognition must occur whether the words are presented in isolation one at a time or presented in a phrase. There are specific goals for the student, including recognizing his or her written name and that of four or five members of their family and recognizing and understanding the meaning of 15 to 20 written words consisting of two direct syllables. Words should include two or three verbs of action known to the child, written in the third person singular in the present tense. A further goal is that the child recognizes 50 to 60 words including the above. Most words will consist of two direct syllables and some of them with three syllables. Words must include five verbs in the first and third person singular of the present tense and some adjectives. The number of words in indicative should not be taken as a hard and fast rule, and the amount of words is gradually increasing.

In order to choose the words the child must learn and add some new ones, we take into account the idea that each word must have a clear meaning known to the child. This usually happens with the names of next of kin and those of commonly used objects, which they know and use on a daily basis in real life. The child has often heard the words used to name them. They do not have to know how to say them. Words are selected that can be clearly represented graphically. Short words will be chosen, and when 30 to 40 words are recognized it is advisable to choose those words that start with letters of the alphabet that have not yet been seen in the initial position of the words. In order to coordinate and consolidate learning, words can be chosen that include concepts (size, shape, and colors), adjectives, and others that can be classified by categories (food, toys, animals, etc.). Finally, another criterion used is the choice of new words that increase a child's vocabulary.

In the second stage, we work on learning syllables. The fundamental objective is for the student to understand that there is a code that allows us to access any written word not previously learned. When we master the code we can read all the texts written in our language, even if we do not know the meaning of some words. The general objective is for the student to read fluently and flexibly words formed by any syllable, and immediately understand their meaning. To achieve this, the specific objectives are that the student observes that the words are formed of syllables, in order to compose with a model words known of 2 direct syllables; in order to compose without a model, words known with 2 direct syllables that are presented to him recognize and read the 2 syllables used to form a word; in order to compose with 2 known syllables, unrecognized words of meaning, quickly recognize and read all direct 2-letter syllables, form words that are dictated to them or that they think have been dictated, choosing the direct syllables needed, read without syllables, understanding previously unrecognized words, which are made up of direct syllables; in order to compose with model, words that have a locked syllable, recognize and read locked syllables, compose words of 2 syllables without a model, one of them locked, fluently read words of 2 syllables, one of them locked; in other to compose with model, words containing 1 reverse syllable, recognize and read reverse syllables; in order to compose, without a model, words containing reverse syllables, model compose words with 1 consonant group and 1 direct syllable, recognize and read the consonant groups, and finally read words containing consonant groups fluently.

Once the student has understood what reading is and gets to know the reading mechanics, the third stage is carried out, that of progress in reading.

In the third stage, the ultimate goal is to get students to read progressively more complex texts and to allow them to make practical and functional use of their reading skills, to see reading as a pleasurable activity, which provides information and allows them to spend their time enjoyably and finally that reading is a tool with which to learn other academic content.

In December of the same year it is reassessed, ending in January 2019.

Statistical Analyses

An intersubjetct design of the quasi-experimental type (Ato et al., 2013) was followed. The data analysis was performed with IBM SPSS Statistics Base software (Version 23.0.0) licensed from the University of Jaén (IBM Corp., 2015; Palant, 2007; Mooi & Sarstedt).

Both groups were equivalent in sex and age; participants were assigned in nonrandom fashion. Due to the size of the sample, nonparametric measures were used; specifically, the Wilcoxon test was applied to contrast differences in the CUMANIN, WPPSI, and PLON-R scores in the pre- and post-phases. The effect size was measured using the criterion of Cohen's index (see Ato et al., 2013). In order to know which variables predicted reading abilities in the participant groups, a multiple regression analysis was applied using the step-by-step procedure (i.e., finding the goodness-of-fit indices first and subsequently assessing whether the model was adapted to the forecasts initially proposed according to the initial hypothesis).

Results

Table 2 presents the differences between the pretest conditions of both the experimental and control groups, the differences between the pre- and posttest conditions of the control group, and the differences between the pre- and posttest conditions in the experimental group. The two groups, EG and CG, were found to start from a similar condition, that is, there were no differences between them prior to the intervention. With respect to the CUMANIN, when the two points of measurement in the CG were compared, significant differences were found only in psychomotor function comprehensive language, spatial structuring, and iconic memory. When both measurement points were compared in the experimental group, significant differences were found in all the variables of CUMANIN and WPPSI, with the exception of language (where there were significant differences only in one of the three variables measured in this area using PLON-R).

Table 3. Values of the Regression Equation for the VIs for Down Syndrome

Variables	*B*	*SE*	*t*	*p*	Exp(*B*)	IC (95%) para Exp(*B*)	
						LL	*UL*
PS	0.88	0.66	0.19	.85	0.05	-0.59	2.36
LA	2.52	0.42	0.43	.67	0.08	1.58	3.45
LC	-0.56	0.33	-1.20	.25	-0.24	-0.19	1.17
LE	--	--	-1.09	.29	-0.19	-0.08	1.45
EE	0.90	0.35	-0.60	.55	-0.14	-0.09	0.87
VP	0.49	0.31	0.84	.41	0.16	-0.15	1.11
MI	1.44	0.72	-0.92	.37	-0.18	-0.08	3.05
R	10.02	1.67	1.89	.00	7.19	-6.74	-13.31
A	5.06	1.10	6.06	.00	3.09	-1.43	3.97
FV	0.75	0.21	3.70	.30	0.60	0.30	1.18

Note. PS = psychomotor; LA = articulatory language; LC = comprehensive language; LE = expressive language; EE = spatial structuring; VP = visuoperception; MI = iconic memory; R = rhythm; A = attention; FV = verbal fluency; B = Beta coefficient; SE = standard error; Wald = statistic of contrast power; Exp(*B*) = result of the regression equation.

The results suggest analyzing independence of the errors to assess the suitability of the multiple regression model. We did so by using the Durwin-Watson test (DW = 1.96); results indicated that this assumption is fulfilled in the IVs (psychomotricity, articulatory language, comprehensive language, expressive language, spatial structuring, visuoperception, iconic memory, rhythm, attention, verbal fluency, and laterality). The assumption of non-multicollinearity was also fulfilled for the IVs, since their value was below 10 (Kleinbaum, Kupper, & Muller, 1988; VIF = 1.3). In addition, the applied regression model seemed to show that the IVs significantly explain (F = 13.3,

Table 2. Differences in Pre- and Posttest Situations in the Experimental Group and Control in the Different Variables Evaluated

				Pre-EG/pre-CG Difference				Pre-/post-CG Difference				Pre-/post-EG Difference		
Tests	Variables	Pre-EG *M* (*SD*)	Pre-CG *M* (*SD*)	Z Wilcoxon	*p*	*r*	Post-CG *M* (*SD*)	Z Wilcoxon	*p*	*r*	Post-CG *M* (*SD*)	Z Wilcoxon	*p*	*r*
CUMANIN	PS	3.94 (2.29)	3.58 (2.27)	2.65	.08	.45	5.00 (2.24)	2.72	.01	.46	4 (2.27)	2.65	.03	.45
	LA	5.83 (1.02)	5.90 (11.94)	3.28	.07	.86	6.00 (11.92)	3.11	.07	.89	6 (11.94)	3.28	.00	.56
	LE	0.20 (0.00)	0.25 (0.18)	3.16	.45	.11	0.82 (3.17)	3.05	.56	.13	0 (3.18)	3.16	.04	.11
	LC	1.45 (1.27)	1.40 (4.59)	1.99	.22	.31	2.00 (4.56)	1.87	.02	.32	2 (4.59)	1.99	.02	.31
	DV	7.80 (6.26)	8.00 (19.72)	3.12	.08	.78	10 (19.70)	3.04	.50	.81	8 (19.72)	3.12	.00	.78
	EE	6.00 (3.17)	5.85 (11.67)	2.35	.10	.76	6.40 (11.65)	2.27	.00	.77	6 (11.67)	2.35	.00	.56
	VP	8.04 (2.73)	8.25 (12.20)	2.57	.09	.95	7.00 (12.16)	2.59	.70	.94	7 (12.20)	2.57	.00	.95
	MI	2.19 (2.58)	2.00 (4.13)	2.07	.69	.01	3.80 (4.10)	2.13	.03	.01	2 (4.13)	2.07	.04	.01
	R	0.94 (0.50)	1.00 (2.23)	2.17	.10	.11	1.00 (2.22)	2.09	.13	.11	1 (2.23)	2.17	.01	.11
	DNV	15.95 (20.41)	16.00 (33.94)	2.72	.07	.78	18.00 (33.91)	2.68	.50	.21	16 (33.94)	2.72	.00	.78
	FV	0.00 (0.00)	0 (0)	2.69	.45	.01	0 (0)	2.73	.45	.01	0 (0)	2.69	.03	.01
	A	6.90 (8.98)	6.00 (10.82)	1.82	.06	.45	8.54 (11.83)	1.88	.10	.47	8 (11.82)	1.82	.00	.45
	L	0 (0)	0 (0)	0.71	.10	.36	4.00 (1.07)	1.98	.09	.38	3 (1.10)	0.71	.02	.26
	E	0 (0)	0 (0)	1.07	.10	.43	2.00 (4.28)	1.04	.1	.42	2 (4.32)	0.19	.04	.43
	DG	24.25 (31.88)	24.60 (46.55)	3.12	.06	.98	25.00 (56.54)	3.14	.80	.99	24 (56.55)	3.12	.00	.98
	CD	73.18 (18.33)	73.00 (18.32)	3.09	.07	.76	75.00 (18.30)	3.03	.57	.81	75.00 (18.32)	3.09	.00	.76
WPPSI	CI	54	54	4.20	.14	.10	54	4.16	.57	.11	58	4.20	.00	.10
Plon-R	Shape	0	0	0	.98	.45	0	0	.97	.44	0	0	.98	.45
	Content	4	4	0.23	.78	.13	4	0.21	.77	.12	4	0.23	.78	.13
	Use	0	0	0.12	.67	.19	1	0.15	.68	.19	1	0.12	.02	.19
	Total	4	4	0.11	.86	.23	5	0.13	.07	.24	5	0.11	.04	.23

Note. PS = psychomotor; LA = articulatory language; LC = comprehensive language; LE = expressive language; EE = spatial structuring; VP = visoperception; MI = iconic memory; R = rhythm; A = attention; FV = verbal fluency; DNV = non-verbal development; DV = verbal development; L = reading; E = writing; DG = global development; CD = development quotient; CI = intelligence quotient.

$p < .01$), in 40% ($R^2 = .40$) of the variance, the increase in the DV (reading). All these criteria offer an adequate prognosis on compliance with the baseline assumptions and suitability, as necessary to apply a multiple regression analysis on the data.

According to the results observed in Table 3, there is a higher score on the rhythm and attention subdimensions (in that order); they predicted a higher score on reading. The remainder of the independent variables did not seem to influence the DS children's reading ($p > .05$). In addition to it, the independent variable (rhythm/attention) that most influences or explains a higher reading score is 7 times more rhythm of attention, Exp(B) = 7.19 vs. 3.09).

Discussion

In this study, the findings from the neuropsychological evaluation underscore the need for treatment. Specifically, there were significant differences in the EG in all the variables evaluated compared to the CG (in which there were no differences between both points of measurement for most of the variables). However, CG children (without the reading program intervention) in ECDC improved significantly in psychomotricity, comprehensive language, spatial structuring, and iconic memory. This is in agreement with what is known in the scientific literature, i.e., that all these variables are strengths in DS, with the exception of spatial structuring (Naess et al., 2012; Roch & Jarrold, 2012). However, the existence of this improvement is not surprising if it is analyzed in the context of these children being immersed in an ECDC. There have been interventions in their development (Robles-Bello et al., 2018) at the motor, cognitive, social, and language level from birth. It is not surprising that there are variables that improve in the course of the evolution of these children.

When we related these findings to the evaluation of reading, we found that a program has been implemented that works to promote success in early childhood education and that prepares children for access to the educational curriculum through activities such as perceiving relationships, comparing and judging similarities and differences, codifying information in progressively more abstract forms, classifying and categorizing, performing memory searches, and retrieving information (Valencia & Robles-Bello, 2017). All of them are activities traditionally included in cognitive development programs (Robles-Bello et al., 2017); in this case, however, they are also adapted to the school environment. Thus, we find that in the CG there are no differences in literacy. In the EG, there were differences (albeit not striking), especially in reading. In this sense, it is also traditional for reading to develop before writing (Troncoso & del Cerro, 2005). What is really interesting about all this is the following: on the one hand, the EG —in contrast to the CG—was significantly improved in all the variables when being evaluated neuropsychologically. On the other hand, they were also improved specifically in reading and writing (especially in reading).

Moreover, the finding that two variables of the study (rhythm and attention) predicted reading in this sample helps us understand what aspects are important to train from a very early age. From a very young age, work should be done to implement specific reading methodologies that take advantage of the strengths of this syndrome in terms of the visual route (Lemons & Fuchs, 2010), but also promote activities that train the phonological route in the acquisition of reading (Lemons & Fuchs, 2010; Ratz, 2013). In both ways, aspects that have been observed to predict improvements in the expression of language, such as segmentation and phonological awareness, are being trained early (Mason-Apps et al., 2018).

These findings add to the growing literature that supports the use of phonological awareness approaches to improve reading instruction in children with DS (Burgoyne et al., 2012; Lemons et al., 2018) but had never been seen, until now, at early ages. In addition, when this specific training is introduced in reading at an early age, aspects that have been found to be predictors of early language improvement in DS children have been found to be strengthened. Thus, tasks of speech segmentation and attention are strong predictors of language acquisition in young children with DS.

This work provides support for incorporating phonological awareness and phonics-based instruction in reading in DS children, since there seems to be no specific learning phenotype (Lemons & Fuchs, 2010; Mason-Apps et al., 2018). We suggest that reading objectives be incorporated at an early age (3 to 6 years old) with tasks that improve rhythm and attention, and which will undoubtedly improve the conscious use of phonological discernment and production in this population (Roch & Jarrold, 2012).

A possible explanation for this important development of reading skills in DS children may be the effect of the interaction between improvement in language skills and the intervention program in the development of literacy skills. The relationship between the development of reading skills and that of language has been identified in different studies. Mengoni et al. (2014) and Naess et al. (2012) conclude that improvement in language development in DS children is associated with an improvement in reading tests. In the same direction, Torppa et al. (2016) highlight the bidirectional relationships between listening comprehension and reading skills of children whose mother tongue is characterized by being transparent in the application of grapheme-phoneme conversion rules.

Limitations and Future Research

Despite our findings, there is a limitation in that we cannot make an exhaustive evaluation of the reading in a personalized way (as was done by Lemons et al., 2018); this would be interesting as a next line of future work. In consequence, while the reading program seemed to improve general learning for many children with DS, it is not clear whether a greater adaptation or individualization of the intervention could lead to further improvement. Further, we would still face challenges in evaluating this population's reading abilities, given that there are no tests that measure reading specifically at these ages and or that are suitably adapted to persons with intellectual disabilities.

Conclusions

We conclude that the CG children significantly improved in psychomotricity, comprehensive language, spatial structuring, and iconic memory. According to the results obtained, this program can work to promote success in early childhood education and prepare children for access to the educational curriculum. The EG, in contrast to the CG, significantly improved in all the variables when being evaluated neuropsychologically and they also improved specifically in reading and writing (especially in reading). Two variables in the study (rhythm and attention) predicted reading in this sample and helps us understand what aspects are important to develop from a very early age. Our findings provide support for the incorporation of phonological awareness and phonics-based instruction in reading for children with DS.

Conflict of Interest

The authors of this article declare no conflict of interest.

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