Reading skills in children with Irlen Syndrome

Habilidades de lectura en niños con síndrome de Irlen

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Abstract

Visual perceptual distortions and physical discomfort that cause difficulties in reading are some of the characteristics of Irlen syndrome. This study examined if students with Irlen syndrome, assessed with different reading tasks, show differences in reading skills when compared to those without this condition. Participants were 110 fourth and fifth graders (mean age = 8.6 years), 55 with Irlen syndrome (ISG group) and 55 without this syndrome (control group). Researchers applied the Irlen Reading Perceptual Scale to evaluate the Irlen Syndrome and the PROLEC-R Test to assess reading processes. The results showed significant group differences in Word Reading, Pseudoword Reading, Punctuation Marks, Sentence, and Text Comprehension. Oral comprehension in the auditory modality was not significantly different, which would support the idea that Irlen syndrome seems to be related to visual sensory processes. In conclusion, participants with Irlen syndrome showed impaired reading processes that might affect overall visual comprehension but not oral reading comprehension.

Keywords: Reading skills, reading difficulties, learning disabilities, Irlen Syndrome, reading comprehension,

Resumen

Las distorsiones visuales perceptivas y las molestias físicas que provocan dificultades en la lectura son algunas de las características del síndrome de Irlen. Este estudio examinó si los estudiantes con síndrome de Irlen, evaluados con diferentes tareas de lectura, presentan diferencias en las habilidades de lectura en comparación con aquellos sin la condición. Los participantes fueron 110 alumnos de cuarto y quinto grado (edad media = 8.6 años), 55 con síndrome de Irlen (grupo GSI) y 55 sin síndrome (grupo de control). Los investigadores aplicaron la Escala de Percepción de Lectura de Irlen para evaluar el Síndrome de Irlen y la prueba PROLEC-R para evaluar los procesos de lectura. Los resultados mostraron diferencias significativas entre los grupos en Lectura de palabras, Lectura de pseudopalabras, Signos de puntuación, Oraciones y Comprensión de textos. La comprensión oral en la modalidad auditiva no fue significativamente diferente, lo que apoyaría la idea de que el síndrome de Irlen parece estar relacionado con procesos sensoriales visuales. En conclusión, los participantes con síndrome de Irlen presentaron procesos de lectura deteriorados que podrían afectar la comprensión visual general, pero no la comprensión lectora oral.

Palabras clave: Habilidades de lectura, dificultades de lectura, dificultades de aprendizaje Síndrome de Irlen, Comprensión lectora.

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Introduction

Irlen syndrome (IS) – also known as scotopic sensitivity syndrome, Meares-Irlen syndrome, or Visual Stress – is a visual perceptual processing disorder that affects reading, characterised by perceptual visual distortions and physical discomfort (Irlen, 2005; Wilkins et al., 1984). It is not considered to cause or to be related to language problems, that is, IS only affects the visual perceptual characteristics in reading.

Most studies that define IS point out the Magnocellular deficit Theory as its primary cause (Nandakumar & Leat, 2008). This theory proposes that an alteration in the magnocellular system is characterised by saturation in the magnocellular cells (MC, from hereon) and inhibition of the parvocellular cells (PC, from hereon). Galaburda and Cestnick (2003) found that MC and PC cells, integrated into the lateral geniculate nucleus, are responsible for the assimilation of reading. This overlap between the MC system (in charge of information on movement, stereopsis, location, and depth) and the PC system (responsible for colour perception, recognition, and resolution) would allow the information to be organized when reading (Galaburda & Livingstone, 1991). It would explain that a failure in this overlap would result in the impossibility of reading fluently. Failure in the magnocellular system could generate binocular destabilization, instability in the perception of stimuli, or the sensation of moving letters (Stein, 2001).

The relation between visual processes and reading problems has become a widely debated subject, especially with the studies of Helen Irlen (Irlen, 1983). Irlen mentioned the existence of a perceptual dysfunction in reading processes that is not exclusive to dyslexia. From this appreciation, Irlen (2005) stated that perceptual problems could be one of the variables related to reading problems. There is also comorbidity with other pathologies, as other subsequent studies have found (Rello & Bigham, 2017).

According to Wilkins et al. (2016), dyslexia should not be confused with visual stress (VS). Galaburda and Cestnick (2003) pointed out that the origin of dyslexia is related to more complex cerebral processes. These researchers also indicate that the concept of visual stress is still controversial because of publicity on unknown methods and partly because of biased reviews. Additionally, Wilkins et al. (1984) argued that even though a reading text might look like confusing lines or patterns of stripes for Irlen sufferers; as part of their educational task compliance, they must read texts. This activity can be a challenging assignment for some children or adults who have symptoms of visual stress or Irlen syndrome.

Regarding the incidence of IS, studies carried out in the United States (Johnson et al., 2000), Australia (Robinson et al., 1995) and England (Jeanes et al., 1997; Scott et al., 2002; Wilkins et al., 2001) stated that the incidence rate of moderate / severe or significantly affected IS ranges between 12 and 15% of the general population and a 40% of dyslexic people. However, not all these studies inform about the instrument used to identify IS, its index of reliability, and its validity.

Some studies (Altman, 2003; Guimarães & Guimarães, 2013; Miyasaka et al., 2019; Sacoman, 2020; Wilkins et al., 2001) showed that there are six main visual alterations in IS: photophobia (resistance and sensitivity to light or complaints of brightness/reflections of white

paper), contrast distortions (difficulty adapting between light and dark), problems in a visuospatial resolution (sensation of blurring and movement of letters), restriction of the focal range (low ability to focus on the most relevant parts of the text and poor collection of characters in each fixation), difficulty in maintaining focus (premature fatigue or visual stress) and problems with depth perception. Similarly, Guimarães (2011) noted that these problems are observed as tearing and a burning sensation that, consequently, produces fatigue, the need to rub the eyes, and the presence of headaches.

Studies on IS such as that of Kriss and Evans (2005) and Seychell (2018) showed that the physical discomfort of a student with Irlen syndrome is characterised by headaches, nausea, tiredness, and sleepiness while reading, as well as problems in math, reading music notes, copying, writing, and skipping and misreading words. Irlen (2010) considered that these difficulties cause other types of behaviours, such as avoiding reading, being easily distracted, searching for spaces with dim light to read. Irlen also mentioned that IS patients reread texts for comprehension, delay compliance with tasks, and create other learning strategies, like "auditory learners" who prefer listening to having to read. Additionally, Stone (2003) stated that symptoms of IS, ADHD, and Dyslexia can overlap.

However, Sacoman (2020) indicated that signs such as speech, writing or auditory perception disturbances, inverted writing, incorrect pronunciation, or failure to understand verbal instructions are not associated with IS. Therefore, it is crucial to underline that we can differentiate reading comprehension problems in IS due to their perceptual nature. Consequently, visual comprehension could be affected without any disturbance to oral comprehension.

Among the IS reading difficulties, Guimarães and Guimarães (2013) found problems in reading acquisition among Brazilian students. These authors also noticed that, although they had good verbal fluency, reasoning agility, intelligence, and were participatory, students with IS tended to fail a lot in reading tasks. In addition, Brien et al. (2013) highlighted that the signs present in the reading of people with IS can be: slow reading with excessive pauses between words, difficulties with white background sheets, hard to read for long periods, and continuous repetition to achieve comprehension, often resulting in little desire and motivation to learn. Along the same lines, other authors suggested that using colour through spectral overlays or coloured lenses would favour reading processes (Irlen, 1983; Monger et al., 2015). Wilkins (2003) also mentioned that despite the controversy of the insufficient scientific evidence regarding the use of colour to improve reading performance, coloured overlays can be an aid to tackle some of the symptoms of visual stress, even headaches when reading, and improve reading speed.

Previous studies on reading and IS with empirical evidence are limited. However, Tacuri-Reino et al. (2018) identified differences between Irlen and non-Irlen groups. For the reading tasks, the authors used two 100-word stories and recorded the errors in reading and comprehension skills. For the evaluation process of the reading comprehension, the number of questions correctly answered was considered, and for the reading skills, the omissions or substitutions of words and punctuation marks were considered. Nonetheless, these authors did not specify whether these tasks had been previously validated.

Thus, the first scientific contribution and novelty of the present study is to examine the characteristics of reading abilities in students with IS (Irlen syndrome group, ISG) and compare them with the non-Irlen group (control group, CG) using the PROLEC-R test (Cuetos et al., 2009), and more specifically, the Letter identification, Lexical, Grammar tasks, and Semantic Processes.

The second novelty of this study is that the researchers carried out a differentiated analysis of the semantic processes, especially between oral and visual reading comprehension to determine

if both are affected or whether IS affects visual reading comprehension more than oral comprehension.

Consequently, the first hypothesis is that no significant differences would be found in letter identification. This process would be very elementary in learning how to read. The authors assumed that 8–9-year-old children will have acquired this skill completely since letter learning is done in an isolated way. Children could have even learned it with didactic material that would guarantee learning at this age. In contrast, letter identification in direct reading could be altered in conjunction with the rest of the text. Additionally, within the Lexical and Grammar Processes, emphasis on the word recognition tasks that might affect reading comprehension was considered (Cuetos, 2010; Perfetti, 1994).

The second hypothesis of the study is that there would be significant differences in the lexical processes. The ISG´s performance would be worse compared to that of the CG. And, as a third hypothesis, it is expected that the ISG would have worse performance than the CG in grammar ability because perceptual functions could alter their efficiency and ability to discriminate words, pseudowords, and punctuation marks. Regarding semantic processes, the fourth hypothesis states that the ISG would perform worse than the CG. This difference would be more notable in visual comprehension tasks. As for oral comprehension, we would not expect to find significant differences as the IS affects visual processes only.

Method

Participants

From the 292 children, 4th and 5th graders assessed with the IRPS, a convenient sample of 110 participants (50% boys and 50% girls) took part in the study; 55 with IS formed the ISG (M = 8.60 ± 0.63 years old), and 55 formed the control group (M = 8.62 ± 0.56 years old). The objective of having these two groups was to count with participants of similar characteristics such as age, school grade, and socioeconomical background. For the IS identification and differentiation between groups, discrimination was made based on the general punctuation of the IRPS section 1 and the clinical criteria of a professional certified Irlen Screener based on IRPS section 3. Two references for the clinical criteria were considered. First, the cases that scored higher than the reference point of the Receiver Operating Characteristic curve (ROC curve) coincided with the evaluation of positive Irlen syndrome (ISG). Second, the participants who scored lower than the reference point ROC curve coincided with an evaluation of non-Irlen syndrome (Control Group). We did not consider cases that did not meet both criteria for this study for the ROC curve with 0.571 degree of sensitivity and 0.379 specificity. For the positive identification of IS, the minimum score in section 1 should be 63.5.

All the participants were from different schools with a similar medium or medium-low socioeconomic level (INEC, 2011). As exclusion criteria, students who presented any psychological diagnosis related to an intellectual disability or any unsolved ophthalmological problem were not considered.

Instruments

The Irlen Reading Perceptual Scale (IRPS; Bernal et al., 2021), an adapted version from the original IRPS (Irlen, 1983) is an instrument for an individual application that measures distortions and visual perceptual discomfort. It serves as a screening test for detecting Irlen syndrome. It consists of three evaluation phases and four sections.

1. In the first phase, the first section consists of a 32-item questionnaire in which the participant indicates through a Likert scale (from 1 to 5) the level of frequency of the events concerning visual and physical discomfort. This first section consists of two dimensions (visual distortions and physical unease).
2. In phase two, the second section has five experimental and observational tasks to analyse the perceptual ability of the participant. In this section, the researchers present four pictures (Cube A and B, and Pumpkin A and B), one by one. The participant performs the tests and then comments on the sensations when looking at the pictures. The child counts the number of squares in a vertical row (for Cube A and Cube B) and the number of "x" or "%" between two squares (in the pumpkin). The Irlen screener monitors the task and asks the children about the distortions and discomfort perceived while performing the task. High scores mark a worse performance and vice versa.
3. Phase three corresponds to the Irlen Screener's assessment and analyses the IRPS Sections 1 and 2 results. S/he administers two different reading tests to observe the children's behaviour as they perform the reading tests. Children with Irlen syndrome usually pause, skip lines or entire paragraphs, and report uneasiness, unwillingness, and lack of attention, among other conducts when reading. Furthermore, the Irlen Screener also observed signs of fatigue, rubbing of the eyes, frowning, and overall discomfort while reading (Al-Zoubi, 2021; Guimarães, et al., 2023; Hollis, & Allen, 2006; Kriss, & Evans, 2005). Based on the observations of the children's behaviours during the reading tasks, the Irlen Screener determined whether they presented Irlen Syndrome symptomatology or not and recommended colour acetates.

The PROLEC-R Test (Cuetos et al., 2009) evaluates reading skills in Primary education, and it consists of Letter identification, Lexical, Grammar, and Semantic processes distributed in nine tasks and indices. For this study, the scores obtained from the principal indices of each task were collected.

a) Letter Identification:
   - Name of Letters (NL), in which the child must mention the name or the sound of 20 letters and record the time;
   - Same - Different (SD) where the child must identify whether 20 pairs of words, some real, and others invented, are the same or different and the time is also recorded.

b) Lexical Process: Reading Words (RW, real words) and Reading Pseudowords (RP, invented words), reading of a series of 20 items per task in which the time and the number of correct answers are calculated.
c) Grammar Processes:
   - Grammar Structures (GS) matching a sentence / instruction with an image of four presented (out of 16 possible);
   - Punctuation marks (PM), checking the knowledge and use of punctuation marks by reading a text in which the correct answers are considered (of the 11 available).

d) Semantic Processes:
   - Sentence Comprehension (SC), where the child must read sentences and respond to the questions (out of 16 possible);

- Text comprehension (TC), where the participant has to read aloud four short texts (two narratives and two descriptive ones) and then answer four inferential questions for each text. The score comes from the total number of correct answers (out of 16 possible).
- Another task is Oral Comprehension (OC) in which the evaluator reads two descriptive texts to the child and checks the oral comprehension capacity with four inferential questions per text (out of 8 possible).

Finally, in order to calculate the principal indices in these tasks (NL, SD, RW, RP, and PM), the authors used the following formula: Index = (Hits / Time) x 100. Hits are the direct score or number of hits in the task, and Time is the seconds invested in its execution. The complete application of the instrument lasted approximately one hour. The resolution rhythm of each participant was carried out individually and in a single session.

Procedure

All the participants were evaluated by following the same order of application of the instruments. To complete the application of all the tasks, three sessions of approximately 45 minutes each were necessary. In the first session, the application sequence was as follows: sections 1 and 2 of the IRPS. In the second session, the researchers used the PROLEC-R test, and finally, in the third session, the Irlen Screener administered section 3 of the IRPS.

The legal representatives of all participants received and signed the informed consent document according to the recommendations of the Bioethics Committee under the Declaration of Helsinki (World Medical Association, 2008). Data was collected after obtaining the signed informed consent document of each legal representative. The research was approved by the Bioethics Committee of the University of Cuenca.

Data analyses

For the data analyses, the researchers used the Statistical Package for Social Sciences (SPSS) version 23 and a 95% reliability index with a margin of error of 0.05. All the variables that implied scores on the evaluated dimensions are an interval and ratio. Therefore, before the inferential statistical analysis, the application of the Kolmogorov-Smirnov test was carried out, which showed a non-normal distribution ($p \leq 0.05$) for all variables. It was also possible to verify employing the test of homogeneity of variances between groups that the variables of PROLEC-R were not homogeneous ($p < 0.05$). For these reasons, for the statistical analyses, this study used non-parametric tests considering their distribution and homoscedasticity: the Mann-Whitney *U* test was used for comparisons between the EG and CG, and Cohen's *d* test to analyse the effect size.

Results

For group discrimination, the ROC curve analysis was used to determine a reference point and distinguish the IS group and the control group based on the total score from section 1 and the criteria as defined from section 3 of the IRPS. The Mann Whitney *U* test showed significant differences in both dimensions of section 1 ($p < 0.05$) and all the tasks of section 2 ($p < 0.05$). These results indicated that distortions, visual disturbances, and perceptual ability were significantly worse in children with IS compared to non-IS (table 1).

Table 1

Means (and SD) of the scores on the Irlen Reading Perceptual Scale (IRPS) in the Irlen Syndrome group (ISG) and the control group No Irlen (CG)

Section	Task	ISG	CG	*U*	*d*
1	Visual Difficulties	46.96 (9.7)	26.49 (6.03)	.001**	2.53
	Visual Discomfort	35.27 (9.12)	22.29 (4.5)	.001**	1.81
2	Alterations in Cube A	7.29 (4.17)	2.55 (2.4)	.001**	1.39
	Alterations in Cube B	9.25 (3.81)	4.07 (2.79)	.001**	1.55
	Alterations in Pumpkin	8.49 (4.29)	2.87 (3.04)	.001**	1.51

*$p < .05$; **$p < .001$

According to *PROLEC-R Test* and in agreement with the first hypothesis on the identification of letters, the results showed that there were no significant differences between groups, as seen in table 2.

Regarding lexical processes, the data indicated significant moderate differences between groups in both the word reading task ($p = 0.019$; $d = 0.57$) and the pseudoword reading task ($p = 0.005$; $d = 0.57$), confirming the second hypothesis of this study. *Post hoc* analysis indicated that the ISG performed worse than the CG in both tasks.

Table 2

Means (and SD) in the scores of the nine PROLEC- R tasks in the Irlen syndrome group (ISG) and the control group No Irlen (CG)

Process	Task	ISG	CG	*U*	*d*
Letter identification	Letter identification	107.19 (39.54)	102.20 (35.58)	.584	.13
	Same-Different	19.02 (11.49)	20.22 (11.67)	.462	.10
Lexical	Word Reading	57.33 (23.38)	73.56 (32.67)	.019*	.57
	Pseudowords Reading	38.38 (14.84)	47.52 (17.34)	.005**	.57
Grammar	Grammar Structure	11.45 (2.29)	12.13 (2.8)	.110	.26
	Punctuation Marks	8.4 (5.23)	12.5 (8.91)	.009**	.56
Semantic	Sentence Comprehension	13.82 (1.93)	14.8 (1.45)	.002**	.57
	Text Comprehension	9.42 (2.99)	10.55 (2.9)	.041*	.38
	Oral Comprehension	3.02 (1.58)	3.35 (1.58)	.110	.20

*$p < .05$; **$p < .001$

Concerning the grammatical processes, the results indicated that there were significant differences in the punctuation marks task ($p = 0.009$; $d = 0.56$), with the ISG group presenting a worse performance than the CG. These data partially confirmed the third hypothesis.

In relation to semantic processes, significant differences were found in visual reading comprehension. The ISG showed low marks compared to the CG. Indeed, the results showed that the ISG had significantly lower performances in visual reading comprehension, specifically in the measure of Sentence Comprehension ($p = 0.02$; $d = 0.57$), and the measure of Text Comprehension ($p = 0.04$; $d = 0.38$).

Discussion

The main purpose of this research was to distinguish the reading skills of children with and without Irlen's syndrome. For the differential analysis, the skills considered by Cuetos et al. (2009) were taken as references: Letter identification capacity, Lexical, Grammar, and Semantic Processes.

The fact that no significant differences were found in the ability to identify letters allowed us to confirm the first hypothesis. This condition that both groups maintained a good performance in this skill allowed us to suppose that essential processes such as letter identification could not be affecting the children's reading skills. Phonological processing and naming speed are precursors to learning to read and write (Perfetti & Staffura, 2014). In fact, according to Perfetti (1994), speedy naming is a predictor of literacy. This essential condition for reading was fully acquired in both groups and therefore was not a variable that interfered with the interpretation of the latter results.

Children with Irlen Syndrome performed at the same level as those without it because, on letter identification tests, the effort is not the same as when they read a complete text. In the identification task, all the children had to recognize isolated letters taken out of context without being part of a paragraph. When reading entire lines of a text, for those who suffer from IS, the effort is greater due to the presence of line patterns in reading texts on white backgrounds that can trigger the presence of visual distortions and physical discomfort when reading which are the hallmarks of Irlen Syndrome symptomatology and developmental dyslexia (Stein 2018; Vilhena, et al, 2021).

However, despite maintaining good performance by both groups, significant differences were found in the more complex skills, such as inferential understanding. Concerning lexical processes, the significantly poor performance in the ISG confirmed the hypothesis. This phenomenon may be closely related to the difficulty that children with IS may have for quick access to words and the limited ability to identify the composition of words and pseudowords.

According to Cuetos et al. (2009), the ability to access text words is usually a rapid mechanism that would depend on the associative capacity that the reader has with previously known words. Probably, in some cases, due to the frequent use of certain words, they tend to identify them without the need to analyse their parts previously. Wilkins et al. (2004) suggested that the visual processing that occurs when recognizing words could be affected by IS and lead the person to use a global methodology for word recognition and would be the cause of the error when recognizing words and pseudowords in detail.

As for grammatical processes, the researchers expected to find a worse performance in the ISG than in the CG. Performance in the grammar structures task was similar. There were

differences between groups in the punctuation mark task. Significant differences were not found in the first task. Images were used for solving it, which could be of great help for children to solve it. Additionally, in the punctuation marks assignment, no type of aid interfered with the visual ability to read and could be considered the main reason for the poor performance of children with IS. According to some studies (Irlen, 2005; Wilkins et al., 2004), IS is characterised by visual distortions that affect the identification and omission of punctuation marks, which would produce a poor reading.

Regarding semantic processes, the differences between groups were very interesting because they support the hypothesis that the most noticeable difference could be found in visual comprehension tasks rather than listening comprehension tasks. The ISG had a lower performance in the assignments of sentence and text comprehension compared with the CG. While in the oral comprehension task, there were no significant differences between either group.

The results of this research indicate that students with Irlen syndrome showed significantly lower performance in all tasks of visual comprehension. Although oral comprehension was slightly lower, the difference between groups was not significant. These results would support the proposed hypothesis that Irlen syndrome can affect visual perception and comprehension and not necessarily oral comprehension. In a systematic review on the Irlen Syndrome, Sacoman (2020) explained that while there are problems in IS cases, verbal capacity is not always affected; however, these affirmations lack empirical data or statistical analysis to support this claim. Given the lack of prior research on Irlen Syndrome and the use of oral comprehension tests, the findings of our empirical study, which provide evidence verifying this group distinction, lead us to suggest that oral comprehension ability is particularly interesting for further exploration.

The results of our study would also support the data previously found by Tacuri-Reino et al. (2018) on visual comprehension in participants with IS. These authors used as a measure a short story that had to be read by the student, who afterwards answered five questions; they counted hits, errors, and reading time. Their results showed that the comprehension of the ISG was significantly lower than that of the CG in all three measures. As can be observed, visual comprehension would be affected in IS patients when using different tests and different measures, as also mentioned by Guimaraes et al., (2020).

Although not directly comparable, this study provides new empirical data for consideration since the researchers used three tasks of the PROLEC-R. In this sense, even though, there is more research that supports that people with Irlen syndrome present problems in reading (Guimarães & Guimarães, 2013), the analyses have been to date limited in terms of empirical procedures and only some have focused solely on detailing reading speed (for example, Hollis & Allen, 2006). Hence, several authors have questioned previous research confirming the existence of the Irlen syndrome, its influence on reading, and the types of evaluation and intervention used (Griffiths et al., 2016; Ritchie et al., 2011; 2012; Uccula et al., 2014).

On the contrary, our investigation offers a comprehensive analysis of reading abilities, not just in terms of reading speed but also in the processes involved in comprehension, which would be the ultimate purpose of reading.

Additionally, the novelty of the present study in comparison to other studies, and especially that of Tacuri-Reino et al. (2018), has been to offer more empirical data than those found in previous studies, and in an area in which research is already very scarce. This research offers a study on the reading skills in people with Irlen syndrome, in which, in addition to the analysis of visual comprehension (with two measures), data are presented with a measure of oral comprehension.

The use of all these different measures allowed us to examine reading skills more broadly and deeply. We considered the postulates of authors such as Cuetos, (2010) and Cuetos et al., (2009) who agreed that to reach the final objective of reading, processes such as letter identification, lexical, grammatical, and semantic processes are required.

The fact of having two measures of visual comprehension has contributed to having a broader perspective of reading comprehension, depending on the degree of difficulty in reading, the need for memory retention, as well as the processing of information and the appropriate use of punctuation marks to understand the message. Likewise, the listening comprehension measure has a special emphasis, as it allowed us to describe how Irlen syndrome specifically influences visual comprehension and, at the same time, it was ruled out that it could significantly affect oral comprehension. Future research might consider including measures of listening comprehension with various tasks, just as visual comprehension has been studied, which would provide a more in-depth analysis of listening comprehension in people with Irlen syndrome.

As for the limitations of this study, it did not have an intelligence measurement, even though one of the exclusion criteria was not to include participants who needed some curricular adaptation or had a psychological diagnosis related to any intellectual disability.

Another limitation was that a single measure was considered to compare with visual comprehension, for which three variables were considered.

Furthermore, although the educational centres were from similar sociocultural contexts, socio-economic conditions, behavioural problems, and subtle pathological issues presented in the participants were not considered in more detail. This aspect should be considered in future studies, as situational factors (Hu et al., 2022) affect reading skills significantly, and in this area of research, on reading skills in people with Irlen syndrome, there are not many studies that analyse these variables.

Additionally, PROLEC-R's psychometric limitations should also be considered, as group differences may exist, but were not identified with this specific instrument. Another limitation concerns the group selection itself, as participants with reading difficulties in IRPS were concentrated in the IS group.

Conclusions

Regarding the identification of letters, it was evident that both the control group and the ISG had similar and favourable performances for their age, which is why it is concluded that the learning of letters, essential for reading, did not influence the differentiation.

About the lexicon processes, the confirmation of the differences between groups allowed us to conclude that the perceptual processes for the rapid acquisition of the word may be affected by Irlen's syndrome, and this would cause difficulty in effectively distinguishing words.

Concerning grammatical processes, the partial difference between groups, equal in Grammatical structures, and different in Punctuation marks, led to the conclusion that perception influenced the results. In the first task, the visual aids could have influenced the inclination for some of the ways of response. In the second, the omissions of the punctuation marks could have been caused by perceptual ability. On a new occasion, the task of grammatical structures could be evaluated by separating the sentence of the statement from the possible response figures.

With the semantic processes in reading comprehension, the results indicated that visual comprehension can be affected by the Irlen syndrome. The different manifestations in visual perception difficulty could influence the processing of the information that is necessary for reading, and more specifically for comprehension. However, oral comprehension does not appear

to be significantly affected by Irlen syndrome. In this sense, future research should delve into oral comprehension.

Data Availability Statement

The data that support the findings of this study are openly available in Reino, T., Tacuri-Reino, R.D., & Bernal, M. (2022). *Datos comparativos de habilidades lectoras de escolares con y sin Síndrome de Irlen*. Harvard Dataverse, V2. https://doi.org/10.7910/DVN/XHSREC

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