



Characteristics of the written compositions of Spanish children with dyslexia and their relationship with spelling difficulties

Olivia Afonso¹ · Marina Carbajo² · Cristina Martínez-García^{2,3} · Paz Suárez-Coalla²

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Abstract

Previous work in English has found that the spelling difficulties of children with dyslexia affect the overall quality attributed to their written compositions. The aim of this study was to investigate whether different processes related to transcription, translation and ideas proposing/planning are affected in developmental dyslexia and to what extent potential deficits are associated to poor spelling. Compositions handwritten by Spanish-speaking children with and without dyslexia aged 9–12 years-old ($n=42$) were compared on measures of productivity, spelling accuracy, legibility, lexical diversity, punctuation, sentence structure and grammar, organisation, ideas quality, and readability. Children with dyslexia performed worse in spelling, lexical diversity, syntax and grammar and ideas quality. Interestingly, in the group with dyslexia spelling accuracy contributed to lexical diversity, while lexical diversity was the only significant predictor of syntax and grammar, organisation and ideas quality. This pattern of results was absent in typically developing children. This evidence suggests that spelling difficulties reduce the lexical diversity of the texts of children with dyslexia, which may affect the activity of the translator and the proposer, diminishing the perceived quality of their written compositions.

Keywords Spelling · Written composition · Handwriting · Lexical diversity · Developmental dyslexia

✉ Olivia Afonso
afonso.o@brookes.ac.uk

¹ Centre for Psychological Research, Oxford Brookes University, Gypsy Lane, Headington, Oxfordshire, Oxford OX3 0BP, UK

² Department of Psychology, University of Oviedo, Oviedo, Spain

³ Department of Psychology and Educational Sciences Studies, Universitat Oberta de Catalunya, Barcelona, Spain

Introduction

At school, children are required to complete different writing tasks across the curriculum every day, so they need to become competent at text production to succeed academically (Fisher & Twist, 2011). However, becoming a competent writer is a challenging task for many children. Children with developmental dyslexia are known to experience both reading and spelling difficulties (American Psychiatric Association, 2013). Importantly, a growing body of evidence suggests that difficulties with spelling may also have a detrimental effect in other aspects of the writing process, such as handwriting speed (Sumner et al., 2013, 2014), vocabulary diversity (Connelly et al., 2006; Sumner et al., 2016; Wengelin, 2007), or the number of ideas included in the text (Sumner et al., 2016). Individuals with dyslexia have been found to compose shorter texts that are rated as being of lower quality than those produced by their typically developing peers, even after spelling errors have been removed (Connelly et al., 2006; Sumner et al., 2016; Tops et al., 2013). There is thus increasing awareness among researchers and teachers of the need to consider the effects that spelling problems may have on other aspects of text production in order to support students with dyslexia to become effective communicators through writing. The present study aims to identify the specific levels of processing involved in text production that are affected in developmental dyslexia and to explore to what extent these deficits are associated with the spelling difficulties.

Any model of writing needs to acknowledge the complexity of the text composition process (Berninger & Amtmann, 2003; Chenoweth & Hayes, 2001; Connelly et al., 2012), which involves linguistic and non-linguistic processes. In their influential model of writing, Chenoweth and Hayes (2001) suggested that at least four cognitive processes can be identified in text production: a proposer, a translator, a transcriber, and a reviser or evaluator. The proposer generates a communicative aim and derives ideas to be included in the text. Although it might deal with some information in linguistic form (Chenoweth & Hayes, 2003), the proposer is mainly a pre-linguistic level of processing. The translator converts the ideas into a verbal message. This process includes choosing the appropriate words and ordering them into syntactically and grammatically correct sentences. The transcriber then transforms this linguistic message into written text. In handwritten text production, transcription includes orthographic retrieval (i.e., spelling) and graphomotor execution (handwriting). The evaluator revises the output of the other levels and judges its adequacy. All these processes recruit part of our limited cognitive resources. Thus, increased demands in one of these components may lead to insufficient resources being available for the rest (Berninger & Amtmann, 2003). Specifically, it is agreed that in the early stages of writing development, before spelling and handwriting have been automatised, transcription processes demand considerable cognitive effort, reducing the capacity available for translation and planning (Berninger & Amtmann, 2003; Berninger & Winn, 2006; Grabowski, 2010; Sumner et al., 2014). However, it remains unclear the extent to which spelling difficulties experienced by children with dyslexia affect other processes involved in written composition.

In studies conducted with typically developing writers, both spelling ability (Graham & Santangelo, 2014; Limpo et al., 2017) and handwriting speed (Graham et al., 1997; Jones & Christensen, 1999; Limpo et al., 2017; Longobardi et al., 2018) have been found to be related to the quality of written compositions. However, Berninger et al. (2008) proposed that, while automaticity in letter writing would be the main factor for typically developing individuals (Graham et al., 1997), spelling skills uniquely contribute to the written composition of individuals with dyslexia. It is certainly possible that spelling has a disproportionate effect on the overall quality of the texts written by individuals with developmental dyslexia, but it is unclear which specific processes involved in text production might be affected. In fact, spelling difficulties have been reported to be associated with handwriting fluency (i.e., transcription), translation processes and even with the highest-order levels (Bereiter & Scardamalia, 1987) of planning and idea generation.

Evidence obtained in different languages seems to confirm that spelling impairments lead to reduced handwriting fluency (Afonso et al., 2015, 2020; Suárez-Coalla et al., 2020; Sumner et al., 2014). Increased writing latencies (Afonso et al., 2020), within-word pauses (Sumner et al., 2014) and handwriting durations (Martínez-García et al., 2021) have been reported in children with dyslexia, and reduced handwriting fluency has been also found in adults with dyslexia (Afonso et al., 2015). This might explain, at least in part, why individuals with dyslexia tend to produce shorter texts. Importantly, increased pausing during writing in dyslexia has been shown to be associated with spelling ability rather than with motor problems (Sumner et al., 2014).

Regarding the translation processes, there seems to be agreement on the existence of word-level problems (Berninger et al., 2008; Sumner et al., 2014, 2016; Wengelin, 2007). The use of a limited vocabulary in comparison to age-matched peers has been detected with both subjective and objective measures (i.e., lexical diversity). Connelly et al. (2006) found that college students with dyslexia obtained a lower score on vocabulary than a group matched by chronological age. Wengelin (2007) reported reduced vocabulary in a group of young adults with dyslexia in written but not in spoken composition. This author proposed that this might be linked to a reduction in the resources available for lexical selection, or to a conscious strategy used by individuals with dyslexia to avoid difficult-to-spell words. In a study conducted with 8–11 year-old children, the texts produced by those with dyslexia obtained a lower subjective score on vocabulary, and reduced lexical diversity was confirmed when an objective measure unaffected by text length was used (Sumner et al., 2016). Crucially, this reduced use of vocabulary was not detected in verbal compositions, suggesting a link with spelling difficulties.

What is less clear is whether spelling affects translation processes beyond the word level in dyslexia. In a study conducted with typically developing Portuguese children, Limpo et al. (2017) explored whether transcription skills (handwriting and spelling) affected writing performance directly by affecting planning or translating processes. Structural equation modelling results revealed that spelling ability had an indirect effect on writing quality via its impact on translating (including syntactic structure correctness). In studies investigating this relationship in dyslexia, compositions produced by both adults (Connelly et al., 2006; Tops et al., 2013) and children

(Sumner et al., 2016) with dyslexia have been reported to be rated more poorly than those of their peers in punctuation. However, the studies that tested adult participants did not find differences between those with dyslexia and their typically developing peers on sentence structure (Connelly et al., 2006). As sentence structure was not assessed in Sumner et al., (2016), it is still unclear if sentence-level translation processes are affected in children with dyslexia.

Even less conclusive is the evidence reported regarding a potential deficit affecting the activity of the proposer. This is true for both typically-developing populations and individuals with dyslexia. Some authors have suggested that spelling processes affect the ability to generate ideas during written composition in typically-developing children and adults (Bourdin & Fayol, 1994, 2002), Limpo et al. (2017) reported that handwriting fluency, but not spelling accuracy, was related to planning skills associated to ideas generation in 12–14 years-old children. Similarly, while Sumner et al. (2006) found that 9-to-11 years of age children with dyslexia obtained lower scores in ideas and development and in organisation, unity, and coherence (which are related to the proposer), this difference was not found in young adults (Connelly et al., 2006).

Several factors may explain the different pattern of results previously reported, but a possibility is that spelling difficulties associated with dyslexia are more challenging in childhood than in adulthood. After years of contact with written language, spelling is expected to be less demanding for adults than for primary school children. Although spelling difficulties are known to persist in adults with dyslexia, their impact on higher-order processes might reduce over time due to an increase in working memory capacity (Kellogg, 2001), or spelling might become less challenging as orthographic knowledge increases (Afonso et al., 2015). If this is the case, effects of spelling difficulties on composition quality might be reduced in languages with orthographic systems less challenging than the English system. Most of the evidence on this issue has been obtained in English, a language with a strikingly inconsistent and irregular orthography. The reduced consistency of the correspondences between phonemes and graphemes in English represents a great challenge for learning to read and write in this language (Ehri, 2005). Application of rules to convert phonemes into graphemes are frequently not enough to produce a correct spelling, and the percentage of spellings that require memorisation have been estimated to represent as highly as a 50% of the English words (Hanna et al., 1966). It is possible that word-level difficulties do not consume as many cognitive resources in languages with more transparent orthographies. This might explain why Limpo and collaborators (2017) did not obtain evidence of a direct link between spelling accuracy and planning in Portuguese, a language with an intermediate orthographic depth (Sucena et al., 2009).

In a language with an even more transparent orthography, such as Spanish, spelling might not be as demanding as to interfere with the activity of the planner. With only a few exceptions (e.g., *b* and *v* can both be used to represent the phoneme /b/, *g* and *j* can be used to spell the phoneme /x/, and both *y* and *ll* can represent the sound /ʎ/), phoneme-to-grapheme correspondences can be used to accurately spell most of the Spanish words, so specific word-level orthographic knowledge might not be as necessary as it is in English. The possibility of largely relying on decoding processes to spell might

substantially reduce the burden imposed by spelling and, as consequence, the scope of the deficits found in English-speaking children with dyslexia.

The present study has a two-fold aim. First, we intend to assess whether the activity of the transcriber (including spelling and handwriting fluency), the translator (both at the word and the sentence level) and the proposer are affected in 9–12 years-old children with developmental dyslexia. Evidence has shown that low-level transcription skills, including spelling, significantly constrain text quality in this age group (Limpo & Alves, 2013). In this study, we aim to explore the relationship between spelling accuracy in a writing composition task and handwriting fluency (i.e., legibility), word-level and sentence-level translation aspects (i.e., lexical diversity, punctuation, and sentence structure), and higher-order, conceptual processes associated to the proposer (i.e., ideas, cohesion and general organisation of the text). Analysing this wide range of measures will give us an idea of the ways in which the relationship between spelling, handwriting, translating and the activity of the proposer differ in children with and without dyslexia. To this end, objective and subjective measures of the quality of the writing product of 9–12 year-old children with dyslexia and of their typically developing peers were collected. Namely, subjective measures of handwriting legibility (transcription), punctuation, and sentence structure and grammar (both tapping into sentence-level translation processes), general organisation and structure, and quality of ideas (both reflecting the activity attributed to the proposer) as well as objective indices of productivity (word, sentence and text length), lexical diversity (reflecting word-level translating), and referential cohesion (proposer) were obtained. Secondly, we explore to what extent spelling difficulties (as one of the known core deficits in dyslexia) relate to any potential difficulties found in the other levels of processing.

Based on the findings reported in previous studies conducted in other languages (Connelly et al., 2006; Puranik and Al Otaiba 2012; Sumner et al., 2016; Wengelin, 2007), we hypothesise that the compositions written by children with dyslexia will obtain lower scores of overall quality and that they will reflect poorer performance in relation to all the linguistic processes involved in text production (i.e., processes related to transcription and translating). Thus, the group with dyslexia is expected to produce shorter compositions including more spelling errors, with less lexical diversity and poorer sentence structure and grammar. Although impairments in organisation and general structure and in idea generation have been reported in English (Sumner et al., 2016), the simplicity of the Spanish orthographic system might lead to processes carried out by the planner (which are more abstract and less reliant on written language processing) being unaffected in Spanish-speaking children with dyslexia. Finally, we hypothesise that processes identified as impaired in text composition will be more strongly associated with the level of spelling ability in the group with dyslexia than in a group of peers of the same age without dyslexia.

Method

Participants

A total of forty-two children (20 boys and 22 girls), attending Grade 4 (around 9 years of age), Grade 5 (around 10 years), and Grade 6 (around 11 years of age) in different primary schools in Asturias (Spain), participated in this study. Twenty-one were children who had received a diagnosis of dyslexia ($M_{age} = 10$ years 5 months, $SD = 0.77$), recruited from the Dyslexia Association of Asturias, Spain. Children in the typically developing group were recruited from primary schools. They were randomly chosen among those who did not have any known language, literacy or learning difficulty and met the criteria to be matched to children included in the group with dyslexia by sex and age ($M_{age} = 10$ years 8 months, $SD = 0.95$). All participants were native Spanish speakers from areas of middle socio-economic status. They all had normal or corrected-to-normal vision and were within normal IQ range.

Children with dyslexia had received a diagnosis of dyslexia at school by a specialist psychologist, who provided scores from reading and spelling assessments. To evaluate reading and spelling performance, the Spanish Reading Assessment Battery (PROLEC-R; Cuetos et al., 2007) and the Spanish Writing Assessment Battery (PROESC; Cuetos et al., 2002) were used. Children with dyslexia performed 1.5 standard deviations below the PROLEC-R and PROESC normed average in reading and spelling ruled words (i.e., words for which a rule can be applied to generate the correct spelling), inconsistent words (i.e., words with and arbitrary spelling that demands word-specific orthographic knowledge), and pseudowords (see Table 1). These results indicate that children included in this group had difficulties in reading and spelling consistent with the diagnosis of dyslexia.

The schooling of the children in the typically developing group had developed without remarkable incidents (i.e., children had not retaken a year of studies). Parents confirmed in an interview the absence of academic difficulties in general

Table 1 Mean performance of children with developmental dyslexia (DD) in reading and spelling assessment tasks compared to normative standard scores

Task	Children with DD M (SD)	Normative standard score M (SD)
Reading		
Word accuracy out of 40	33.87 (4.42); CI=31.97–35.76	39.889 (0.33)
Word speed (s)	85.75 (29.01); CI=73.34–98.15	35.111 (4.81)
Pseudoword accuracy	30.87 (5.19); CI=28.65–33.08	38.555 (0.53)
Pseudoword speed	108.87 (53.09); CI=86.16–131.57	57.333 (5.60)
Spelling		
Inconsistent words (out of 25)	11.14 (3.53); CI=9.63–12.64	21.666 (0.72)
Ruled words (out of 25)	15.86 (1.46); CI=15.23–16.48	22.666 (0.72)
Pseudowords (out of 25)	16.14 (2.67); CI=14.99–17.28	23.667 (0.71)

and in reading or writing in particular. Children with any physical, or sensory disability were not invited to take part in the study.

Materials and procedure

A written compositional task was administered. Children were asked to write, on a lined sheet of paper, about their ideal trip (“*What would be your ideal trip and why?*”). The prompt was selected because it does not require specialised knowledge, so all children were expected to be able to generate ideas in relation to the topic. The task was carried out individually, in a room without distractions. The examiner explained the task to the participants as well as what the session would involve. Children were given two minutes to plan their narration, after which they were asked to write for 12 min in response to the prompt. Children were asked to choose the pencil or pen with which they felt most comfortable and able to produce their best handwriting. No specific instructions about writing speed were given.

The testing session took place during the spring, when children were in the last quarter of the academic year. The research design and procedure were approved by the Ethics Committee for Research of the Principality of Asturias, Spain. It was developed in accordance with the Declaration of Helsinki and the Spanish Law of Personal Data Protection (15/1999 and 3/2018) principles. Prior to administration of the writing task, parents received information about the study and its objectives and authorised participation by signed consent.

Measures

Written compositions were analysed to obtain separate measures for different transcription, translation and processes associated to the proposer. Overall measures of writing quality and productivity were also obtained. Scores for punctuation, sentence structure and grammar, organisation and general structure, and ideas were obtained by applying the rubric for punctuation of the Writing Assessment Measure scale, WAM (Dunsmuir et al., 2015). WAM is a tool to evaluate written compositions produced in response to a prompt based on the Wechsler Objective Language Dimensions Written Expression subtest (WOLD; Rust, 1996). For each measure, a minimum score of 1 and a maximum score of 4 could be obtained (see full rubric in Appendix A). Descriptive measures of productivity as well as objective measures of cohesion and readability were obtained with Coh-Metrix-Esp (Quispesaravia et al., 2016), an instrument for the automatized analysis of written texts. Coh-Metrix-Esp offers a quantitative dimension of text complexity through a wide range of indices. The Spanish version (Coh-Metrix-Esp) was created from the English version (Coh-Metrix 3.0; Graesser et al., 2004), developed in the University of Memphis. The analytic measures provided by Coh-Metrix 3.0 have been found to be related to holistic scores of writing quality (Cameron et al., 1995).

For all measures based on subjective ratings (i.e., legibility, punctuation, sentence structure, organisation, and number of ideas), three trained speech therapists otherwise unconnected to the study and who were blinded to participant group acted as

judges. For each of them, Intraclass Correlation Coefficients (ICC) were calculated using the average of the three scores with a two-way mixed-effect model. A detailed description of the overall characteristics of the compositions, as well as measures obtained in relation to the three main components of the writing process (transcription, translation, and proposer) are given below.

Overall measures

Descriptive measures

Number of sentences, total number of words, average number of words per sentence, average number of syllables per word, and average number of letters per word. The number of paragraphs was not considered because all participants wrote only one paragraph.

Overall quality

The three judges provided an overall measure of quality of the compositions using a scale from 1 (*low quality*) to 7 (*high quality*) based on the criteria of ideas quality, organisation, sentence structure, and vocabulary. ICC = 0.88.

Readability

Coh-Metrix-Esp applies the Fernández-Huertas Formula (Fernández-Huertas, 1959). This formula is an adaptation for Spanish of the Flesch Grade Level, an indicator of the school level required to understand the text. This index is calculated based on the length of words (in syllables) and the length of sentences (in words) included in a given passage. Texts including longer word and sentences obtain a higher score than text with shorter words and sentences. The higher the score in this measure, the easier is to understand the text (i.e., less effort would be required to understand it).

Transcription measures

Spelling accuracy

Firstly, the *percentage of errors* based on the total number of words in each text was considered. Moreover, separate percentages were calculated for different types of errors: capitalisation errors, grapheme substitutions (errors in which one grapheme is substituted for another, such as in *baso* instead of *vaso* [glass]), word unions (errors in which words are incorrectly joined, such as *laniña* instead of *la niña* [the girl]), word fragmentations (words were incorrectly divided; e.g.: *len tamente* instead of *lentamente* [slowly]), grapheme omissions (errors in which a grapheme was omitted; e.g.: *mimo* instead of *mismo* [same]), grapheme inversions (when the order of the graphemes was reversed; e.g.: *palta* instead of *plata* [silver]), grapheme additions (a grapheme was

incorrectly added; e.g.: *mensa* instead of *mesa* [table]), stress mark errors (a stress mark was omitted or erroneously included; e.g.: *camion* instead of *camión* [lorry]), self-corrections or crossed-out segments, and morphological errors (errors affecting derivational or inflectional morphology; e.g., *perro* [dog] instead of *perros* [dogs]). For each written composition, a transcription with these spelling errors corrected was created. These transcriptions were used to obtain measures of writing productivity and scores of punctuation, structure, organisation and number of ideas (see below).

Legibility

To evaluate handwriting ability, we obtained the total legibility score from the Handwriting Legibility Scale, HLS (Barnett et al., 2018). This scale includes five items to be scored on a 5-point Likert-type scale, with higher scores indicating poorer performance. The scale assesses legibility in terms of readability (general impression of global readability based on your first reading of the text), effort (general impression of the amount of effort required to read the written text for the first time), page layout (general impression of the distribution of writing on the page), letter formation (general impression of letter formation) and alterations (general impression of attempts to rectify the letters within the words). The total score is obtained by summing the scores obtained in each item (ICC=0.98).

Translation measures

Lexical diversity

Type-token ratio (TTR, Templin, 1957), which estimates the diversity of the vocabulary in the text, was calculated. We then obtained the Guiraud's R index: $\text{types}/\sqrt{\text{tokens}}$ (Guiraud, 1954), a mathematical transformation of type-token ratio that provides a measure of lexical diversity unaffected by the length of the text.

Sentence structure and grammar

A subjective score between 1 and 4 of the complexity of the sentences produced and the ability to use different structures such as conditional and passive voices appropriately (ICC=0.76).

Punctuation

A subjective measure of the appropriate usage of punctuation marks with a minimum score of 1 and a maximum score of 4 could be obtained (ICC=0.86).

Proposer measures

Ideas quality

A subjective measure between 1 and 4 of the number, interest, originality and detail of development of the ideas included in the composition.

Organisation and general structure

A subjective measure between 1 and 4 of the cohesion of the composition's content (ICC = 0.81).

Referential cohesion

An index of noun, argument, stem, and content word overlap, which are known to facilitate comprehension (Graesser et al., 2003).

Statistical analysis

Several independent-samples t-tests were conducted with SPSS.24 to compare performance between the groups with and without dyslexia. P-values were adjusted using to the Holm-Bonferroni method to correct for multiple comparisons. Pearson's Product-Moment Correlations were calculated separately for each group to establish whether the association between different aspects of the written composition was similar for children with and without dyslexia. Legibility (reflecting transcription processes), lexical diversity and sentence structure (word- and sentence-level translation, respectively) and general organisation and ideas quality (proposer) were submitted to separate linear regression analyses to ascertain the precise contribution of spelling to different processing components of writing.

Results

Overall measures

Descriptive statistics and results of the t-tests for the differences between groups obtained in these measures can be seen in Table 2. Regarding the descriptive measures, there was a significant difference between groups in the average number of words per sentence, with children with dyslexia writing shorter sentences than their peers. Moreover, the compositions written by children with dyslexia were rated as being of significantly lower overall quality than the compositions of typically

Table 2 Scores obtained by the group with developmental dyslexia (DD) and the typically developing (TD) group in overall measures

Measures	DD <i>M (SD)</i>	TD <i>M (SD)</i>	<i>p-value*</i>	<i>Cohen's d</i>
Descriptive measures				
Number sentences	6.90 (3.21); CI=5.52–8.27	6.00 (1.97); CI=5.15–6.84	= .256	0.34
Number of words	92.76 (39.46); CI=75.88–109.63	112.857 (37.84); CI=96.66–129.03	= .180	0.53
Word per sentence	14.08 (4.01); CI=12.36–15.79	19.39 (5.22); CI=17.15–21.62	= .006	1.14
Syllables per word	1.82 (0.26); CI=1.70–1.93	1.98 (0.15); CI=1.91–2.04	= .105	0.74
Letter per word	3.95 (0.85); CI=3.58–4.31	4.43 (0.33); CI=4.28–4.57	= .105	0.74
Overall text quality	4.05 (0.92); CI=3.63–4.47	5.29 (0.90); CI=4.87–5.60	< .001	1.36
Readability	87.76 (5.65); CI=85.34–90.17	82.90 (9.98); CI=78.63–87.16	= .177	0.60

*Holm-Bonferroni corrected p-value

developing peers. There were no significant differences in the rest of measures considered.

Transcription measures

Significant differences were found between both groups in overall percentage of errors, percentage of capitalisation errors, grapheme substitutions, word unions, grapheme omissions, grapheme additions, stress mark errors, and self-corrections (see Table 3). Significant differences between the groups were also found in

Table 3 Percentage of type of errors made by the group with developmental dyslexia (DD) and the typically developing (TD) group

Error type	DD % <i>M (SD)</i>	TD % <i>M (SD)</i>	<i>p-value*</i>	<i>Cohen's d</i>
Total errors	38.89 (15.37); CI=31.90–45.89	11.02 (5.52); CI=8.53–13.98	< .001	2.41
Capitalisation	3.59 (3.63); CI=2.03–5.14	1.44 (1.71); CI=0.7–2.17	= .092	0.76
Stress mark	9.12 (4.25); CI=7.30–10.93	4.57 (3.57); CI=3.04–6.09	= .009	1.16
Word union	2.74 (3.60); CI=1.20–4.27	0.39 (0.77); CI=0.06–0.72	= .048	0.92
Fragmentation	0.52 (0.96); CI=0.11–0.93	0.45 (0.66); CI=0.16–0.73	= .746	0.09
Omission	1.82 (2.17); CI=0.89–2.74	0.11 (0.34); CI=– 0.03–0.25	= .009	1.10
Substitution	10.42 (6.36); CI=7.69–13.14	0.60 (0.98); CI=0.18–1.02	< .001	2.16
Inversion	0.14 (0.49); CI=– 0.06–0.35	0.06 (0.29); CI=–0.06–0.18	= .428	0.18
Addition	1.05 (1.75); CI=0.30–1.79	0.04 (0.20); CI=–0.04–0.12	= .065	0.81
Self-correction	5.78 (4.96); CI=3.65–7.90	2.29 (2.44); CI=1.24–3.33	= .042	0.90
Morphological	0.93 (1.20); CI=0.41–1.44	0.39 (0.83); CI=0.03–0.74	= .099	0.56

*Holm-Bonferroni corrected p-value

Table 4 Scores obtained by the group with dyslexia (DD) and the typically developing (TD) group in the translation measures

Measures	DD <i>M (SD)</i>	TD <i>M (SD)</i>	<i>p-value*</i>	Cohen's <i>d</i>
Lexical diversity	5.57 (0.84); CI=5.19–5.95	6.08 (0.50); CI=5.77–6.23	= .020	0.75
Punctuation	1.60 (1.17); CI=1.09–2.10	2.84 (0.65); CI=2.56–3.11	< .001	1.31
Sentence structure and grammar	2.02 (0.73); CI=1.69–2.35	2.95 (0.35); CI=2.77–3.11	< .001	1.65

*Holm-Bonferroni corrected *p-value***Table 5** Scores obtained by the group with dyslexia (DD) and the typically developing (TD) group in the proposer measures

Measures	DD <i>M (SD)</i>	TD <i>M (SD)</i>	<i>p-value*</i>	Cohen's <i>d</i>
Organization structure	2.03 (0.74); CI=1.70–2.35	2.51 (0.61); CI=2.26–2.78	= .100	0.70
Ideas	2.24 (0.84); CI=1.85–2.62	2.87 (0.41); CI=2.68–3.06	= .012	0.95
Referential cohesion				
Noun overlap	.30 (.21); CI=.21-.39	.37 (.13); CI=.31-.42	= .831	0.38
Argument overlap	.45 (.19); CI=.36-.53	.60 (.21); CI=.51-.69	= .100	0.72
Stem overlap	.17 (.27); CI=.05-.28	.24 (.23); CI=.14-.33	= .831	0.59
Content overlap	.12 (.03); CI=.10-.13	.11 (.03); CI=.09-.12	= .880	0.03

*Holm-Bonferroni corrected *p-value*

legibility, with children with dyslexia obtaining higher scores, indicating poorer performance ($M_{TD}=6.47$, $SD=1.60$; $M_{DD}=11.81$, $SD=4.36$; $t(40)=4.914$, $p<0.001$, *Cohen's d*=1.62).

Translation measures

Significant differences between groups were also obtained in lexical diversity, punctuation, and sentence structure and grammar (see Table 4). Children with dyslexia produced text with less lexical diversity than their peers and obtained lower scores in both subjective translation measures.

Proposer measures

Significant differences between groups were found in ideas quality. Scores in this measure were lower in the group for dyslexia. There were not significant differences in organisation and structure or in any objective measure of referential cohesion (see Table 5).

Table 6 Pearson correlations between the measures obtained in the written composition for the typically developing group

Measure	1	2	3	4	5	6	7	8	9	10	11	12
1. Legibility	-											
2. Spelling errors	.50*	-										
3. Words per sentence	-.22	-.25	-									
4. Syllables per word	-.17	-.16	-.25	-								
5. Letters per word	.05	-.16	-.23	.91***	-							
6. Lexical diversity	.34	-.26	.38	.11	.21	-						
7. Argument overlap	-.19	.06	.39	.08	-.02	-.10	-					
8. Punctuation	-.34	-.55**	.29	-.25	.22	.39	-.21	-				
9. Sentence structure and grammar	-.60**	-.28	.34	-.04	.10	.67***	.16	.58**	-			
10. Organization and structure	-.33	-.38	.11	-.20	-.25	.30	-.39	.49*	.44*	-		
11. Ideas	-.28	-.06	.08	-.19	-.22	.45*	-.25	.29	.59**	.47*	-	
12. Readability	-.03	.07	.47*	-.99***	-.91***	.07	.00	.32	-.12	-.31	-.21	-

* $p < .05$. ** $p < .01$. *** $p < .001$

Correlations between measures

The relationship between spelling performance, legibility and text characteristics was examined using the Pearson's correlation coefficient. As each group should be considered independently (Rosen, 2003), separate analyses were performed for children with and without dyslexia. As shown in Table 6, for typically developing children the percentage of spelling errors was negatively correlated with the performance in punctuation. Children who made more spelling errors performed worse in punctuation. Legibility showed a strong positive correlation with performance in sentence structure and grammar, as children with poor handwriting exhibited poorer performance in this index. Lexical diversity was positively correlated with sentence structure and grammar and with the number of ideas included in the composition; finally, readability negatively correlated with word length (measured both in number of syllables and letters) and with sentence length. Texts that were easier to read included shorter words and shorter sentences.

For the group with dyslexia (see Table 7), we found significant negative correlations between the percentage of spelling errors and legibility, number of words per sentence, lexical diversity, sentence structure and grammar, organization and general structure, and number of ideas. Children with dyslexia who made more spelling errors produced less legible handwriting and wrote compositions with fewer words per sentence, less lexical diversity, lower quality in terms of syntax and discourse organization, and fewer ideas. Legibility also correlated negatively with lexical diversity, sentence structure and grammar, organization and general structure, and number of ideas. Lexical diversity positively correlated with adverbs incidence, performance in sentence structure and grammar, organization and general structure, and ideas quality. Readability was negatively correlated with the number of syllables per word, and (differently from the pattern observed from the control group), with organisation and general structure.

Regression analyses

As revealed in the correlation analysis, the percentage of spelling errors was negatively associated with the scores obtained in lexical diversity, sentence structure and grammar, organisation and general structure and ideas quality in the group with dyslexia. However, legibility was also negatively correlated with the score obtained in these indices. The strong association between spelling and handwriting ability poses questions about whether legibility makes a unique contribution to the prediction of the performance in translating, organisation, and idea generation in dyslexia. Moreover, both transcription processes were strongly associated to lexical diversity, which is known to have a substantial impact on overall composition quality (Connelly et al., 2006; Olinghouse & Wilson, 2013; Sumner et al., 2016; Wengelin, 2007). To determine the precise contribution of spelling and handwriting to the prediction of the different aspects of text production observed to be impaired in the compositions of children with dyslexia, separate linear regression analyses for each were conducted, including lexical diversity (Guiraud's R), syntax and grammar structure, organization and general structure, and ideas quality as outcome variables. In the

Table 7 Pearson correlations between the measures obtained in the written composition for the group with developmental dyslexia

Measure	1	2	3	4	5	6	7	8	9	10	11	12
1. Legibility	-											
2. Spelling errors	.61**	-										
3. Words per sentence	-.25	-.44*	-									
4. Syllables per word	-.17	-.36	.16	-								
5. Letters per word	-.13	.01	.02	.06	-							
6. Lexical diversity	-.50*	-.67***	.01	.35	-.32	-						
7. Argument overlap	-.13	-.10	.69***	-.07	.05	-.24	-					
8. Punctuation	-.16	-.20	-.09	.18	-.26	.39	-.65**	-				
9. Sentence structure and grammar	-.59**	-.59**	.27	.30	-.26	.78***	-.08	.54**	-			
10. Organization and structure	-.54*	-.49*	.06	.28	-.43	.75***	-.26	.65**	.81***	-		
11. Ideas	-.52*	-.54*	.09	.21	-.44	.87***	-.13	.46**	.87***	.83***	-	
12. Readability	.33	.16	.07	-.60**	-.14	-.29	.28	-.26	-.22	-.48*	-.18	-

* $p < .05$. ** $p < .01$. *** $p < .001$

regression conducted for lexical diversity scores, legibility and spelling errors were included as predictors. Legibility, spelling errors and lexical diversity were included as predictors in the analyses conducted for syntax and grammar structure, organization and general structure, and ideas. Legibility was included to test whether avoidance of more complex and diverse words by children with dyslexia might be one of the main factors underpinning reduced perceived quality in higher-order aspects of the texts (Sumner et al., 2016). Collinearity statistics indicated that multicollinearity was not a concern in any of the regressions conducted (for all variables, tolerance > 0.62 and VIFs < 2).

First, we considered lexical diversity as the outcome variable. For the group with dyslexia, a model with legibility and spelling errors explained a 46% of the variance in lexical diversity, $\Delta R^2 = 0.40$, $F(2,18) = 7.59$, $p = 0.004$. The only variable that was a significant predictor was spelling errors, $\beta = -0.03$, $SE = 0.01$, $t = -2.61$, $p = 0.018$. Spelling accounted for 20% of the variability in lexical diversity. For the typically developing group, the model with legibility and spelling was not significant, $F < 2$.

When the score on sentence structure and grammar structure was included as an outcome variable, the model with legibility, spelling and lexical diversity as predictors was significant for the group with dyslexia, $\Delta R^2 = 0.60$, $F(3,17) = 11.16$, $p < 0.001$. Neither legibility nor spelling reached significance, $ts < 2$, but lexical diversity was a significant predictor, $\beta = 0.56$, $SE = 0.17$, $t = 3.39$, $p = 0.003$. This variable explained 23% of the variance in the scores obtained in sentence structure and grammar by the children with dyslexia. For the typically developing group, the same model was also significant, $\Delta R^2 = 0.54$, $F(3,17) = 8.74$, $p < 0.001$. Both legibility, $\beta = -0.09$, $SE = 0.04$, $t = -2.53$, $p = 0.022$, and lexical diversity, $\beta = 0.36$, $SE = 0.11$, $t = 3.29$, $p = 0.004$, were significant predictors of this measure for this group, accounting for approximately 15% and 25% of the variability in the scores, respectively.

In the analysis conducted on organization and general structure, the model including legibility, spelling and lexical diversity as predictors was significant, $\Delta R^2 = 0.54$, $F(3,17) = 8.89$, $p < 0.001$. Again, only lexical diversity was a significant predictor of this measure, $\beta = 0.64$, $SE = 0.18$, $t = 3.51$, $p = 0.003$, accounting for 24% of the variance (all other $ts < 2$). The same model was not significant for the group without dyslexia, $F < 2$.

Finally, in the analysis conducted with number of ideas as the outcome variable, the model with legibility, spelling and lexical diversity was significant, $\Delta R^2 = 0.73$, $F(3,17) = 19.01$, $p < 0.001$, but lexical diversity was again the only predictor found to be significant, $\beta = 0.90$, $SE = 0.16$, $t = 5.62$, $p < 0.001$. This factor explained 28% of the variability in the number of ideas included in the compositions. The model was not significant for the typically developing group.

Discussion

In the present study, a written composition task was used to investigate the components of the writing process that are affected in developmental dyslexia and to explore to what extent spelling difficulties are associated to these deficits.

Specifically, variables tapping into transcription, translation, and the proposer as defined in the model proposed by Chenoweth and Hayes (2001) were assessed. Taken together, our findings suggest that children with dyslexia struggle with all the levels of processing involved in written composition, even in a relatively easy and familiar writing task and in a language with a transparent orthography and suggests a relationship between these difficulties and spelling ability that is absent in their typically developing peers.

Overall, the texts produced by children with dyslexia were rated as being of lower quality. This result replicates previous findings (Sumner et al., 2016; Tops et al., 2014). Objective measures confirmed that the compositions of students with dyslexia fell short of some of the elements typically associated with high writing quality. Although there was not a substantial difference in the total number of words produced by each group, children with dyslexia produced shorter sentences than the group without dyslexia. Thus, it seems that the writing product of children with dyslexia differs from that of children without difficulties beyond the level of spelling accuracy. More importantly, differences with their peers seem to concern transcription, translation, and proposing/planning processes.

In line with previous literature, we hypothesised that the compositions written by children with dyslexia would obtain lower scores in overall quality and in transcription and translation aspects of writing production. This hypothesis was confirmed by the findings. At the lowest level of transcription, typically developing children outperformed children with dyslexia both in spelling and handwriting measures. Children with dyslexia included significantly more spelling errors in their compositions than their peers without dyslexia. More specifically, children with dyslexia made more errors in most of the error categories considered. They were less accurate regarding stress marking, and made more letter errors (namely, letter omissions and substitutions) and they incorrectly joined words more often than their peers.

Texts written by children with dyslexia were also rated as less legible. This finding is consistent with the association between handwriting and spelling skills reported in previous studies (Afonso et al., 2018; Roux et al., 2013). In the present study, this association was also present in the group without dyslexia, and it has been claimed to exist at least up to the approximate age of 11 in Spanish-speaking children (Afonso et al., 2018). In line with this idea, several studies have reported reduced handwriting fluency in individuals with dyslexia (Afonso et al., 2020; Lam et al., 2011; Martínez-García et al., 2021; Suárez-Coalla et al., 2020; Sumner et al., 2013, 2014). To the well-known effects of reduced handwriting speed, the present study adds reduced legibility, presumably as a consequence of the challenge posed by spelling processes during writing. However, it must be acknowledged that poor spelling can affect legibility. Thus, the HLS score might be influenced by the presence of spelling errors. More research is necessary to clarify this point, although it might be difficult to obtain evidence that could differentiate between these two options.

Our findings also confirm the presence of difficulties with translating processes in Spanish-speaking children with dyslexia. Similarly to the pattern observed in studies conducted with English-speaking children (Sumner et al., 2016), participants with dyslexia produced texts with less lexical diversity than their peers without dyslexia.

This difference was obtained with a measure of lexical diversity that is not affected by the text length (Giraud's R), so it cannot be completely ascribed to the reduced length of the sentences produced by the children with dyslexia. This tendency to use a less diverse vocabulary is also present in adults with dyslexia (Connelly et al., 2006; Wengelin, 2007) and it might be the result of a conscious attempt to avoid difficult to spell words or it might be associated to a reduction in the cognitive resources available for lexical selection (Wengelin, 2007).

Children with dyslexia were also outperformed by peers without reading difficulties in measures related to sentence-level translating. Namely, compositions written by the typically developing group obtained higher scores in sentence structure and grammar and in punctuation. The score in syntax and grammar was correlated with handwriting legibility in the group without reading difficulties and with spelling in the group with dyslexia. In fact, spelling was not associated with the score in sentence structure in the typically developing group. These results seem to support the claim made by Berninger et al. (2008) that handwriting ability might be the most important factor contributing to writing quality in typically developing children, while spelling ability would have a disproportionate relevance in the writing of children with dyslexia. Previous empirical evidence regarding the quality of sentence structure and grammar in the written compositions of individuals with dyslexia had been inconclusive. In fact, both Connelly et al. (2006) and Tops et al. (2013) did not find significant differences in this criterion between the texts produced by college students with and without dyslexia. More research is necessary to clarify to what extent and in which specific conditions spelling difficulties affect sentence construction.

In contrast, poor punctuation is a common and well-known feature of the written work of English-speaking students with dyslexia, both in childhood (Sumner et al., 2016) and in adulthood (Connelly et al., 2006). Our results extend this finding to the case of Spanish-speaking children. Moreover, a significant negative correlation between punctuation and number of spelling errors was observed for both groups. This might indicate that spelling and punctuation ability develop as a common skill during school years. Both spelling and punctuation reflect knowledge of the rules of written language and require an understanding of its particular conventions, which are different from those of oral language. Thus, they might both be particularly dependent on reading exposure, for example. The present findings allow us to confirm this link also in the written production of Spanish-speaking children, but considered together the evidence reported here and in previous studies suggest a more important burden of spelling on translating processes in children than in young adults. In any case, Limpo et al. (2017) found that, in children without a diagnosis of dyslexia, spelling ability is related to translating skills as measured in a sentence-combining task.

Finally, the activity of the proposer seems to also be disrupted during written composition in dyslexia. The general structure of the text was not considered poorer in the group with dyslexia than in typically developing children, but the ideas included in the text were rated more poorly. This pattern mirrors what has been found in English with children of a similar age (Sumner et al., 2016) and with adults (Tops et al., 2013). The relatively transparent relationship between phonemes and graphemes in Spanish does not seem to protect children with spelling difficulties from more generalised negative effects in translating and in the generation of ideas. Interestingly, results from the regression analyses suggested that performance in sentence structure and grammar, and ideas quality might be related to the reduced lexical diversity of the compositions written by children with dyslexia, and not to spelling difficulties directly. Spelling difficulties might affect lexical selection during written composition, which, in turn, might affect the outcome of sentence-level translating and higher-order levels of processing. Congruently, lexical diversity was strongly associated to spelling ability in these children, while in the group without difficulties lexical diversity was independent of both transcription skills. Lexical diversity was the only significant predictor of the scores in sentence structure and grammar, organisation and structure and number of ideas for children with dyslexia, but for the typically developing children this variable only contributed to the sentence structure and grammar score. The pattern of evidence obtained here consistently points to the existence of a relationship between spelling ability and lexical selection during composition that might lead to the use of a reduced range of words. This restricted vocabulary use seems to be linked to the quality of the ideas discussed, the structure of the sentences created, and the organisation of the text more generally. More research is necessary to confirm whether this is due to the selection of less-than-ideal structures to fit words more recurrently used.

Although the present study represents an important contribution to the empirical investigation of writing composition in dyslexia, some limitations can be identified and must be taken into account. First, caution must be taken before extracting conclusions about a potential causal relationship between phenomena in correlational research. The evidence reported here reflects the existence of a different pattern of association between the different levels of processing involved in writing composition in dyslexia than in typically developing children, but it is not possible to determine a causal link between spelling difficulties and reduced lexical diversity, or between lexical diversity and impaired higher-order levels of writing.

Second, it was not possible for the research team to directly assess other cognitive skills that may have affected writing performance. Measures of non-verbal intelligence, memory or attention were not obtained, although they were reported by the school to be within the range expected for the age group for all participants. However, and although it is possible that significant differences in these abilities might have existed between the groups, it is difficult to see how this would lead to a change

in the pattern of association between spelling skills, translation and the proposer's activity.

Third, the size of the sample tested is small, although similar to that of experimental studies previously conducted on this topic. However, the statistical power of the present study might not have been sufficient to detect potential additional differences between the group with dyslexia and the typically developing group in other dependent variable considered. Nevertheless, the pattern of results obtained across the wide range of measures collected is thoroughly consistent with the interpretation that spelling is associated with lexical diversity, and that lexical diversity is associated with the perceived quality of the sentence structures and ideas included in the texts written by students with dyslexia. Finally, verbal composition was not assessed in the present study. Thus, we cannot rule out the possibility that the children with dyslexia who participated in this study might exhibit reduced lexical diversity also in their verbal compositions. Such a finding would suggest that the results reported here might be better explained in terms of reduced vocabulary skills rather than by the existence of specific difficulties associated to spelling. However, previous studies that assessed both written and verbal composition in children with dyslexia did report a reduction in lexical diversity specific to the written modality (Sumner et al., 2016; Wengelin, 2007). Further research should try to overcome these limitations and assess a larger sample of children in a wider range of relevant tasks. A larger sample size would help confirm some of our claims by allowing to perform more sophisticated statistical analyses, such as hierarchical regression analyses.

In conclusion, the present study confirms that the written compositions of Spanish-speaking children with dyslexia include more spelling errors, shorter sentences, a less diverse vocabulary, and ideas of less quality, as previously reported for English writers. To these shortcomings, the evidence obtained here revealed that poorer legibility of the text and poorer sentence structure and grammar must be added and suggests a prominent influence of lexical diversity in the perceived quality of the composition. These results have important implications for the design of more effective interventions to improve writing skills among students with reading and spelling difficulties. A spelling intervention combined with specific training to encourage students with dyslexia to attempt to include a wider range of words in their texts might be particularly effective in enhancing the quality of written compositions in children with dyslexia and have a positive effect on their academic achievement.

Appendix A

See Table 8

Table 8 Rubric of the four elements of writing composition of the Writing Assessment Measure (WAM) applied

Criterion	Score
<i>Punctuation</i>	
Uses a range of punctuation to clarify structure and create effect	4
Secure use of full stops and capital letters. Uses punctuation in addition to capital letters and full stops, the majority used correctly	3
Evidence of accurate use of capital letters and full stops, however few they are	2
Shows awareness of how full stops are used in writing	1
<i>Sentence structure and grammar</i>	
Secure control of complex sentences, Understands how clauses can be manipulated for effect. Able to use conditional and passive voice	4
Beginning to write extended sentences including subordinators. The basic grammatical structure if sentences usually correct	3
Beginning to use conjunctions to create compound sentences and may be using multiple clauses	2
Write simple sentences which include the conjunction 'and'	1
<i>Organisation and general structure</i>	
Paragraphs are well organised, based on themes and provides cohesive text for the reader	4
Uses paragraphs to organise writing, showing an identifiable structure. There may be short sections	3
Themes are expanded upon and linked together in a series of sentences	2
Communicates meaning but it may 'flit' from idea to idea and any themes that are expanded are done so in one sentence	1
<i>Ideas</i>	
Ideas are creative and interesting in a way that engages the reader. Uses a range of strategies and techniques	4
Ideas are imaginative and varied evidence of descriptive detail about characters, settings, feelings, emotions, and actions	3
Ideas are developed to by adding detail	2
Produces short sections of ideas which may be repetitive and limited in nature	1

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