

Abstract

While copying skills are used daily at school and involve spelling abilities, studies examining copying performance in children with dyslexia are very scarce. The present study aims to determine whether children with dyslexia present a specific deficit in their copying processes or if their difficulties in copying are a consequence of their spelling deficit. Nineteen children with dyslexia were compared to two groups of typically developing children: 19 chronological age matched children and 19 spelling age matched children. All children were asked to perform a copying task of 40 words, varying in orthographic complexity. This task was scored on spelling accuracy, handwriting quality and speed, and gaze lifts. Our main results showed that children with dyslexia do have difficulties in copying. They made more spelling errors than their age-matched peers, despite the model provided by the task. Gaze lift analyses revealed that children with dyslexia used different copying strategies compared to their classmates. Globally, children with dyslexia seem to behave like younger children, suggesting that their difficulties arise from their spelling deficit. These findings may have practical implications. Given that children with dyslexia face copying difficulties, one possible way to help them could be to enable them to improve their copying strategies, and not just their spelling skills.

Keywords: copying, dyslexia, gaze lifts, handwriting, spelling

Copying Skills in Children With and Without dyslexia

Writing is an important skill that impacts everyone's academic and social development. It requires a long and complex development process throughout primary school. The ability to write involves the mastery of two major skills: spelling retrieval and handwriting production (Rapp, Epstein, & Tainturier, 2002; Van Galen, 1991). In school, one specific activity that allows children to learn spelling and handwriting is the copying task (Martinet & Rieben, 2006). In the French-language school system, children have to copy every day until the end of primary school, when they learn new words, when they write their class diary or when they learn new lessons (Bernardin, 2001; Ministère de l'Education nationale et de la jeunesse, 2018). At the beginning of primary school, children are more engaged in copying tasks at the letter or word level, in order to learn handwriting and lexical spelling. Towards the end of primary school, children are more engaged in copying tasks at the sentence or text level, in order to learn new lessons and improve their spelling skills (Bernardin, 2001). Copying is a cognitively complex central task, which involves the processes of both reading and writing, based on perceptual, linguistic, attentional, memory and fine motor skills (Maldarelli, Kahrs, Hunt, & Lockman, 2015). All these skills require a significant number of cognitive resources and can be difficult for primary school children, especially at the beginning of their learning (Kandel & Perret, 2015; Karlsdottir & Stefansson, 2002; Maldarelli et al., 2015).

Children with dyslexia are known to have a deficit in reading but also in spelling (Lyon, Shaywitz, & Shaywitz, 2003). The main hypothesis to explain dyslexia is the phonological core deficit hypothesis but some studies have also shown that children with dyslexia can present other difficulties, such as fine motor disorders, poor binocular coordination or limited visual-motor integration (Bucci, Brémond-Gignac, & Kapoula, 2008; Jover et al., 2013). It so happens that these three skills, potentially problematic in children with dyslexia, are involved in copying. Consequently, it is interesting to evaluate whether children with dyslexia have specific difficulties in copying activities. Unfortunately, despite the daily use of this activity in school, studies investigating copying skills in children with dyslexia are very scarce. However, it is important to provide a better understanding of children's potential disorders in copying tasks to be able to help them properly.

The present study intends to shed some light on the copying ability of French-speaking children with dyslexia in comparison to typically developing children, by assessing spelling, handwriting (quality and speed) and gaze lifts. This could lead to a deeper understanding of children with dyslexia's difficulties and provide new therapeutic or pedagogical perspectives to help children with the copying process.

The Copying Task

Copying requires the transformation of a visual input into a comparable graphomotor code (Kandel & Valdois, 2006). This is the case when children have to copy text from the blackboard into their school diary for example (Bernardin, 2001; Humblot, Fayol, & Lonchamp, 1994). This copying task involves the reading and spelling processes (Humblot et al., 1994) as well as a number of underlying cognitive processes (Martinet, 2013; Re & Cornoldi, 2015; Zesiger, 1995). To copy a word, children have to perform a visual analysis of the letter string to be copied. To do this, two procedures may be used (Rapp et al., 2002). Children can recognize the word in their orthographic lexicon if they are using a lexical procedure that activates the spelling representation in long-term memory; or children can break the word into sub-lexical units if they are using a sub-lexical procedure. In the latter case, the sub-lexical units are transformed into an internal graphemic pattern that is maintained in working memory. Then, this graphemic pattern allows the programming and handwriting execution of the units (Kandel & Valdois, 2006). After this motor execution, children's eyes are on what they have written. If children have not copied the whole word, they produce a gaze lift to the model to extract new information and copy it (Kandel & Valdois, 2006). This copying mechanism is repeated until the whole word is produced. In sum, the copying task involves reading, spelling, handwriting, working memory and attention (Maldarelli et al., 2015; Re & Cornoldi, 2015) which require considerable cognitive resources (Bosse, Kandel, Prado, & Valdois, 2013).

To investigate children's copying strategies, the few existing studies use gaze lift analysis (Bosse et al., 2013; Humblot et al., 1994; Kandel & Valdois, 2006). Gaze lifts are the way children take visual information about the word to be copied. They can be considered as an indicator of the reading procedures used by children during copying (Bosse et al., 2013). Not to produce a gaze lift

during the copying of a word can reflect the use of a lexical route, while producing several gaze lifts can reflect the use of a sub-lexical route (Bosse et al., 2013). According to Rieben and Saada-Robert (1997), there is significant inter-individual variability in the different strategies of word copying amongst 5- to 7-year-old French-speaking children. Nevertheless, these copying strategies seem to evolve broadly in the same way for typically developing children (Humblot et al., 1994; Kandel, Valdois, & Orliaguet, 2003). At the beginning of written language learning, children are not able to copy a word with a single eye fixation. In first grade, French-speaking children tend to break down the target word into sub-lexical units (Humblot et al., 1994). They copy most of the words with a letter-by-letter strategy, producing a gaze lift after each letter *or after each grapheme* of the target word. They can also copy words with a syllabic strategy, producing a gaze lift after each word syllabic boundary (Humblot et al., 1994; Kandel & Valdois, 2006; Kandel et al., 2003). In Grade 2, a transition period is observed: children still process some words in a syllabic way but they also start to copy other words with a global strategy, with a single eye fixation. At this stage, the way the child processes the word depends on its orthographic regularity, frequency, and lexicality. For example, a regular word is processed more globally than an irregular word (Lambert, Alamargot, Larocque, & Caporossi, 2011). In Grade 3, children preferentially copy words in a single instance of information gathering (Kandel & Valdois, 2006; Kandel et al., 2003).

By examining the result of the copying, Guyon and Fijalkow (1999) showed that only 10% of 7 to 9-year-old French-speaking children are able to copy a text without making spelling mistakes. Some children are conscious that, if they use a global strategy, they will experience difficulty in copying the words. Therefore, they produce several gaze lifts to the model, reducing the risk of spelling errors (Saada-Robert & Rieben, 1993). On the other hand, other children overestimate their spelling abilities and copy words more globally (Martlew, 1992; Re & Cornoldi, 2015). As a result, they make more spelling mistakes. Thus, the child's attitude may influence the accuracy of his or her copying (Martlew, 1992).

Copying Skills in Children With Dyslexia

Dyslexia is characterized by poor reading and spelling abilities (Lyon et al., 2003). To explain dyslexia, there is a wide variety of cognitive theories. The phonological core deficit hypothesis is the most well-known cognitive explanation of dyslexia (Snowling, 2000). According to this hypothesis, children with dyslexia present some difficulties in phonological tasks that are considered predictors of reading abilities (Snowling, 2000). Another potential explanation of dyslexia is the magnocellular hypothesis (Stein, 2001; Stein & Walsh, 1997). This theory postulates a deficit in the magnocellular system that is involved in the visual guidance of eye and limb movements (Stein, 2001; Stein & Walsh, 1997). Therefore, reading difficulties could be explained by a magnocellular disorder. Besides, studies have shown that some children with dyslexia present a magnocellular disorder (Lovegrove, Bowling, Badcock, & Blackwood, 1980; Martin & Lovegrove, 1987). According to Stein (2001), the magnocellular dysfunction in children with dyslexia extend into the posterior parietal cortex and cerebellum. Therefore, this general magnocellular theory could be related to the cerebellar theory of dyslexia, which postulates a cerebellar impairment in people with dyslexia (Fawcett & Nicolson, 1992; Nicolson, Fawcett, & Dean, 2001). Overall, this general magnocellular theory could explain studies showing that some children with dyslexia have difficulties in handwriting, binocular coordination, or visual-motor integration (Bucci et al., 2008; Jover et al., 2013).

Only a few studies have investigated copying in children with dyslexia. These studies focused mainly on the results of the copying (spelling accuracy or handwriting; Martlew, 1992; Re & Cornoldi, 2015; Sumner, Connelly & Barnett, 2013) and only one study focused on gaze lifts (Kandel, Lassus-Sangosse, Grosjacques & Perret, 2017). Knowing whether children with dyslexia experience difficulties is important since this task involves several processes potentially affected, such as not only reading, spelling or handwriting, but also binocular coordination and visual-motor integration. By focusing on spelling accuracy in a copying task, Re and Cornoldi (2015) showed that 9-year-old Italian-speaking children with spelling difficulties made more spelling mistakes in a text copying task than typically developing children of the same age, even if they had the text in front of them. So, even in a transparent orthographic system like Italian, children with dyslexia showed difficulties in a copying task. On the contrary, Martlew (1992) observed that 10-year-old English-speaking children

with dyslexia made fewer spelling mistakes in a word copying task than their age-matched peers. According to Martlew (1992), children with dyslexia are conscious of their difficulties and pay more attention to the spelling model they are provided in the copying task. English being an opaque orthographic system, children may possibly pay more attention to irregularities. Indeed, in this context, in addition to knowledge of the correspondences between phonemes and graphemes, children must develop their orthographic lexicon to be able to spell correctly. Children with dyslexia can present difficulties to learn these correspondences, to increase their orthographic lexicon or both (Castles & Coltheart, 1993). By focusing on handwriting in a copying task, Sovik and Arntzen (1986) showed that Norwegian children with dyslexia took more time to copy sentences than their age-matched peers. In a more recent study using digitizing tablets, Sumner et al. (2013) found that English-speaking children with dyslexia wrote at the same speed but produced more pauses than their age-matched peers while copying sentences. Afonso, Suárez-Coalla and Cuetos (2020) confirmed the findings reported by Sumner et al. (2013) on Spanish children with dyslexia and showed that they produced longer written latencies than their age-matched peers. In sum, whether in a transparent or opaque orthographic system, latencies seem to be longer for children with dyslexia. By focusing on the impact of spelling on handwriting, Kandel et al. (2017) observed that French-speaking children were slower and produced more dysfluent movements when copying an irregular word in comparison to a regular word. Interestingly, this impact of orthographic irregularity was stronger in children with dyslexia (Kandel et al., 2017). Finally, by focusing on gaze lifts in a copying task, Kandel et al. (2017) showed that 11-year-old children with dyslexia produced more gaze lifts when writing irregular words than when writing regular words. French being an opaque orthographic system like English, these children may possibly pay more attention to irregularities and produce more gaze lifts. Unfortunately, Kandel et al. (2017) did not compare the gaze lifts of children with dyslexia with those of typically developing children (Kandel et al., 2017). Taken together, experiments presented above all showed differences between children with dyslexia and their age-matched peers in copying tasks even if these studies took place in different orthographic systems (Afonso et al., 2020; Kandel et al., 2017; Re & Cornoldi, 2015; Sumner et al., 2013).

To sum up, studies examining copying performances in children with dyslexia are very scarce. To the best of our knowledge, no experiment has specifically looked at copying processes in these children, assessing simultaneously spelling accuracy, handwriting (quality and speed) and gaze lifts, and there is no clear experimental evidence showing a copying deficit in children with dyslexia. In addition, no study has compared a copying task with a dictation task in order to better understand the children with dyslexia's difficulties. Therefore, it is essential to more precisely evaluate these children's skills, not only regarding the result of the copying – spelling accuracy and handwriting – but also analyzing gaze lifts and comparing copying and dictation performance.

Present Study

The aim of the present study was to determine whether children with dyslexia show a specific deficit in their copying processes or not. Participants' copying skills were assessed in a word copying task which evaluated spelling accuracy, handwriting quality and speed, and gaze lifts. Our research questions were: Do children with dyslexia have a specific deficit in copying skills or are their difficulties in copying a consequence of their spelling deficit? Do they make more spelling mistakes or produce slower and poorer quality handwriting than typically developing children do in a copying task? Do they show a different gaze lift strategy compared to typically developing children? To better understand the origin of the potential difficulties of children with dyslexia, the children also performed a dictation task with the same target words. In addition, in order to evaluate whether children with dyslexia (DYS children) have a delay profile or a deviant profile, the results of these children were compared to those of the same chronological age (CA children) as well as those of younger children with the same spelling level (SA children).

We made the following hypotheses:

- (a) According to the magnocellular theory (Stein, 2001; Stein & Walsh, 1997), DYS children should have a deficit in copying, affecting spelling accuracy, handwriting and gaze lift processes.
- (b) Conversely, if their potential difficulties in copying are a consequence of their spelling deficit, we should not observe a different profile between DYS children and SA children, matched on spelling level.

In line with these hypotheses, we made the following predictions:

(a) If DYS children have a specific deficit in copying, they should present a less marked copying advantage in comparison to typically developing children (i.e., a copying performance closer to the dictation performance). Focused on the copying task, we should observe more spelling mistakes, slower or poorer quality handwriting, and a different use of gaze lifts in DYS children in comparison to both CA and SA children.

(b) If DYS children have difficulties in copying as a consequence of their spelling deficit, the differences observed between the dictation and the copying tasks should be the same for all children. Focused on the copying task, we should observe more spelling mistakes, slower or poorer quality handwriting, and a different use of gaze lifts in DYS children in comparison to CA children but we should observe the same profile as SA children, because they have the same spelling level.

Method

Participants

Fifty-seven French-speaking children took part in this experiment. They came from three rural primary schools in Belgium of a middle socio-economic status. The first group included 19 DYS children. Eleven of these children were in Grade 3 and eight were in Grade 4 (DYS, $n = 19$, 10 girls, $M_{age} = 9;1$ years, age range: 8;1 – 10;1 years). They had all been diagnosed with dyslexia by a speech therapist and they performed below 2 standard deviations in the standardized spelling test Chronosdictées (Beneath, Boutard, & Alberti, 2006). Each DYS child was matched to a typically developing child on chronological age (CA children) and to another typically developing child on spelling age (SA children), based on their raw scores at the standardized spelling task. Thus, the SA group included 19 typically developing children matched on spelling skills to the DYS children, but younger than them. They were all in Grade 2 (SA children, $n = 19$, 8 girls, $M_{age} = 7;8$ years, age range: 7;1 – 8;3 years). The CA children also included 19 typically developing children with average reading and spelling skills. It was composed of 11 children in Grade 3 and eight in Grade 4 (CA children, $n = 19$, 10 girls, $M_{age} = 9;2$ years, age range: 8;1 – 10;1 years). Therefore, the present sample was composed of 57 French-speaking Belgian children. All the children showed average intellectual performance ($M = -.23$, $SD = .17$) and none of them had any visual or auditory disorders. A one-way analysis of variance (ANOVA) demonstrated that the three groups were equivalent in non-verbal IQ

ability, $F(2, 52) = 1.88, p = .16$. A one-way ANOVA on age revealed a difference between the three groups, $F(2, 54) = 35.87, p < .001, \eta^2 p = .57$). Bonferroni post-hoc comparisons revealed that the DYS children were accurately matched in chronological age with the CA children ($p = .88$) but both groups were older than the SA children ($ps < .001$). A one-way ANOVA on spelling showed a difference between the three groups, $F(2, 54) = 20.90, p < .001, \eta^2 p = .44$. Bonferroni post-hoc comparisons revealed that DYS children were accurately matched in spelling with SA children ($p = 1.00$) but both groups performed lower than CA children ($ps < .001$). More details regarding the participants' characteristics and differences between groups are presented in Table 1. All the children and their parents gave active consent for participating in the experiment. The study received approval by the Hospital-Faculty Ethics Committee from University Clinic Saint-Luc.

Measures

Control measures. Control tests were used to match the DYS children with the SA children and in order to exclude typically developing children who had an inadequate score in literacy.

Non-verbal reasoning ability. Matrices subtest of the WISC IV (Wechsler Intelligence Scale for Children – Fourth Edition; Wechsler, 2005) was administered to participants to assess their non-verbal reasoning. It is composed of a series of 35 incomplete matrices containing abstract patterns and designs. The children were required to select the best of five choices, corresponding to the appropriate missing piece, in order to complete the matrix. The maximum raw score is 35. For this subtest, the reported internal consistency coefficient is .86. It is a standardized test providing norms for different age groups.

Receptive vocabulary. The level of receptive vocabulary was assessed by the standardized test EVIP (Echelle de vocabulaire en images Peabody [Peabody Picture Vocabulary Test]; Dunn, Dunn, & Theriault-Whalen, 1993). In this task, the child is shown a board with four different pictures and must choose the one that corresponds to the word said by the experimenter. The maximum raw score is 170 and the reported internal consistency coefficient of this test is .81.

Word reading. Reading was assessed with the LUM task (Lecture en Une Minute [One minute reading]; Khomsi, 1999). This task consists of reading aloud as many of words as possible in

one minute. The child's score is calculated by counting the number of words correctly read in one minute. It is a standardized test providing norms according to grade level.

Word spelling. To assess spelling ability, we administered a standardized sentence dictation task (Chronosdictées, Beneath et al., 2006). This test examines phonological, lexical and grammatical spelling. The child's score is calculated by the number of spelling errors made. The number and complexity of sentences vary according to the child's grade. This standardized test provides norms according to grade level.

Handwriting quality. To assess handwriting, we administered a text copying task from the BHK ([Concise evaluation scale for children handwriting]; Charles, Soppelsa, & Albaret, 2004), in a limited time of five minutes. In this copying task, each sentence is scored according to 13 aesthetic criteria (e.g., relative size of the letters, correction of letter forms, letter distortion, etc.). The presence of one of the graphical errors leads to attributing 1 point. Therefore, low scores reflect good handwriting quality, whereas high scores reflect poor handwriting quality. The task has a very high reported interrater reliability ($r = 0.90$). BHK is a standardized test providing norms for different age groups and grade levels.

Handwriting speed. Handwriting speed was also assessed with the BHK test (Charles et al., 2004). The child's score is calculated by the number of letters copied in 5 minutes.

Experimental measures. Experimental tasks consisted of a copying task and a single-word dictation task for which spelling, handwriting and gaze lifts were measured. The two experimental tasks were designed to answer our research questions about the copying skills of children with dyslexia.

Spelling accuracy in both experimental tasks. Children received one point for each word correctly spelled and the score 0 if they made a spelling error. In our sample, the internal reliability given by Cronbach's alpha is .86.

Handwriting quality in both experimental tasks. Assessment of handwriting quality in both experimental tasks was based on the BHK test (Charles et al., 2004), taking into account five of its 13 aesthetic criteria, like in Authors' study (2018). Only five criteria were selected because they were suitable to the context of a single-word writing task. The first criterion corresponds to a distortion of a

letter in the word, leading to an abnormal letter form. The second criterion corresponds to inconsistent letter size, where there is an abnormal variation in the size of the small letters (e.g., “a”, “m”, “i”) within the same word. The third criterion corresponds to inconsistent relative letter height, where one small letter (e.g., “a”, “m”, “i”) is produced at the same height as one ascender (e.g., “l”, “h”) or one descender letter (e.g., “g”, “y”). The fourth criterion corresponds to bad letter alignment, where not all the letters within the word are aligned horizontally. The fifth criterion corresponds to correction of letter form, when there is the presence of a graphic correction on the paper. Each written word receives one score per criterion. A score of 1 means the presence of a graphic abnormality, while a score of 0 means good handwriting quality. A total score per word was computed, by adding the score for each criterion, leading to a maximum score of 5 per word written. High scores refer to poor handwriting quality and lower scores refer to better handwriting quality. Percentages of agreement were calculated within the present sample for each aesthetic criterion and they revealed high interrater reliability: 92% for distortion of letters, 90% for inconsistent letter size, 85% for inconsistent relative letter height, 80% for correction of letter form and 94% for bad letter alignment. In our sample, the internal reliability given by Cronbach’s alpha is .96.

Handwriting speed in both experimental tasks. Children received a score of handwriting speed for each word, directly extracted from the tablets. The recording started at the very beginning of each word’s pen stroke, and ended at the very end of the word. The pauses inside the words and in air phases (i.e., pen lifts) were not taken into account. This speed measure corresponds to the distance covered while the pen was on the sheet of paper (cm/s). A low value refers to slow handwriting, whereas a high value refers to fast handwriting execution (Authors, 2020).

Gaze lift coefficient in the experimental copying task. The experimenter noted the position where the child lifted his or her gaze to extract information on the target word to be copied. For this purpose, the experimenter had a sheet with the written words and placed a bar between the two letters where the child stopped writing to look up at the model. To ensure the reliability of this measure, a video camera (Panasonic HDC-SD40) recorded some of the children ($n = 15$) who agreed to be filmed by active consent. This made it possible to ensure that the gaze lifts noted during the task by the experimenter corresponded accurately to the gaze lifts noted through the video analysis. The Intraclass

Correlation Coefficient (ICC) between the notation during the task and the video analysis was .99.

After counting the number of gaze lifts made within a word, a “gaze lift coefficient” was calculated, as in Kandel and Valdois’ experiment (2006). It corresponded to the number of times the child lifted his or her gaze with respect to the total gaze lifts possible if he or she had copied the item using a letter-by-letter analysis. In this case, we didn’t count a gaze lift at the last letter of the item because if there was one, it could be for verification purposes, and not for information extraction. For example, the word *brebis* (ewe) has six letters, which would result in five possible gaze lifts if the child copied the word letter by letter. If the child produced two gaze lifts, the gaze lift coefficient would be: $2/5 = 0.4$. So, for each word, the gaze lift coefficient could be between 0 and 1, where 0 corresponds to a copy of the word without any gaze lift, and 1 corresponds to a gaze lift after each letter of the word. In this way, the gaze lifts for the items in our experiment could be compared irrespective of word length.

Copying strategy in the experimental copying task. We analyzed the copying strategy used by the child. It could be: (1) a letter-by-letter strategy or grapheme-by-grapheme strategy, where the child needed to get information after each letter or grapheme (e.g., *ch* in *chambre* pronounced /ʃɑ̃bʁ/ [bedroom]) of the target word; (2) a syllabic strategy, where the child needed to get information after the syllabic boundary of the word; (3) a global strategy, where the child was able to copy the word in one attempt; or (4) a random strategy, where none of the strategies above were used. For each word, one strategy type used by the child was obtained. For this measure, the intraclass correlation coefficient (ICC) was .99.

Gaze lift location in the experimental copying task. To analyze more precisely the information gathering, we looked at the gaze lift position in the word, according to the presence of inconsistencies or difficulties in the words: (1) double consonants (e.g., *cc* in *accord* pronounced /akɔʁ/ [agreement]); (2) silent letters (e.g., *p* in *sirop* pronounced /siʁo/ [syrup]), when a letter is not pronounced; (3) complex graphemes (e.g., *au* in *gauche* pronounced /goʃ/ [left]), when several letters translate into a single phoneme; (4) clusters (e.g., *br* in *sabre* pronounced /sabʁ/ [saber]), when two consonants follow each other successively within a word; and (5) final *e* (e.g., *e* in *score* pronounced /skɔʁ/ [score]), when the last letter of the word is an *e* that is not pronounced. For each word, the

experimenter noted whether the child produced one gaze lift at any of these inconsistencies or difficulties. As explained before, the ICC for this measure was also .99.

The number of inconsistencies or difficulties was not the same in the experimental task. For example, there were 10 silent letters and 20 complex sounds within all the words. Therefore, for each category of inconsistency or difficulty, a score was calculated by dividing the number of gaze lifts for an inconsistency by the number of such inconsistencies in the task. In other words, if a child produced six gaze lifts on silent letters, his or her score was 0.6: six gaze lifts on silent letters divided by 10, the number of silent letters in the task.

Materials for the Experimental Tasks

The single-word dictation task and the copying task were composed of the same 40 words. In order to avoid a fatigue effect on the last words, these 40 words were proposed in a random order within each word list that was different between each class and each condition (copying or dictation task). The words were the same as in Authors' experiment (2020). The words consisted of 20 orthographically complex words and 20 orthographically simple words. To create these two categories of words, the word regularity and word success rate for children in Grade 2 in the French database EOLE (Echelle d'acquisition en orthographe lexicale [lexical spelling acquisition scale]; Pothier & Pothier, 2003) were taken into account. A word was considered complex when it was composed of complex or irregular phoneme-grapheme correspondences and it had a low success rate (< 50% in EOLE for Grade 2). A word was considered simple when it was composed of highly-consistent sound-to-spelling correspondences and it had a high success rate (> 75% in EOLE for Grade 2). The number of letters, the number of syllables, the number of morphemes, the printed word frequency and the digram frequency were checked to ensure that the two conditions did not differ. Digram frequency was computed by CELEX (Baayen, Piepenbrock, & van Rijn, 1993) and the other characteristics are derived from the French lexical database LEXIQUE (New, Pallier, Brysbaert, & Ferrand, 2004). All these characteristics are described in Table 2.

Procedure

Testing took place in children's respective schools. Control measures were administered individually in an empty classroom and the testing lasted about 40 minutes per child. Experimental

tasks were administered in small groups of two or four children. They were asked to write words on a white sheet that was stuck to a digital tablet using a digital inking pen (Wacom Intuos Pro Medium and Wacom Inking Pen). The tablet size was 380 x 251 x 12mm, with an active area of 224 x 140mm. The children's productions were recorded in real time, with a sample frequency of 7/8ms. To make sure the children had enough space to write the 40 words, three A4 sheets of paper were provided to each child for each task. Moreover, in order to ensure that the children would write in the correct space, dashes followed by each word's determinant (either /le/ or /la/ [the], or /un/ or /une/ [a]) were placed vertically, according to the order of the words.

The dictation task was administered in small groups of four children. In this dictation task, the children were asked to write the words they heard, with their usual handwriting. There was no time constraint. It lasted approximately 20 minutes. All the children completed the dictation task before the copying task, in order to avoid children being exposed to the orthographic representations of the words before the dictation task.

The copying task was administered by two experimenters in small groups of two children. Each experimenter was in front of one child, in order to note precisely the position where the child lifted his or her gaze. In this copying task, in addition to the sheets stuck on the tablet for writing the words, the children were provided with a sheet listing the words to be copied, placed next to the tablet on which the child was writing. The words were written in lower-case Calibri font size 11 on three sheets of paper. The sheets of paper were similar to the sheets on which the children wrote. The experimenter changed the sheet as soon as the child reached the end of the page. The children were asked to copy the words they saw, one after another. It lasted approximately 15 minutes and there was no time constraint.

Data Analysis

All statistical analyses were run using IBM SPSS Statistics 24. Preliminary analyses on the dependent variables revealed no distributional problems. Data met the normality assumption for parametric procedures (all measures $Sk < |3|$ and $Ku < |10|$; Kline, 2005) except for the letter-by-letter strategy. In this case, we decided not to transform it because it is usual that by Grade 2, children

almost never use this letter-by-letter strategy. Descriptive statistics for the dependent variables are provided in Tables 3 and 4.

We conducted two series of analyses. The first set of analyses was conducted on the whole data set to compare copying and dictation performances. These analyses were conducted on the three dependent variables that were common to the two tasks: spelling accuracy, handwriting quality and handwriting speed. Next, a set of analyses focused on the copying task only. The goal of this analysis was to compare in detail the copying skills of DYS children with those of CA and SA children on six dependent variables: spelling accuracy, handwriting quality, handwriting speed, gaze lift coefficient, copying strategy and gaze lift location.

For the variables handwriting quality and handwriting speed, the analyses were conducted on the correctly spelled words only. Indeed, when a word is too difficult to spell, a child will sometimes simplify its spelling and shorten the word. However, handwriting quality and speed are determined on the basis of the letters of which the word is composed. Therefore, when a production is misspelled and shortened, handwriting scoring could disadvantage children who produced accurate spelling. For example, the word *brebis* (ewe) was spelled accurately by Child 1 but Child 2 produced *bebi*. In this case, Child 2 simplified the target word, since he only wrote four letters out of the six target letters. Consequently, the chance of finding aesthetic errors in Child 2's production was reduced compared to Child 1 who produced accurate spelling. By conducting the analyses for handwriting quality and speed on correctly spelled words only, we ensured that we were comparing the exact same productions between children. Therefore, for these two variables, one hundred and nine errors (4.78%) were excluded from the analyses in the copying task data set. In the whole data set, one thousand three hundred and forty-three errors (29.45%) were excluded from the analyses. Moreover, for the variable handwriting speed only, due to technological recording issues, one missing value was excluded from the analyses in the copying task data set and four missing values were excluded from the analyses in the whole data set.

Comparison between dictation and copying tasks. Generalized Linear Mixed Models (GLMM) were conducted to answer the research questions. These analyses can account for both the variability introduced by the children and that introduced by the items within the same analyses. A

GLMM was run separately for spelling accuracy, handwriting quality, and handwriting speed. In each GLMM, participants ($n = 57$) were entered as a random factor. Orthographic complexity [simple, difficult] as well as task [copying, dictation] and group [DYS, SA, CA] were entered as fixed factors. We examined whether the interactions were significant between Group $\times$ Task, Group $\times$ Orthographic Complexity, Task $\times$ Orthographic Complexity and Group $\times$ Task $\times$ Orthographic Complexity. [Partial eta square values from repeated measures ANOVAs were used to be able to report effect sizes.](#)

Copying task. A GLMM was run separately for spelling accuracy, handwriting quality, handwriting speed and gaze lift coefficient. Regarding the dependent variable gaze lift coefficient, we had to transform it into a binary variable to be able to run the GLMM as it is impossible to run a GLMM on an ordinal variable. In each GLMM, participants ($n = 57$) were entered as random factor. Orthographic complexity [simple, difficult] as well as group [DYS, SA, CA] were entered as fixed factors. We also checked whether the interactions were significant between Group $\times$ Orthographic Complexity.

Copying strategy and gaze lift location analyses were conducted using repeated measures ANOVAs to which we applied Greenhouse-Geisser corrections when the data violated the sphericity assumption. For the copying strategy variable, [we first ran an analysis on all the words copied,](#) entering group [DYS, SA, CA] as a between-participants factor and strategy type [letter-by-letter, syllabic, global, random] [as well as orthographic complexity \[simple, difficult\]](#) as within-participants factors. [In order to determine whether copying strategies differed according to lexical orthographic knowledge, we second ran this analysis only on the words that were correctly spelled in the dictation task, entering group \[DYS, SA, CA\] as a between-participants factor and strategy type \[letter-by-letter, syllabic, global, random\] as a within-participants factor.](#) For the gaze lift location variable, we entered group [DYS, SA, CA] as a between-participant factor and location type [double consonant, silent letter, complex grapheme, cluster, final *e*] as a within-participants factor. For these analyses, we checked whether the interactions between the within-participants factors and the between-participants factor were significant.

Results

Comparison Between the Dictation and Copying Tasks

Spelling accuracy. The GLMM conducted on spelling accuracy revealed a significant effect of task, $F(1, 4548) = 507.81, p < .001, \eta^2 p = .97$: spelling performance was lower in the dictation task ($M = .46, SD = .50$) than in the copying task ($M = .95, SD = .21$). The GLMM also revealed a group effect, $F(2, 4548) = 21.63, p < .001, \eta^2 p = .54$. Sequential Bonferroni post-hoc showed that DYS children ($M = .69, SD = .46$) and SA children ($M = .65, SD = .48$) performed lower in both tasks than CA children ($M = .78, SD = .41$), all $ps < .001$. Moreover, an effect of the orthographic complexity was also found, $F(1, 4548) = 256.54, p < .001, \eta^2 p = .96$: a lower performance in spelling on complex words ($M = .52, SD = .50$) than on simple words ($M = .89, SD = .31$). The interaction between task and orthographic complexity was significant, $F(1, 4548) = 80.41, p < .001, \eta^2 p = .96$. However, the interactions between group by orthographic complexity; group by task; and group by task by orthographic complexity did not reach significance, respectively $F(2, 4548) = 0.08, p = .92$; $F(2, 4548) = 0.38, p = .68$ and $F(2, 4548) = 0.98, p = .37$.

Handwriting quality. For this GLMM, the factor of orthographic complexity was removed from the analyses because complex words resulted in widespread failure in the dictation task (spelling success rate of 10.5%). The analysis conducted on handwriting quality revealed a significant effect of task, $F(1, 3211) = 11.21, p = .001, \eta^2 p = .10$: all children had poorer handwriting quality in the copying task ($M = 1.64, SD = 0.99$) than in the dictation task ($M = 1.47, SD = 1.04$). The effect of group and the interaction of group by task were not significant, respectively $F(2, 3211) = 2.03, p = .13$ and $F(2, 3211) = 0.50, p = .61$.

Handwriting speed. Since handwriting speed data for SA children in the dictation task could not be collected *because of technical issues*, the data from SA children in the copying task were likewise excluded. In this GLMM, the effect of task was not significant, $F(1, 2227) = 0.41, p = .52$, nor was the group effect between the remaining two groups, $F(1, 2227) = 0.00, p = .98$.

Copying Task

Spelling accuracy. The GLMM conducted on spelling accuracy revealed a significant effect of group, $F(2, 2274) = 6.57, p = .001, \eta^2 p = .16$. Sequential Bonferroni post-hoc showed that DYS

children ($M = 0.95$, $SD = 0.23$) and SA children ($M = 0.93$, $SD = 0.26$) performed worse than CA children ($M = 0.98$, $SD = 0.12$), all $ps < .05$. DYS children made the same number of spelling mistakes as SA children, $p = .19$. A GLMM also revealed that the orthographic complexity effect was significant, $F(1, 2274) = 16.41$, $p < .001$, $\eta^2p = .27$: mistakes were more frequent for complex words ($M = 0.93$, $SD = 0.26$) than for simple words ($M = 0.97$, $SD = 0.16$). The interaction Group $\times$ Orthographic Complexity did not reach significance, $F(2, 2274) = 0.30$, $p = .74$.

Handwriting quality. We did not find any significant effect of group, orthographic complexity or any interaction between group and orthographic complexity on handwriting quality, respectively, group: $F(2, 2165) = 1.76$, $p = .17$; orthographic complexity: $F(1, 2165) = 0.00$, $p = .95$; and interaction: $F(2, 2165) = 0.22$, $p = .81$.

Handwriting speed. The GLMM conducted on handwriting speed revealed a significant effect of group, $F(2, 2164) = 8.71$, $p < .001$, $\eta^2p = .24$. Sequential Bonferroni post-hoc showed that SA children ($M = 1.21$, $SD = 0.57$) were slower than CA children ($M = 1.82$, $SD = 0.69$) and DYS children ($M = 1.81$, $SD = 0.66$), all $ps = .001$. No significant difference appeared between DYS and CA children. The GLMM also revealed that orthographic complexity effect was significant, $F(1, 2164) = 83.13$, $p < .001$, $\eta^2p = .51$: all children were slower when they had to write complex words ($M = 1.53$, $SD = 0.68$) compared to simple words ($M = 1.70$, $SD = 0.75$). The interaction between group and orthographic complexity did not reach significance, $F(2, 2164) = 2.26$, $p = .10$.

Gaze lift coefficient. The GLMM conducted on gaze lifts revealed a significant effect of group, $F(2, 2274) = 14.37$, $p < .001$, $\eta^2p = .33$. Sequential Bonferroni post-hoc showed that DYS children ($M = .15$, $SD = .18$) produced more gaze lifts than CA children ($M = .06$, $SD = .11$) but fewer than SA children ($M = .24$, $SD = .23$), all $ps < .05$. GLMM also revealed that the orthographic complexity effect was significant, $F(1, 2274) = 211.29$, $p < .001$, $\eta^2p = .72$: complex words lead to more gaze lifts ($M = .20$, $SD = .21$) than simple words do ($M = .10$, $SD = .17$). However, the interaction between gaze lift coefficient and group was not significant, $F(2, 2274) = 1.30$, $p = .27$.

Copying strategy. Taking into account all the words, a repeated measures ANOVA revealed a significant effect of strategy type, $F(3, 162) = 89.12$, $p < .001$, $\eta^2p = .62$. All children used the global strategy ($M = .53$, $SD = .28$) more than the random strategy ($M = .32$, $SD = .18$), which was

used more than the syllabic strategy ($M = .11$, $SD = .10$), all $ps < .01$. The letter-by-letter strategy was the least commonly-used strategy ($M = .04$, $SD = .10$), all $ps < .01$. The interaction of orthographic complexity by strategy type was significant, $F(3, 162) = 105.30$, $p < .001$, $\eta^2p = .66$. Simple effect analyses on the letter-by-letter strategy revealed a significant effect of orthographic complexity, $F(1, 56) = 7.98$, $p < .01$, $\eta^2p = .13$: letter-by-letter strategy was more used for complex words ($M = .06$, $SD = .15$) than for simple words ($M = .02$, $SD = .07$). Regarding the syllabic strategy, there was no significant difference between complex and simple words, $F(1, 56) = 1.48$, $p = .23$. Regarding the global strategy, results revealed a significant effect of orthographic complexity, $F(1, 56) = 173.75$, $p < .001$, $\eta^2p = .76$: global strategy was less used for complex words ($M = .39$, $SD = .30$) than for simple words ($M = .66$, $SD = .29$). Regarding the random strategy, results revealed a significant effect of orthographic complexity, $F(1, 56) = 105.52$, $p < .001$, $\eta^2p = .65$: random strategy was more used for complex words ($M = .45$, $SD = .21$) than for simple words ($M = .20$, $SD = .19$). The interaction of group by strategy type was also significant, $F(6, 162) = 12.23$, $p < .001$, $\eta^2p = .31$. Simple effect analyses on the letter-by-letter strategy revealed a significant effect of group, $F(2, 54) = 5.69$, $p < .01$, $\eta^2p = .17$. Bonferroni post-hoc showed that DYS ($M = .02$, $SD = .06$) and CA children ($M = .00$, $SD = .00$) used the letter-by-letter strategy less than SA children ($M = .10$, $SD = .16$), all $ps < .05$. Regarding the syllabic strategy, the results revealed a significant effect of group, $F(2, 54) = 4.31$, $p < .05$, $\eta^2p = .14$. Bonferroni post-hoc showed that there was no significant difference between DYS ($M = .12$, $SD = .09$) and either CA ($M = .06$, $SD = .09$) or SA ($M = .15$, $SD = .10$) children. However, SA children used the syllabic strategy more than CA children, $p < .05$. Regarding the global strategy, results revealed a significant effect of group, $F(2, 54) = 14.96$, $p < .001$, $\eta^2p = .36$. Bonferroni post-hoc showed that DYS children ($M = .50$, $SD = .27$) and SA children ($M = .34$, $SD = .22$) used the global strategy less than CA children ($M = .75$, $SD = .20$), all $ps < .01$. There was no significant difference between DYS and SA children. Finally, regarding the random strategy, results revealed a significant effect of group, $F(2, 54) = 11.56$, $p < .001$, $\eta^2p = .30$. Bonferroni post-hoc showed that DYS children ($M = .37$, $SD = .20$) and SA children ($M = .41$, $SD = .11$) used the random strategy more than CA children ($M = .19$, $SD = .13$), all $ps < .01$. There was no significant difference between DYS and SA children. All these results are detailed in Table 4, and Figure 1 represents the interaction of group by

strategy. Supplementary analyses were conducted to see whether the random strategy was associated with more spelling mistakes but the effect of the random strategy use on spelling accuracy was not significant, $F(1, 2278) = 0.01, p = .93$.

Taking into account only the words that were correctly spelled in the dictation task (1046 out of 2280, which is 45.88% of the words), results showed the same significant effect of strategy type, $F(3, 162) = 143.62, p < .001, \eta^2 p = .73$. The interaction of group by strategy type was also significant, $F(6, 162) = 6.13, p = .001, \eta^2 p = .19$, but simple effect analyses showed some differences compared to those conducted on all the words. Regarding the letter-by-letter strategy, the differences found above between DYS and SA children were no longer significant, $p = .053$. DYS children ($M = .00, SD = .02$) did not use the letter-by-letter strategy less than SA children ($M = .05, SD = .10$) when they knew the spelling of the word. Regarding the syllabic strategy, the results were the same than presented above: there was no significant difference between DYS ($M = .11, SD = .10$) and either CA ($M = .06, SD = .12$) or SA ($M = .16, SD = .13$) children. Regarding the global strategy, the differences found above between DYS and CA children were no longer significant, $p = .09$. DYS children ($M = .67, SD = .26$) did not use the global strategy less than CA children ($M = .85, SD = .20$) when they knew the spelling of the word. Finally, regarding the random strategy, the differences found above between DYS and CA children were no longer significant, $p = .07$. DYS children ($M = .21, SD = .21$) did not use the random strategy more than CA children ($M = .09, SD = .09$) when they knew the spelling of the word.

Gaze lift location. A repeated measures ANOVA revealed a significant effect of group, $F(2, 54) = 13.41, p < .001, \eta^2 p = .33$. Bonferroni post-hoc showed that DYS children ($M = .25, SD = .19$) and SA children ($M = .29, SD = .15$) produced more gaze lifts on inconsistencies and difficulties than CA children ($M = .12, SD = .30$), all $ps < .01$. There was no significant difference between DYS and SA children. Analyses also revealed a significant effect of location type, $F(4, 216) = 44.78, p < .001, \eta^2 p = .45$. Bonferroni post-hoc showed that more gaze lifts were produced on double consonants ($M = .42, SD = .27$) than all other inconsistencies, all $ps < .001$. After double consonants, more gaze lifts were produced on complex graphemes ($M = .21, SD = .15$) than on clusters ($M = .17, SD = .17$) and final *es* ($M = .10, SD = .10$), all $ps < .05$, but there was no significant difference between complex graphemes ($M = .21, SD = .15$) and silent letters ($M = .20, SD = .18$). The final *e* inconsistency led to

the fewest gaze lifts ($M = .10$, $SD = .10$). The interaction of group by location type was also significant, $F(8, 216) = 2.25$, $p = .05$, $\eta^2 p = .08$. Simple effect analyses revealed a significant effect of group on silent letters, $F(2, 54) = 5.47$, $p < .01$, $\eta^2 p = .17$, double consonants, $F(2, 54) = 6.94$, $p < .01$, $\eta^2 p = .20$, complex graphemes, $F(2, 54) = 8.57$, $p = .001$, $\eta^2 p = .24$, and clusters, $F(2, 54) = 11.43$, $p < .001$, $\eta^2 p = .30$. Regarding final *e*, there was no significant effect of group, $F(2, 54) = 1.10$, $p = .34$, $\eta^2 p = .04$. Bonferroni post-hoc showed that DYS and SA children produced more gaze lifts than CA children on double consonants, complex graphemes and clusters, all $ps < .05$. There was not a significant difference between DYS and SA children. Regarding silent letters, DYS children produced the same number of gaze lifts as CA and SA children. All these results are detailed in Table 4, and Figure 2 represents the interaction of group by location type.

Discussion

The aim of this experiment was to better understand the potential difficulties of DYS children in a copying task. In this experiment, DYS children copied words varying in orthographic complexity level on a digitizer and wrote the same words under dictation. They were compared to CA children and SA children. Two different predictions were made: (a) if DYS children have a specific deficit in their copying processes in addition to their spelling deficit, *they should present a less marked copying advantage in comparison to typically developing children. Focused on the copying task only*, they should perform worse than both CA and SA children, with more spelling errors, slower or lower quality handwriting and different use of gaze lifts; (b) if DYS children present difficulties in copying as a consequence of their spelling deficit, *the differences observed between the dictation and the copying task should be the same for all children. Focused on the copying task*, DYS children should perform worse than CA children but they should behave like SA children. For each dependent variable, i.e., spelling accuracy, handwriting quality, handwriting speed, gaze lift coefficient, copying strategy, and gaze lift location, we examined whether there were differences between DYS and both CA and SA children. The main results suggested that DYS children have difficulties in copying because of the spelling errors they make and the copying strategies they use.

The first series of analyses was conducted on the whole data set. Regarding spelling accuracy, all the children produced fewer spelling mistakes in the copying task than in the dictation

task, which was expected. All the children were facilitated in the copying task by having the model in front of them (Martlew, 1992; Re & Cornoldi, 2015). Regarding handwriting quality, the results revealed that all the children showed poorer handwriting quality in the copying task than in the dictation task. This can be explained by stops made during the word writing when the children look at the model to get more information about the word to be copied. Regarding handwriting speed, no difference between tasks or group was found. However, it should be noted that speed data for SA children in the dictation task was not available. The comparison was therefore only made between the DYS and CA children. Taken together, these results show that the differences in performance between the dictation and the copying task are the same for all children. This suggests that DYS, SA and CA children present similar writing patterns, irrespective of the writing condition (dictation or copying) and that potential difficulties of DYS children in copying are more a consequence of their spelling deficit than a specific deficit in their copying processes.

The second series of analyses focused on the copying task only, in order to get more details about the copying skills of DYS children. Regarding spelling accuracy, our results showed that DYS children made more spelling mistakes than their same-age peers whilst they made the same number of mistakes as the SA children. Their percentage of spelling errors in the copied words is about 5%, which is still high when you consider the daily use of copying in class. Although the model provides the correct spelling of the words in the copying task, DYS children still have difficulties copying them correctly. This difference observed between DYS and typically developing children (CA) confirm the results of Re and Cornoldi (2015), which showed that 9-year-old Italian-speaking children with spelling difficulties made more spelling mistakes in a text copying task than typically developing children of the same age, even in an orthographically transparent language. French orthographic system being opaque and therefore more difficult, we expected to observe a similar or worse profile than in Italian, which was the case. Our results also showed that all children produced more spelling mistakes when words were orthographically complex (about 7%) than when words were orthographically simple (about 3%). This suggests that some children read the word and automatically produce their habitual spelling without considering the difficulty of complex words.

Regarding handwriting quality, our results revealed a similar handwriting quality in the copying task between the DYS children and the typically developing children (CA and SA), which means that all children pay attention to the shape of the letters they have to write. Our results are inconsistent with a previous study showing that DYS children had poorer quality handwriting than typically developing children (Martlew, 1992). However, Martlew's study (1992) analyzed handwriting quality with a more subjective global judgment while in our experiment, handwriting quality was analyzed using several criteria based on the BHK (Charles et al., 2004) which provided a more fine-grained analysis of the quality.

Regarding handwriting speed, our results showed that DYS children were faster than SA children but they were not slower than CA children. These results are consistent with the study of Sumner et al. (2013) and Afonso et al. (2020) demonstrating that DYS children execute handwriting at the same speed as typically developing children even if they produce more pauses or longer written latencies. However, in our study, pause times and latencies have not been taken into account. It is possible that DYS children also produced more pauses and longer latencies in our sample. In future research, it might be interesting to include these variables in our speed measure because it may also be an indicator of handwriting difficulty in DYS children even if they do not have a deficit in their motor skills as such (Afonso et al., 2020; Sumner et al., 2013).

Regarding gaze lift coefficient, the number of times children need to get information about the model, our results showed that DYS children looked up at the model more often than CA children. This suggests that DYS children need more spelling information to finish copying words (Kandel et al., 2017). However, DYS children produced fewer gaze lifts than SA children. This may be explained by cognitive or memory abilities being less developed in younger children. Our results also showed that all children had to look up at the model more often when words were orthographically complex than when they were orthographically simple, suggesting that sub-lexical processing is more frequent for complex words for all children. French being an opaque writing system, this could be linked to opacity of orthographic system.

Regarding copying strategies, our experiment is, to the best of our knowledge, the first to examine these copying strategies in DYS children. Our results revealed that DYS and SA children

used the random strategy more than CA children. Indeed, DYS children used the random strategy in 37% of cases while CA children used it in only 19% of cases. CA children mainly used the global strategy (about 75%), which corresponds to the copy of a word with a single eye fixation. This suggests that DYS and SA children do not have enough orthographic information available to be able to copy some items as a whole spelling unit and therefore decompose them into random sub-lexical units (Kandel & Valdois, 2006). However, when DYS children have the word to be copied in their orthographic lexicon, they behave like CA children. This suggests that the type of strategy used is function of the quality of the child's lexical representations of word spelling. DYS children use different copying strategies in comparison to CA children because their orthographic lexicon is less developed. More generally, our results showed that all children used more the random strategy for copying complex words while they used more the global strategy for copying simple words, suggesting they are conscious of the complexity of words. Besides, the use of letter-by-letter and syllabic strategies in our study was very rare for all children. This is in line with other studies showing that children in Grade 2 start to copy some words with a global strategy and that the way the child processes the word depends on its orthographic regularity (Humblot et al., 1994; Kandel et al., 2003, Lambert et al., 2011). It should be noted that the random strategy was not taken into account in those previous studies that only considered the letter-by-letter strategy, the syllabic strategy or the global strategy. In our sample, we observed that this random strategy was frequently used by DYS and SA children and for this reason, it is important to better understand it.

Regarding gaze lift location, our study is, as far as we know, also the first one that has investigated whether children produce gaze lifts at specific places in words. Our results showed that DYS and SA children had to look up at the model more often at word inconsistencies or difficulties than CA children. More precisely, the results demonstrated that DYS and SA children looked up at the model more often when faced with the double consonants (e.g., *cc* in *accord*), complex graphemes (e.g., *au* in *gauche*) and clusters (e.g., *br* in *sabre*) than CA children. It suggests that DYS and SA children are conscious of such difficulties within words because they stop to get more information. Despite this, producing more gaze lifts on word inconsistencies or difficulties does not seem to be effective, since they make more spelling errors than CA children. More globally, our results showed

that all children produced more gaze lifts on double consonants and complex graphemes than on other inconsistencies or difficulties. This observation can be related to other studies (Kandel, Peereman, & Ghimenton, 2014; Kandel & Spinelli, 2010). These studies showed that words including complex graphemes or double letters took longer to write than words including simple graphemes or simple letters, suggesting that these inconsistencies are particularly difficult to process for everyone. Our study seems to confirm these results and additionally suggests that these inconsistencies are even more difficult to process for DYS children. However, it is important to keep in mind that our study and that of Kandel et al. (2014) and Kandel and Spinelli (2010) took place within the French writing system. In the English writing system, one study showed that words including double letters took less time to write in comparison to words including simple letters (Kandel, Peereman, Ghimenton & Perret, 2019). Even if these two opaque languages contain a lot of inconsistencies (Ziegler, Jacobs & Stone, 1996), these results are inconsistent. This could be explained by the fact that the predictability of double letters' occurrence differs between French and English (Kandel et al., 2019). So, depending on the language particularities, the gaze lift locations could be slightly different.

Taken together, all these results can be related to the capacity theory of writing (McCutchen, 1996). It is known that DYS children need to dedicate more resources to reading and spelling than typically developing children. These two processes being involved in a copying task, copying can be particularly difficult for these children, who have to allocate their limited available resources between the different simultaneous processes.

As a whole, our results provide evidence of copying difficulties in DYS children, because of the spelling errors they make, the number of gaze lifts they need, the type of copying strategies they use and the place where they produce gaze lifts. When they copy words, they make more spelling mistakes than CA children, while at the same time making more gaze lifts, which leads them to use a more frequent random strategy and to use information on double consonants, complex graphemes and clusters more often than CA children. For these reasons, DYS children have difficulty copying compared to CA children. However, they behave like SA children, since they make the same number of spelling mistakes, and globally use similar gaze lifts. As a result, the copying difficulties of DYS children would not represent a specific deficit in themselves but would be more related to the children

with dyslexia's inherent reading and spelling difficulties, highlighting a delay rather than a deviance profile. Finally, a pedagogical recommendation of this study could be the following: considering that children with dyslexia need to look up more for double consonants, clusters or complex graphemes, one possible way to help them improve their copying strategies could be to highlight the difficulties of words with colors (e.g., having the teacher underline the double consonants in colour when writing on the blackboard). This would help draw the children's attention to these difficulties and possibly avoid spelling mistakes. However, the effectiveness of this recommendation needs to be evaluated in a future intervention study.

Limitations

A few limitations can be noted in this study and should be considered in future research. First, the number of participants in each of our three groups was quite small. This can limit the extent to which our results can be generalized. It would be interesting to replicate this experiment with a larger sample to ensure that our results can be generalized. Second, the copying task involves many processes and it is difficult to control all of them. For example, short-term memory and visual attention span certainly play an important role in this kind of task (Bosse et al., 2013; Maldarelli et al., 2015). Therefore, it may be interesting in future studies to evaluate these skills to see to what extent they could explain the differences observed. Third, in our study, the children copied words that varied in their level of orthographic complexity. In future research, it could be useful to take into account other variables such as lexicality or frequency, known to have an impact on handwriting or on the number of gaze lifts in copying (Kandel et al., 2017; Kandel et al., 2003; Lambert et al., 2011). Fourth, our speed measure missed for the SA group in the dictation task and did not include pauses. Because of the number of stops induced by the gaze lifts in the copying task, it might be useful to include pauses in our speed measure. Finally, it might be interesting to replicate this study with younger children. Indeed, most typically developing children can copy words with a global strategy in Grade 3, as their copying processes are starting to become automatized (Humblot et al., 1994; Kandel & Valdois, 2006). It would be interesting, therefore, to find out if there are already differences between children at risk of dyslexia or poor readers/spellers at the beginning of written language learning.

Conclusion

In summary, these findings bring new insights regarding copying skills in children with dyslexia. This study is innovative in that it assessed simultaneously spelling, handwriting and gaze lifts while other studies, which are few in number, focused on a single aspect. The main results showed that children with dyslexia do have difficulties in copying. They made more spelling errors than their age-matched peers, despite the model provided during the copying task. Gaze lift analyses revealed that the children with dyslexia used different copying strategies compared to their classmates. Indeed, they produced more gaze lifts and used the random strategy more than their age-matched peers, who mainly used the global strategy. Moreover, the children with dyslexia produced more gaze lifts on double consonants, complex sounds and clusters compared to their age-matched peers. Globally, children with dyslexia seem to behave like younger children, suggesting that their difficulties arise from their spelling deficit. These findings may have practical implications. Given that children with dyslexia face copying difficulties, one possible way to help them could be to enable them to improve their copying strategies, and not just their spelling skills.

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