Writing and Revision Strategies of Students with and without Dyslexia

Emma Sumner[1] and Vincent Connelly[2]

[1]University College London, Institute of Education; [2]Oxford Brookes University

Author Contact Information

Emma Sumner

Department of Psychology and Human Development

University College London, Institute of Education

20 Bedford Way,

London

WC1H 0AL

Email: e.sumner@ucl.ac.uk

Vincent Connelly

Email: vconnelly@brookes.ac.uk

Author's Note

This research was joint funded by The Waterloo Foundation and Oxford Brookes University.

Special thanks go to all students that participated in this study.

Writing and Revision Strategies of Students with and without Dyslexia

Abstract

Previous work suggests that written text produced by university students with dyslexia is scored lower than that produced by their peers. The present study used a digital writing tablet to examine the writing process and the quality of text written by university students with dyslexia. Revision behaviour during and after writing was also investigated. Thirty-two university students with dyslexia (mean age, 20 years), were compared to 32 typically-developing (TD) students matched by age. Students composed a written text in response to an expository essay prompt. In line with previous research, students with dyslexia made a higher number of spelling errors and their essays were rated as poorer than TD students. However, students with dyslexia were comparable to their peers on measures of time spent writing, amount of text produced, and the temporal analyses (handwriting execution, pause times). Students with dyslexia made significantly more revisions to spelling during and after transcription than their peers, although other revision behaviour was similar across groups. Explanations for the finding of poor writing quality are explored. Importantly, the findings suggest that continued support with spelling and writing is needed for university students with dyslexia. Instruction directed towards effective revision strategies may also prove useful. Limitations and directions for future research are discussed.

Keywords: Dyslexia, handwriting, revision behaviour, spelling, writing.

Writing and Revision Strategies of Students with and without Dyslexia

Writing remains the main method of assessment throughout education. In particular, at university level, students are expected to demonstrate their knowledge of a topic through independent writing. The majority of disciplines require written coursework and, in the United Kingdom (UK), most university students are required to produce handwritten essays in exams at a number of points in their education. While the proportion of United States (U.S) and other international universities that require handwritten exams is dropping in favour of keyboarded assessments, there are still many university students who choose, or are required, to handwrite under time pressure.

One group of students that self-report long-standing problems with spelling and, specifically, written expression are students with dyslexia (Mortimore & Crozier, 2006). Dyslexia is a specific learning disorder, defined by poor reading (American Psychiatric Association [APA], 2013) and therefore, not surprisingly, persistent difficulties with spelling are frequently noted in this population (Coleman, Gregg, McLain & Bellair, 2009; Peterson & Pennington, 2012). Reading informs writing in terms of providing opportunity to develop procedural and linguistic knowledge (Shanahan, 2016) and models of writing depict both reading and spelling as important foundational components when writing (Hayes, 2012; Shanahan, 2016). Limited exposure to written text coupled with problems with phonology and orthography may therefore hinder the development of written skills.

In 2015/16, students with specific learning difficulties, which largely includes dyslexia, accounted for 6.2% of the student Higher Education (HE) population (Higher Education Statistics Authority, 2016) in the UK. Research has shown that students with dyslexia generally leave university with lower grades than their peers without dyslexia (Richardson & Wydell, 2003). One possible explanation for this may be due to their

difficulties with meeting the written requirements. Several studies have demonstrated that, in comparison to their same-age peers, written compositions produced by university students with dyslexia are graded lower in quality, while being characterised by a larger proportion of spelling errors (Bogdanowic, Lockiewicz, Bogdanowicz, & Pachalska, 2014; Connelly, Campbell, MacLean, & Barnes, 2006; Sterling, Farmer, Riddick, Morgan, & Matthews, 1998) and that these differences in quality persists even after scripts have been corrected for spelling and handwriting (Galbraith, Baaijen, Smith-Spark, & Torrance, 2012; Gregg, Coleman, Davis, & Chalk, 2007; Tops, Callens, Van Cauwenberghe, Adriaens, & Brysbaert, 2013). Another reported finding is that students with dyslexia present with a slower handwriting speed (letters per minute) than their peers (Connelly et al., 2006; Hatcher, Snowling, & Griffiths, 2002).

Models of the writing process (Berninger & Swanson, 1994; Hayes, 2012) highlight how transcription skills (handwriting and spelling) need to be automatic to allow working memory resources to be devoted to generating text and higher-level planning of the text (including reviewing what has been written). In adulthood, the transcription processes are expected to be proficient (Olive, 2014) and less of a constraint on writing. However, little is known about how poor spelling in adulthood influences the real-time production of text and the possible repercussions on text quality. Research using digital writing tablets has highlighted how spelling interferes with the writing process for children with dyslexia and, in turn, results in less text being composed (Sumner, Connelly, & Barnett, 2013, 2014). Children with dyslexia were found to move the pen across the page at the same speed as their peers, but they paused for longer while writing (i.e., demonstrated a period of inactivity), which was attributed to their difficulty with spelling. It is conceivable that the spelling difficulties experienced by adults with dyslexia could constrain written text production in the same way.

When considering possible explanations for writing problems in dyslexia, spelling and handwriting alone cannot fully explain their textual shortcomings as poorer quality texts remain even after correcting for spelling and handwriting (Galbraith et al., 2012). There may be a cumulative effect of poor spelling and more pausing on the other writing processes that should happen in parallel with transcription. Skilled writers often carry out an evaluation (reviewing/revising) process on the contents of the translation process (converting pre-verbal ideas into surface language structure) as they transcribe their texts (Hayes, 2012). However, given the potentially more limited cognitive resources of students with dyslexia while writing, due to the heavy load of spelling, this may be less likely. Wengelin (2007) reported that, in comparison to a control group, Swedish-speaking adults with dyslexia made more spelling-related revisions when keyboarding. In contrast, a study on Norwegian-speaking adolescents found that within-word revision behaviour when keyboarding was similar across weak decoders and those without decoding difficulties (Torrance, Rønneberg, Johansson, & Uppstad, 2016), suggesting little impact of reading difficulties on the frequency of within-word revisions. Of note, Swedish and Norwegian have a shallower orthography than English which has a deep orthography (Schmalz, Marinus, Coltheart, & Castles, 2015) and, therefore, we may see a different profile for English-speaking students with dyslexia. Further, revisions while handwriting may differ to keyboarding revisions. It may be that students with dyslexia produce text that has not been evaluated (revised) to the same extent as their peers and this may contribute to the lower quality compositions.

The aim of the present study was to examine the writing product and process of English-speaking university students with dyslexia and to investigate how students approach revising their written compositions. Performance was compared to a typically-developing group of students matched for age. The writing process was assessed using a digital writing tablet, which enables the observation of revisions made during transcription and has the

added benefit of not interrupting the composing process, as in think-aloud protocols. Post-transcript revisions were also analysed to determine whether students pick up on changes to be made (or mistakes) when they proof-read their text after composition.

Based on the existing literature, it was predicted that texts written by students with dyslexia would contain a higher number of spelling errors and be rated as poorer in quality than their peers (Connelly et al., 2006; Galbraith et al., 2012). Based on findings from younger populations with dyslexia (Sumner et al., 2014), it was expected that students with dyslexia would spend more time pausing than their peers, reflecting a breakdown in text-making. Thus, the amount of time pausing and the number of pauses were measured. In addition, considering revision behaviour, Chenoweth and Hayes (2001) reported that poorer adult writers revise frequently, but Torrance et al. (2016) found no evidence that weak decoders were more likely to make changes to their text. Since students with dyslexia have both reading and spelling difficulties, we predicted that they would make spelling mistakes while writing and, as a result, we expected their revision behaviour to reflect this difficulty by observing more frequent crossings out or returning to spellings and consequently less changing of the meaning of their texts compared to their peers. Thus, given the significant spelling challenges for students with dyslexia, we would predict that any revisions made would focus largely on spelling. However, we also expected that students with dyslexia would revise their spellings less effectively (during and post-transcription): successfully correcting proportionally fewer spelling errors than their peers. In contrast, we would expect the comparison group that do not present with spelling difficulties to show a range of revision behaviours (e.g., editing spelling, adding in or removing text or punctuation).

Method

Participants

Participants had English as their first language. Inclusion criteria for both groups were performance within the average range (+/- 1.5 SDs) on measures of verbal (similarities task) and non-verbal (matrices task) cognitive ability (Wechsler Adult Intelligence Scale-3 [WAIS-III], Wechsler, 1997). Table 1 reports group characteristics. No significant group differences in age ($p = .78$) or cognitive ability ($p > .18$) were found, and both groups scored close to the population mean (10) on the cognitive tasks. All but three students with dyslexia were students studying psychology as their major (the other subjects consisted of early childhood studies, law, and occupational therapy), and all but four of the typically-developing (TD) students were also students studying psychology (the remaining were business studies, architecture, sport and exercise, and geography students). Therefore, both samples of participants would likely be equally well versed in writing essays to social science essay topics. The majority of the sample were first year undergraduate students, apart from seven second year students (4 with dyslexia; 3 TD students). Year of study did not correlate with any of the writing quality measures and, therefore, was not included as a covariate in subsequent analyses.

Students with dyslexia. Thirty-two students with dyslexia (23 female; 18-25 years) were recruited from Oxford Brookes University in the UK, via poster advertisements and through the psychology department to gain course credits. 88% of the sample had received a dyslexia statement from an Educational Psychologist, while the remaining 12% reported previously being identified by teachers as having dyslexia. No students reported any additional diagnoses (such as attention-deficit-hyperactivity disorder (ADHD) or language impairment). Single-word reading and spelling ability (both from the Wide Range Achievement Test-3, [WRAT3], Wilkinson, 1993) as well as word and nonword reading fluency (Test of Word Reading, [TOWRE]; Torgesen, Wagner, & Rashotte, 1999) were

assessed. Analyses revealed that students with dyslexia scored significantly below the TD group on spelling and reading performance (*p*s < .001).

{Insert Table 1 here}

TD control group. Thirty-two TD students (24 female; 18-26 years) were recruited from Oxford Brookes University, using the same method and assessments as above. Students did not report any developmental diagnoses such as dyslexia, language impairments, ADHD, autism, nor medical conditions; and performed age-appropriately on the cognitive, reading and spelling assessments.

Measures

Written composition. Participants were given 20 minutes in which to write an essay. The following writing prompt was taken from the Graduate Record Examinations (GRE) Analytical Writing Measure (Educational Testing Service, 2012), and was appropriate for social science based university students (Connelly et al., 2006): "Present your perspective on the issue below, using relevant reasons and/or examples to support your views: *'The media (e.g. books/film/music/television, for example) tend to create rather than reflect the values of society.* '" This prompt was read aloud to the participant and typed above the writing paper. All participants wrote in English.

Participants wrote their essay with an inking pen, on to lined paper that was placed on the surface of a digital writing tablet. On completion of the writing task, all students were given the opportunity to read over their writing and could make any amendments that they felt were necessary. Students made any changes with a different colour pen so that edits could be identified by the researcher.

Procedure

This study was approved by Oxford Brookes University Research Ethics Committee. Participants were tested individually by the first author, beginning with the selection measures and then the writing task. The writing task was recorded on a digital writing tablet (Wacom, Intuos 4) and analysed using Eye and Pen software (100Hz sampling frequency). The tablet angle could be adjusted to a comfortable writing position.

Data Analysis

Product measures. Spelling errors were counted from each composition. As a measure of productivity, the numbers of words written and crossed out were also counted, but does not include words added or deleted in the later revision stage. Prior to rating text quality, compositions were typed and spelling errors were corrected to eliminate scoring bias. The Wechsler Objective Language Dimensions (WOLD; Rust, 1996) analytical marking criteria were used, which comprises 6 sub-components: Ideas and development, Organisation and coherence, Vocabulary, Sentence structure, Grammar and usage, and Capitalisation and Punctuation. Each component is given a score between 1 and 4, generating a total raw score out of 24 (higher scores indicating better performance). This scoring scheme was chosen for the high level of inter-rater reliability reported in previous research across a wide age range, from adolescents to adults (e.g., Dockrell, Lindsay, Connelly & Mackie, 2007; Connelly et al., 2006). This was confirmed when inter-rater reliability was measured for 20% of the samples (randomly selected) and ranged from $\kappa = .72$ to .84 ($p < .001$) for the six component scores, while the Pearson's correlation for the overall raw score demonstrated an agreement of .94.

Process measures. Eye and Pen software enables the analysis of temporal characteristics of the written text. The tablet surface records the XY coordinates of the pen

position to a laptop. Time spent on the writing task was identified from the time when the pen first started to write until it was last lifted. Pauses were identified using a 30 milliseconds (ms) threshold (as used in Sumner et al., 2013), which is a baseline value set by the software according to the sampling frequency (Alamargot et al., 2006). A pause represents a period of inactivity, either off the paper (in-air) or when the pen is held stationary on the paper. Both these types of pauses were combined to provide an overall picture of the duration of time spent pausing while on task (in comparison to 'writing time' which represents physically writing on the paper). Mean pause duration and the overall number of pauses made were also calculated.

Execution speed (cm/s) is the physical distance covered by the pen divided by the time spent writing. Time spent pausing is excluded from the calculation and thus provides a clear indication of the speeded production of the motor processes required when handwriting.

Online revisions. Compositions were played back in real-time and, when observed, the type of revisions were recorded and sorted into the following six categories: Crossing out text, Adding in text, Correcting spelling, Improving legibility (i.e., going over handwriting), Punctuation and Capitalisation, and Correcting grammar (e.g., correcting tense, changing to the plural form). The number of correct spelling changes was also noted. Revisions were watched/coded by 2 raters and reliability for the revision categories ranged from $\kappa = .82$ to .87 ($p < .001$).

Post-transcription revisions. The number of revisions made in each category (i.e., changes to the text after the full text had been composed) were calculated. The same categorisation was used as above, but with the addition of: Inserting arrows to change the order of text. Identifying and coding post-transcript revisions that were clearly marked in a different colour pen was particularly easy and is reflected by the 100% inter-rater reliability.

Results

Table 2 presents product characteristics of the written text produced by the two groups. The word count includes all words, even those crossed out. Speed of productivity was calculated as the total number of words written per minute. For normally distributed data, independent samples t-tests revealed no significant group differences between students with dyslexia and the TD group on the measures of the overall writing time, $t(62) = -.14$, $p = .88$, $d = 0.04$, word count, $t(62) = -.78$, $p = .44$, $d = 0.28$, and words per minute, $t(62) = -1.12$ $p = .27$, $d = 0.15$.

{Insert Table 2 here}

For the two remaining measures in Table 2 that were not normally distributed, Mann-Whitney U tests revealed that students with dyslexia made significantly more spelling errors in their final texts than TD students, $U = 104.50$, $Z = -5.54$, $p < .001$, $d = 1.81$, but no group differences were found for the number of crossings out made, $U = 396.50$, $Z = -1.56$, $p = .12$, $d = 0.30$. In proportion to text length, 4% of the text produced by students with dyslexia contained spelling errors, in comparison to only .5% for the TD group.

Product Findings

Table 3 presents the WOLD quality ratings of the written compositions. Overall (raw score), the compositions of students with dyslexia were rated as significantly poorer than the TD students, $t(62) = -4.73$, $p < .001$, $d = 1.18$. To control for multiple comparisons of each WOLD component, the significance level was Bonferroni-corrected to .008. Only those measures that met this criteria are flagged in the table. Students with dyslexia were rated as significantly lower than their peers in Organisation and Coherence, $U = 298.00$, $Z = -3.12$, $p = .002$, $d = 0.69$, Sentence structure, $U = 256.00$, $Z = -3.91$, $p < .001$, $d = 0.88$, Grammar, $U =$

249.00, Z = -3.92, p < .001, d = 0.91, and Capitalisation and Punctuation, U = 248.50, Z = -3.87, p < .001, d = 0.91. However, there were no group differences in Vocabulary, U = 412.00, Z = -1.53, p = .13, d = 0.25, or Ideas and Development, U = 350.50, Z = -2.41, p = .02, d = 0.48 (albeit there is a trend towards significance for the latter).

{Insert Table 3 here}

Process Findings

Table 4 reports the temporal writing measures. Pause time was calculated as a percentage of overall time. Writing time represents only the time spent making a mark on the paper (excludes pause time). Execution speed (cm/s) also excludes pause time and examines the distance covered by the pen divided by the writing time. No significant group differences were found for any of the measures in Table 4: mean pause duration, t(62) = .13, p = .89, d = 0.04, total number of pauses, t(62) = -.77, p = .45, d = 0.19, pause time percentage, t(62) = 1.12, p = .26, d = 0.29, writing time percentage, t(62) = -1.15, p = .12, d = 0.18, or execution speed, t(62) = .39, p = .69, d = 0.10.

{Insert Table 4 here}

Revisions: Online and Post-Transcription

One student with dyslexia and two TD students did not make any online revisions. Of those that did revise their texts, no group differences (dyslexia: M = 9.87, SD 5.78; TD: M = 7.53, SD 5.21) were found for the mean number of online revisions made, t(59) = 1.64, p = .11, d = 0.31. In contrast, six students with dyslexia did not make any post-transcription revisions to their text, as well as 10 TD students. Again, of those students that did revise post-

transcription, no group differences (dyslexia: *M* = 8.65, *SD* 7.78; TD: *M* = 6.41, *SD* 6.56) were found in the number of revisions made, *U* = 224.00, *Z* = -1.29, *p* = .19, *d* = 0.31.

Table 5 details the types of online and post-transcription revisions made by both groups, shown as a frequency distribution across the various revision categories (each column amounting to 100%)[1]. Online + post-transcription frequencies for each group were compared statistically (the final column detailing the *p* values). Students with dyslexia made significantly more spelling revisions than the TD group, *U* = 308.00, *Z* = -2.84, *p* = .005, *d* = 0.65, suggesting an awareness of their spelling mistakes. However, all other group comparisons of revisions were non-significant (*p*s > .12). It is clear that, for both groups of students, crossing out text revisions were most common, and then adding text. However, comparisons from the word count composed on the tablet (shown in Table 2) to the final word count after the revisions actually made very little difference. In fact, as a whole, the mean number of words written by students with dyslexia and the TD group decreased by 5 words each. The data also suggest that students with dyslexia go back to add in punctuation more frequently than the TD group, although this was not significant.

{Insert Table 5 here}

Of the total number of spelling errors made by students with dyslexia (including those made initially and later corrected online or post-transcription) only 20% of the errors were corrected either online or post-transcription; meaning that 80% of spelling errors were not corrected. Moreover, when students with dyslexia did edit their spellings, 85% of the edits

[1] Of note, for the online revisions, there was no obvious pattern of stopping to make a revision at the end of the sentence being written (sentence-boundary). Revisions largely occurred mid-sentence (close to 90% of the revisions were made mid-sentence for both groups).

were made to the correct version of the spelling, indicating that even when students with dyslexia worked on a spelling error it was not always corrected properly. In contrast, 34% of the total spelling errors were corrected by the TD group either online or post-transcription and each time they were corrected properly. Typically a spelling error went unnoticed in the TD group (no attempt to revise 64% of errors made), although as seen in Table 2 their average number of errors was only 1.25 (SD 2.21).

Predictors of Writing Quality

The final stage was to determine the proportion of variance in writing quality accounted for by those variables where we noted significant group differences. WOLD overall score was the outcome measure in a regression analysis. Reading and spelling ability (WRAT-3), and the proportion of spelling revisions made, were entered as predictors in Step 1. The Group variable (Dyslexia *vs.* TD) was entered into Step 2. The regression results are shown in Table 6. The overall model was significant, $F(3, 59) = 8.19$, $p < .001$, and predicted 30% of the variance overall. Only spelling ability was a significant predictor (in Step 1) of writing quality. Including the group comparison at Step 2 did not result in a better model fit overall ($p = .08$) indicating that group differences no longer existed after accounting for the role of spelling ability on writing quality, thus suggesting any impact of group was already accounted for by the variables entered in the previous step (spelling ability).

{Insert Table 6 here}

Discussion

This study provides a novel contribution to the literature by examining both product and process characteristics of writing, as well as the types of revisions made during and after

transcription. In doing so, we gain insight into the transcription process for students with and without dyslexia and the higher-level self-regulating behaviour of reviewing written compositions, both of which have been shown to be important components of the writing process (Hayes, 2012; Olive, 2014).

As expected, students with dyslexia made a higher proportion of spelling errors within their text than the TD group (Connelly et al., 2006, Galbraith et al., 2012; Tops et al., 2013). Further supporting existing studies, compared to their age-matched peers, and after correcting for spelling errors, the written texts composed by students with dyslexia were rated as lower in quality and text quality was predicted by spelling ability. Consideration of the WOLD subcomponents revealed that students with dyslexia and their age-peers actually performed similarly on the ratings of vocabulary, but below their peers on the assessment of organisation/coherence, punctuation, grammar, and sentence structure, and a trend towards significance was noted when comparing the two groups on the ideas and development rating. Another study on adolescents with writing difficulties (Dockrell et al., 2007) found that the WOLD ideas and vocabulary components load on to the same factor in a factor analysis, which they interpreted as relating to semantics/meaning of the text, while the remaining components were related and classed as rule-based factors of written language. This fits nicely with our data, as reliable group differences were found to suggest that students with dyslexia have difficulty with the rule-based factors and not with written vocabulary (relating to semantics). However, as noted above, it is unclear whether the semantic aspects of developing ideas in writing is an area of difficulty for students with dyslexia and this could be usefully investigated further with larger samples.

In contrast to child studies (Sumner et al., 2013), overall lower quality ratings cannot be attributed to less text being produced, less time spent on the task, or more time spent pausing and not ‘text-making’. Students with dyslexia wrote a similar amount of text to their

peers - a finding also found by Galbraith et al. (2012) - and, interestingly, these groups were comparable on handwriting execution, pause time and the number of pauses made. This pattern of results suggests that the spelling problems of university students with dyslexia do not hinder the transcription process (fluency of handwriting/writing). Moreover, spelling difficulties do not appear to influence students' ability to self-regulate the executive process of reviewing/revising text. Students with dyslexia engaged in the reviewing process during and after transcription a similar amount to those without dyslexia. However, students with dyslexia did spend a higher proportion of their revisions on correcting spellings, in comparison to their peers; although 80% of spelling errors were still not identified.

Although our initial predictions about spelling ability directly constraining the resources available for the transcription and revision processes do not appear to be fully confirmed, it may be that the influence of spelling ability on working memory and executive resources happens in a more indirect way since spelling ability predicts writing quality. Given the lower quality ratings, it is clear that students with dyslexia have more to respond to/revise and, although they revise a similar amount to the control group, they may not have the resources to identify all of the sections that need working on, and to correct them appropriately, and so more difficulties with organisation/coherence, punctuation, grammar, and sentence structure remain. Additionally, as suggested by Torrance et al. (2016), lower quality ratings in adulthood may be partly attributed to poorer knowledge of written language conventions, as a result of less reading exposure over the years. It is also likely that students with dyslexia will have had less writing practice. This may, in part, explain why students with dyslexia demonstrated a specific difficulty with rule-based aspects of writing: having limited text exposure linking to an underdeveloped awareness of how to use written language, even though they can use their verbal skills to compensate in other ways (idea generation and vocabulary).

Limitations of the present study should be addressed. Although comparable to existing studies, the sample may be considered small and was taken from one university. Furthermore, it is recognised that students with dyslexia in the present sample are considered 'high-functioning' in comparison to the wider population of adults with dyslexia (Mapou, 2008). They may have developed other compensatory strategies to writing, given that they are often required to submit written coursework, including choosing to return to errors after production ceases, but with a higher likelihood that they will miss the errors (Van Waes, Leijten & Quinlan, 2010). In addition, many students now use word processors where spelling errors are highlighted and so pausing performance in the present handwritten study may be related to the lack of awareness of every spelling error being produced. Students with dyslexia report that a spell check error notification causes them to pause more than other writers (O'Rourke, Connelly & Barnett, 2017). Moreover, allowances are now made in Higher Education when students with dyslexia make spelling errors in assignments (Conway & Turner, 2011), which may add to students not registering these mistakes. Future research considering compositions that have been typed by UK students with and without dyslexia would be an interesting comparison to the present data. In addition, relating to the present writing measure, reliability measures were unfortunately not available for the writing prompt, as it was not a standardised assessment. However, other researchers have used prompts from the GRE database with similar populations (Connelly et al., 2006) and inter-rater reliability for the scoring of the product and process measures was considered.

Although beyond the scope of the present paper, other research could examine revision strategies in more detail by either coupling handwriting (or keyboarding) recordings/analysis with eye tracking or think-aloud protocols to explore the cognitive strategies that students are using when reviewing their work; or investigating whether students with dyslexia are effective at proofreading written texts to determine whether they

can identify and correct rule-based errors (sentence structure, punctuation and grammar). Further, examination of executive functions in students with dyslexia and the link to self-regulatory behaviour when writing could also be explored.

Practical implications that can be raised from the present findings point towards support still being required in spelling for university students with dyslexia, as well as writing more generally (i.e., organisation/coherence, punctuation, grammar and sentence structure). Less of a focus is given to teaching the mechanics of writing in secondary and further education (Kiuhara, Graham, & Hawken, 2009), but students with dyslexia are being shown to require such support (as found here and in Connelly et al., 2006). Furthermore, instruction directed towards revision strategies may also prove useful for this group; yet further research is needed in this area to determine how this may be targeted.

In summary, students with dyslexia compose handwritten texts that, overall, are rated as poorer quality (demonstrating a difficulty with rule-based conventions of writing) and contain a higher proportion of spelling errors than their peers. However, they demonstrate a similar temporal profile to their peers and adopt similar revision strategies, aside from correcting spelling more. It may be that students with dyslexia need to dedicate time to reviewing punctuation, grammar and the organisation of their texts, as these are the areas that they performed worse on in comparison to their peers. Poorer quality written text may be a product of less exposure to print or less writing practice in students with dyslexia. Further research is warranted to determine the factors that constrain written text quality in this population, especially given that written assessments form a large part of university assessment.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (DSM, 5th ed.). Arlington, VA: American Psychiatric Association.

Alamargot, D., Chesnet, D., Dansac, C., & Ros, C. (2006). Eye and Pen: A new device for studying reading during writing. *Behaviour Research Methods, 38*(2), 287-299. doi.org/10.3758/BF03192780

Berninger, V. W., & Swanson, H. L. (1994). Modifying Hayes and Flower's model of skilled writing. In E. Butterfield (Ed.), *Children's Writing; Toward a Process Theory of Development of Skilled Writing* (pp. 57-81). Greenwich, CT: JAI Press.

Bogdanowisc, K. M., Lockiewicz, M., Bogdanowicz, M., & Pachalska, M. (2014). Characteristics of cognitive deficits and writing skills of Polish adults with developmental dyslexia. *International Journal of Psychophysiology, 93*, 78-83. doi.org/10.1016/j.ijpsycho.2013.03.005

Chenoweth, A., & Hayes, J. (2001). Fluency in writing: Generating text in L1 and L2. *Written Communication, 18*, 80-90. doi.org/10.1177/0741088301018001004

Coleman, C., Gregg, N., McLain, L., & Bellair, L. W. (2009). A comparison of spelling performance across young adults with and without dyslexia. *Assessment for Effective Intervention, 34*, 94-105. doi.org/10.1177/1534508408318808

Connelly, V., Campbell, S., MacLean, M., & Barnes, J. (2006). Contribution of lower order skills to the written composition of older students with and without dyslexia. *Developmental Neuropsychology, 29*, 175-196. doi.org/10.1207/s15326942dn2901_9

Conway, J., & Turner, J. (2011). Guidance for good practice: Institutional marking practice for dyslexic students. Association of Dyslexia Specialist in Higher Education. UK.

Dockrell, J. E., Lindsay, G., Connelly, V., & Mackie, C. (2007). Constraints in the production of written text in children with specific language impairments. *Exceptional Children, 73*, 147-164. doi.org/10.1177/001440290707300202

Educational Testing Service. (2012). The GRE Analytical Writing Measure. Retrieved from https://www.ets.org/

Galbraith, D., Baaijen, V., Smith-Spark, J., & Torrance, M. (2012). The effects of dyslexia on the writing processes of students in higher education. In M. Torrance, D. Alamargot, M. Castello, F. Ganier, O. Kruse, A. Mangen, L. Tolchinsky, & L. van Waes (Eds)., *Learning to write effectively: Current trends in European research* (pp. 195-198). Bingley, UK: Emerald Group Publishing. doi: 10.1163/9781780529295_044

Gregg, N., Coleman, C., Davis, M., & Chalk, J. C. (2007). Timed essay writing: Implications for high-stakes tests. *Journal of Learning Disabilities, 40*, 306-318. doi.org/10.1177/00222194070400040201

Hatcher, J., Snowling, M.J., & Griffiths, Y.M. (2002). Cognitive assessment of dyslexic students in higher education. *British Journal of Educational Psychology. 72*, 119-133. doi.org/10.1348/000709902158801

Hayes, J. R. (2012). Modelling and remodelling writing. *Written Communication, 29*, 369-388. doi.org/10.1177/0741088312451260

Higher Education Statistics Authority. (2016). Students in Higher Education 2015/16. Retrieved from https://www.hesa.ac.uk/

Kiuhara, S., Graham, S., & Hawken, L. (2009). Teaching writing to high school students: A national survey. *Journal of Educational Psychology, 101*, 136–160. doi:10.1037/a0013097

Mapou, R.L. (2008). Comprehensive evaluation of adults with learning disabilities. In L.E. Wolf, H.E. Schreiber, & J. Wasserstein (Eds.), *Adult learning disorders:*

Contemporary issues. (pp. 248-273). Hove, NY: Psychology Press, Taylor & Francis Group.

Mortimore, T., & Crozier, W. R. (2006). Dyslexia and difficulties with study skills in higher education. *Studies in Higher Education, 31,* 235-251. doi.org/10.1080/03075070600572173

Olive, T. (2014). Toward an incremental and cascading model of writing: a review of research on writing processes coordination. *Journal of Writing Research, 6,* 173-194. doi: 10.17239/jowr-2014.06.02.4

O'Rourke, L., Connelly, V., & Barnett, A.L. (2017). *Investigating the impact of spellcheck on text production for writers with and without dyslexia.* Paper presented at Writing Research Across Borders (WRAB) IV. Bogota, Columbia.

Peterson, R. L., & Pennington, B. F. (2012). Developmental dyslexia. *The Lancet, 379,* 1997-2007. doi.org/10.1016/S0140-6736(12)60198-6

Richardson, J. T. E., & Wydell, T. N. (2003). The representation and attainment of students with dyslexia in UK higher education. *Reading and Writing: An Interdisciplinary Journal, 16,* 475-503. doi.org/10.1023/A:1024261927214

Rust, J. (1996). The Manual of the Wechsler Objective Language Dimensions (WOLD) UK edition. London: The Psychological Corporation.

Schmalz, X., Marinus, E., Coltheart, M., & Castles, A. (2015). Getting to the bottom of orthographic depth. *Psychonomic Bulletin and Review, 22,* 1614-1629. doi.org/10.3758/s13423-015-0835-2

Shanahan, T. (2016). Relationships between reading and writing development. In C. A. MacArthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of Writing Research*. New York, USA: The Guilford Press.

Sumner, E., Connelly, V., & Barnett, A. L. (2013). Children with dyslexia are slow writers

because they pause more often and not because they are slow at handwriting execution. *Reading and Writing, 26*, 991-1008. doi.org/10.1007/s11145-012-9403-6

Sumner, E., Connelly, V., & Barnett, A. L. (2014). The influence of spelling ability on handwriting production: children with and without dyslexia. *Journal of Experimental Psychology: Learning, Memory and Cognition, 40*, 1441-1447. doi: 10.1037/a0035785.

Sterling, C., Farmer, M., Riddick, B., Morgan, S., & Matthews, C. (1998). Adult dyslexic writing. *Dyslexia, 4*, 1-15. doi: 10.1002/(SICI)1099-0909(199803)4:1<1::AID-DYS87>3.0.CO;2-F.

Tops, W., Callens, C., van Cauwenberghe, E., Adriaens, J., & Brysbaert, M. (2013). Beyond spelling: The writing skills of students with dyslexia in higher education. *Reading and Writing, 26*(5), 705-720. doi.org/10.1007/s11145-012-9387-2

Torgesen, J. K., Wagner, R. K., & Rashotte C. A. (1999). *Test of Word Reading Efficiency*. Austin, TX: PRO-ED Publishing, Inc.

Torrance, M., Rønneberg, V., Johansson, C., & Uppstad, P. H. (2016). Adolescent weak decoders writing in a shallow orthography: process and product. *Scientific Studies of Reading, 20*, 375-388. doi.org/10.1080/10888438.2016.1205071

Van Waes, L., Leijten, M., & Quinlan, T. (2010). Reading during sentence composing and error correction: A multilevel analysis of the influences of task complexity. *Reading and Writing,* 23, 803–834. doi.org/10.1007/s11145-009-9190-x

Wechsler, D. (1997). *Wechsler Adult Intelligence Scale-3, UK edition.* San Antonio, TX: The Psychological Corporation.

Wengelin, A. (2007). The word-level focus in text production by adults with reading and writing difficulties. In Gert Rijlaarsdam (Ed.) *Writing and cognition: Research and*

applications (Studies in Writing, Vol 20, pp. 68-82). Amsterdam, Netherlands: Elsevier.

Wilkinson, G. S. (1993). *Wide Range Achievement Test (3rd ed).* Wilmington, DE: Wide Range Inc.

Table 1.

Means (M) and Standard Deviations (SD) for Scores Obtained on the Background Measures by Students with and without Dyslexia

Background measures	**Dyslexia** (*n* = 32) M (SD)	**TD** (*n* = 32) M (SD)	***F***	***df***	***p***
Age					
years; months	20;0 (1.82)	19;8 (1.68)	.36	1,62	.55
Nonverbal[a]					
Scaled	10.44 (2.04)	11.23 (2.20)	2.52	1,62	.12
Verbal ability[a]					
Scaled	10.28 (1.92)	10.19 (1.71)	.61	1,62	.44
Reading[b]					
Standard	99.77 (11.72)	113.46 (4.97)	36.86	1,62	<.001
Spelling[b]					
Standard**	92.94 (9.87)	109.34 (5.52)	67.41	1,62	<.001
Reading fluency[c]					
Standard**	82.78 (10.87)	98.34 (11.02)	32.35	1,62	<.001
Nonword fluency[c]					
Standard**	82.25 (12.72)	105.41 (12.44)	54.21	1,62	<.001

Note. [a]Nonverbal (Matrices), verbal (Similarities) scaled scores *M* 10 *SD* 3 (WAIS-III; Wechsler, 1997). [b]Reading, spelling (both WRAT-3; Wilkinson, 1993), [c]reading fluency measures (TOWRE; Torgesen, Wagner, & Rashotte, 1999) standard scores *M* 100 *SD* 15.

*p <.05, **p <.001

Table 2.

Means (M) and Standard Deviations (SD) for Scores Obtained on the Writing Product Measures

Productivity	**Dyslexia** (*n* = 32) M (SD)	**TD** (*n* = 32) M (SD)	***p***
Writing time (mins)	15.20 (3.70)	15.34 (3.35)	.88
Word count	279.75 (89.39)	297.93 (96.22)	.44
Words per min	18.56 (4.55)	19.78 (4.01)	.27
Number of spelling errors**	9.56 (8.30)	1.25 (2.21)	<.001
Number of crossings out	5.03 (5.06)	3.93 (4.59)	.12

Note. Word count = all words written on the digital tablet. Words per min = word count/writing time. *$p < .05$, **$p < .001$

Table 3.

Means (M) and Standard Deviations (SD) for Scores Obtained on the WOLD Writing Quality Ratings

Text quality	**Dyslexia** (*n* = 32) M (SD)	**TD** (*n* = 32) M (SD)	***p***
WOLD raw[a]*	17.03 (2.66)	19.18 (2.68)	< .001
Ideas & development	2.78 (.71)	3.08 (.59)	.02
Organisation & coherence*	2.41 (.66)	2.97 (.69)	.002
Vocabulary	3.00 (.67)	3.25 (.56)	.13
Sentence Structure*	2.66 (.61)	3.28 (.52)	< .001
Grammar and usage*	2.59 (.61)	3.25 (.57)	< .001
Capitalisation & Punctuation *	2.53 (.72)	3.22 (.55)	< .001

Note. [a]Writing scoring criteria (WOLD; Rust, 1996). Raw score out of 24; each component out of 4. *Bonferroni-corrected significance, $p < .008$. TD = typically developing group.

Table 4.

Means (M) and Standard Deviations (SD) for Scores Obtained on the Writing Process Measures

	Dyslexia (*n* = 32)	**TD** (*n* = 32)	
Temporal performance	M (SD)	M (SD)	***p***
Mean pause duration (ms)	707.02 (391.25)	692.61 (403.93)	.89
Total number of pauses	897.06 (601.06)	1016.06 (639.22)	.45
Pause time (mins)	7.95 (2.25)	7.53 (2.21)	.46
Pause %	53%	49%	.26
Writing time (mins)	7.17 (2.09)	7.83 (2.63)	.28
Writing %	47%	51%	.12
Execution Speed (cm/s)	3.67 (.95)	3.58 (.91)	.39

Note. ms = milliseconds. TD = typically developing group.

Table 5.

Frequency Distribution of Revisions made by Students with and without Dyslexia

	Dyslexia		**TD**		
Revision type	*Online*	*Post-transcript*	*Online*	*Post-transcript*	*p*
Correcting spelling*	10%	26%	6%	14%	.005
Crossing out text	48%	19%	52%	19%	.84
Adding in text	8%	25%	6%	40%	.53
Punctuation	17%	13%	9%	10%	.12
Legibility	13%	11%	23%	9%	.75
Correcting grammar	4%	5%	4%	7%	.58
Inserting arrows	--	1%	--	1%	.96

Note. Number of students making online revisions, D = 31, TD = 30; and post-transcription revisions, D = 26, TD = 22. *p* values – revisions (online + post-transcription) combined; **p* <.05. TD = typically developing group.

Table 6.

Regression Analysis: Results Predicting Writing Quality

	β	t	R^2	ΔR^2	*p*
Step 1			.25	.21	.001
Reading ability[a]	.12	.86			.39
Spelling ability[a]	.42	2.84			.006
Spelling revisions[b]	.03	.19			.85
Step 2			.30	.24	.08
Reading ability[a]	.03	.21			.84
Spelling ability[a]	.27	1.57			.12
Spelling revisions[b]	.05	.41			.68
Group (D *vs.* TD)	.31	1.82			.08

Note. [a]Reading, spelling (both WRAT-3; Wilkinson, 1993). [b] Taken from the writing task (GRE; Educational Testing Service, 2012). D = Dyslexia group; TD = Typically-developing group. TD = typically developing group. Standardised coefficients and t-values are shown. ΔR^2 represents the change in R^2 with the addition of Step 2 (the Group variable).