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III: COLLEGE STUDENTS

Contribution of Lower Order Skills to the Written Composition of College Students With and Without Dyslexia

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There has been a growth in students with dyslexia attending university. These students commonly rate writing as one of their greatest problem areas. Our research set out to describe the effects of dyslexia on the writing skills of students compared to age-matched peers and a spelling-skill-matched group. Generally, the texts of the students with dyslexia were poorer than age controls but not poorer than the spelling-skill controls. However, there were no major differences in "higher order" skills such as ideas and organization with the chronological age controls, only in "lower order" transcription skills such as spelling and handwriting fluency. The students with dyslexia made more spelling errors in their essays than one would predict given their dictated spelling skills.

There has been a resurgence of research into the reading skills of adults with dyslexia and university students with dyslexia in particular (see Rice, 2004, for a review). This research has shown that university students with dyslexia continue to have problems with the phonological aspects of reading and spelling. Recent research has been very successful at identifying likely causes and potential remedies for the reading problems of these students at all ages. Yet it has always been known that reading levels in undergraduates with dyslexia are higher than expected, despite their disability, because reading is a process open to compensatory or alterna-

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tive strategy use (Bruck, 1992). Writing is a much more difficult skill, as it involves production as well as processing of print. However, there has been little research into the writing skills of students with dyslexia at university, and so considerably less is known about the effects this disability on writing. This is despite the belief of students with dyslexia and their tutors that writing, not reading, is in fact their biggest problem at university (Hatcher, Snowling, & Griffiths, 2002; Riddick, Farmer, & Sterling, 1997; Singleton, 1999).

All universities now have much larger populations of students with dyslexia than a few years ago. This success is due to more accurate identification and effective support from schools prior to entering higher education. However, academic support for these undergraduates once at university is patchy, and practice is not usually based on a reliable research corpus (Singleton, 1999). As a consequence, these students do consistently less well than other undergraduates (Richardson & Wydell, 2003; Singleton, 1999). Writing forms a major part of student assessment, so there is a dire need for basic research into the interactions between dyslexia and writing.

In this study we examine the written language skills of a cohort of students with dyslexia; we investigate the relationship between their writing skills, other literacy skills, and their working memory, and we examine the extent to which their written language performance can offer a wider understanding of the problems experienced by these students compared to controls.

Writing is a complex skill involving a number of linguistic and nonlinguistic processes. Much of our understanding of the writing process has been based on the model developed by Hayes and Flower (Hayes, 1996; Hayes & Flower, 1980). In this model, the skilled writer is conceptualized as using the three recursive skills of translation, planning, and reviewing to produce text. The model was derived from work with adults and therefore does not address how adults become good writers. Berninger and colleagues in the United States have adapted the model to address the developmental processes of how children learn to write (Berninger & Swanson, 1994). More recently Berninger et al. (2002) proposed the "simple view of writing, " according to which transcription and executive functions are the foundational base that contributes to text generation within a working memory environment. Transcription consists of handwriting and spelling skill, whereas executive functions include planning, monitoring, reviewing, revising, organizing, and attending. Research on the role of transcription has only recently become prevalent when studying children's writing and has been sadly neglected in adult research on writing.

There are a number of reasons to predict that people with dyslexia would experience difficulties with writing, and transcription skills specifically. Poor spelling skill is one of the continuing primary problems of students with dyslexia (Rice, 2004). Spelling as we have pointed out is one of the key components of transcrip-

tion skill in writing. A second key component involved in transcription is handwriting fluency (Berninger, 1999). There is mixed evidence that children with dyslexia have slower handwriting fluency than controls (Martlew, 1992; Scott, 1999). However, a recent study by Hatcher, Snowling, and Griffiths (2002) showed that their sample of university students with dyslexia copied text more slowly than chronological-age controls.

Therefore, it is likely that any sample of students with dyslexia will show impairments in transcription skills. This is likely to have an impact on the number of words produced in a text and the number of spelling errors contained within it. It may also have an effect on aspects related to spelling such as punctuation and capitalization. It is open to question whether a deficit in transcription will lead to problems with other, higher order aspects of writing. There is evidence from work on children's writing development that transcription skills account for a large portion of the variance in overall compositional quality scores (see Berninger, 1999, for a review). However, this influence of transcription may fall away in adults.

A recent study found that exam essay writing was constrained by handwriting fluency in a sample of undergraduate students who were slow handwriters (Connelly, Dockrell, & Barnett, 2005). The undergraduate sample was as fast as typical 11-year-olds at handwriting. The portion of variance of overall essay quality for an exam essay accounted for by handwriting fluency in this sample was typical of 11-year-old writers (40%). Therefore, there is some evidence that writing in adults can be constrained by slow handwriting as in children.

It has been shown that students with dyslexia have smaller than expected reading vocabularies (Hanley, 1997). Reading experience assists the development of a wide-ranging vocabulary. The reduced vocabulary of individuals with dyslexia may impact directly on written outputs. More advanced writing is associated with a greater lexical diversity (Beard, 1986). Thus, a more limited writing vocabulary is likely to influence both the length and content of the written texts of students with dyslexia.

It is a well-documented finding that students with dyslexia typically show lower levels of performance on working-memory tasks (Baddeley, 1986). Primarily these differences have been found in tasks measuring phonological working memory. Controversy exists over inconsistent differences found in visual working-memory tasks in participants with dyslexia (Witruk, 2003). The development of writing skill is clearly tied to working-memory capacity. Therefore, the high cognitive demands placed on the individual in creating written text may overload a language system that is reduced in processing capacity. Such difficulties would lead to reduced length of texts and higher levels of errors than in others of a similar age.

There have been a number of studies on the writing skills of children with reading disabilities (see McCutchen, 1995, and Scott, 1999, for a review). These stud-

ies have confirmed that children with dyslexia are indeed poorer at producing text than age-matched peers. Texts produced are generally shorter, are less complex, have poorer grammatical structure, and contain more spelling and punctuation errors. This all conforms to the predicted pattern of writing skills we have just outlined.

Therefore, we might expect this pattern of difficulties with writing to continue into adulthood. However, most of the studies previously carried out only used chronological-age control groups to compare to the children with dyslexia. It is unclear if the difficulties faced in writing by the children with dyslexia were actually beyond what we may expect given the children's depressed reading and spelling skills. There is also the complication that most work in the United States contains samples of children defined as learning disabled. Although the vast majority of these children may well have dyslexia (Scott, 1999), some will not, and this may have implications for the generalization of results.

There have been very few studies examining the writing skills of university students with dyslexia. One recent study (Sterling, Farmer, Riddick, Morgan, & Matthews, 1997) found that students with dyslexia produced more spelling errors in their texts than controls. They also produced fewer words overall and were more limited in their choice of words. For example, they produced lower numbers of words that had more than three syllables. This was taken as evidence for more limited vocabulary in the students with dyslexia. The overall quality of the text though was not impaired in comparison to the controls. Differences were limited to spelling, words produced, and vocabulary range. However, the Sterling et al. (1997) study analyzed a free narrative task on an undemanding topic. The students were asked to write about their lives as a student. The students also had a writing frame that provided prompts for information they should include in their writing. This undemanding task with additional writing support may not have served to highlight potential differences in essay construction or organisation. Sterling et al. (1997) acknowledged that their results should be treated with caution when making assumptions about academic performance.

Therefore, we decided to examine the writing skills of university students with dyslexia by giving them a more ecologically valid and more demanding writing task. We also compared the students with dyslexia to two control groups. One was a chronological-age control and the other a spelling-skill control group. Because spelling is one of the key problems of students with dyslexia and spelling is such a key part of the transcription process, we considered it useful to match on this skill. This will provide a more informative comparison and allow us to determine if writing skill is poorer than expected given the spelling skills of students with dyslexia.

A measure of handwriting fluency was administered to all participants so that we had information on the other aspect of translation skill aside from spelling. Our

design also included controls for working-memory deficits in the form of a phonological working-memory test and measures involving both processing and storage in both the verbal and visuo-spatial domains. Given the selection of spelling skill as a matching variable, it was important to include other literacy measures, and in particular measures of reading ability, to permit us to control for these differences between groups.

PREDICTIONS FOR DIFFERENCES BETWEEN STUDENTS WITH DYSLEXIA AND AGE-MATCHED PEERS IN WRITING AND RELATED MEASURES

Given previous evidence, we predict that students with dyslexia would produce texts that have fewer words overall, have less lexical diversity, and contain more spelling errors than a group of age-matched peers. There will be a deficiency in lower level skills such as spelling and handwriting fluency, and this will have an impact on the overall quality of the written product compared to age-matched peers.

PREDICTIONS FOR DIFFERENCES BETWEEN STUDENTS WITH DYSLEXIA AND SPELLING-SKILL MATCHED PEERS IN WRITING AND RELATED MEASURES

We do not predict that the overall quality of writing produced by dyslexic students at university should be less than that displayed by a control group matched on spelling skills. Therefore, there should be no difference in words produced, lexical diversity, or spelling errors in the texts of the spelling-skill-matched group.

PREDICTIONS FOR VARIABLES INFLUENCING OVERALL WRITING QUALITY IN STUDENTS WITH AND WITHOUT DYSLEXIA

We predict that handwriting fluency, word reading, working memory, and lexical diversity will contribute to the overall writing quality of students with and without dyslexia.

PREDICTIONS FOR DIFFERENCES BETWEEN STUDENTS WITH DYSLEXIA AND BOTH COMPARISON GROUPS IN PARTICULAR ASPECTS OF ESSAY QUALITY

We plan to analyze the essays produced by students in both higher order skills, such as organization and coherence, and lower order skills, such as spelling and punctuation. We predict that analyzing essays in depth would show that the higher order aspects of writing will be less affected by a diagnosis of dyslexia as skills in these areas are more remotely related to specific literacy levels. There should be no difference between the writing of students with dyslexia in these areas and the writing of chronological-age peers.

METHOD

Participants

Table 1 shows the chronological age and the spelling performance of the dyslexic and control groups. The dyslexic group was matched to the chronological-age group and did not differ in spelling performance from the spelling-skill control group.

Dyslexic group. There were 21 adults with dyslexia. These were all students at Oxford Brookes University. There were 3 men and 18 women. The university requires that all students either receive a dyslexia assessment at university or have been formally assessed as an adult from age 16 on. The process of confirming diagnosis at the university involves a formal assessment of IQ and literacy ability by an educational psychologist. The assessment of dyslexia is confirmed if the educa-

TABLE 1
Chronological Age and Spelling Performance by Groups

	Group					
	Dyslexic[a]		*CA Match*[b]		*SS Match*[c]	
Matching Variables	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age in years	25.71	10.90	26.00	10.61	18.37	6.80
Spelling raw score (WRAT–3)	42.05	3.85	48.90	2.40	43.74	4.15
Spelling standard score (standardized for age)	101	8.1	117.6	5.1	122.2	14.2

Note. CA = chronological age; SS = spelling skill; WRAT–3 = Wide Range Achievement Test–Third Edition.

[a]$n = 21$. [b]$n = 20$. [c]$n = 19$.

tional psychologist reports a discrepancy between IQ and literacy measures. These criteria are in line with the recommendations of the 'Report of the National Working Party on Dyslexia in Higher Education.' in the United Kingdom (Singleton, 1999). The average age of this assessment for our group of students was 19 years. All of the students had English as their first language.

We did not have time in this study to carry out a full IQ test on the participants. However, as all our participants had been diagnosed using the criteria just set out, we were satisfied that a discrepancy between IQ and literacy skill had been established. A random anonymous sample of data from 53 dyslexic students at the university was made available to us for research purposes (representing about 10% of the dyslexic population at the university). This showed a mean IQ score on the full Wechsler Adult Intelligence Scale–Third Edition (WAIS–III) of 110 and a mean standard score on the Wide Range Achievement Test–Third Edition (WRAT–3; Wilkinson, 1993) word reading of 100 and a score of 101 for WRAT–3 spelling. There were no differences between men and women in this sample, and the WRAT–3 spelling standard score exactly matched our sample in this study. Therefore, we were satisfied that our sample of students had been formally identified as dyslexic by the university and that our sample was typical of the population of students with dyslexia at the university.

The university has a number of support measures in place for students with dyslexia. Students are registered for exam provision, whereby extra time is given in exams at the university. Other exam help (scribes, etc.) are available if required. Students can also sign up for individual sessions with dyslexia-support tutors to discuss university work. The sign-up rate for this across the university is low, and there is no formal record of its effectiveness. Therefore, it was not taken into account in our participant discussions. No other literacy interventions were mentioned by participants as having had a major impact on their work at university or prior to starting at university.

Chronological-age control group. There were 20 adults in this sample. All were students at Oxford Brookes University in the United Kingdom. There were 6 men and 14 women. All spoke English as a first language and had no known cognitive or linguistic deficits.

Spelling-skill control group. There were 19 participants in this sample, 9 males and 10 females. To ensure a valid match with the wide range of dyslexic spelling skills displayed, the sample varied in age from 11 to 31 and had a mean chronological age of 18. All spoke English as a first language and had no known cognitive or linguistic deficits.

Spelling skill. Spelling was assessed using the WRAT–3 (Wilkinson, 1993) single word-spelling task. The task was administered according to the procedures

laid out in the manual and is suitable for children from age 8 up to adulthood. A graded series of words were spoken out to the participant, who had to write down each word as accurately as he or she could. The raw score was the number of words correctly spelled. The raw spelling scores are shown in Table 1 for each group. Raw scores were used as we were interested in absolute spelling skill, and the WRAT–3 standard scores are based on age banding and so did not provide an appropriate comparison.

Matching the groups. The sample comprising students with dyslexia was identified and tested. Subsequently volunteers coming forward from the university student population were individually matched on age until a comparison group was complete. The spelling-skill-matched group was drawn from the university student population and a local school. Parents of school children were contacted by letter and gave permission. The spelling-skill group members were individually matched on WRAT–3 raw scores until the comparison group was complete.

An analysis of variance (ANOVA) showed that there was a significant difference in age across the three groups, $F(2, 57) = 3.89$, $p < .05$. Post hoc testing showed that the spelling-skill-matched group members were significantly younger than either the students with dyslexia group or the chronological-age-matched group. There was no significant difference in age between the students with dyslexia and the chronological-age control group.

An ANOVA also showed that there was a significant difference in spelling skill across the three groups, $F(2, 57) = 20.55$, $p < .001$. Post hoc testing showed that the chronological-age-matched group was significantly better at spelling than were the students with dyslexia group and the spelling skill match group. There was no significant difference in spelling skill between the students with dyslexia and the spelling-skill-matched group.

Tasks and Procedures

The writing task. Participants were given 30 min in which to write an essay. They wrote on lined white paper by hand using an inking pen. The task was to produce an essay in 30 min to a written prompt. The following instructions were presented to the students: "Present your perspective on the issue below, using relevant reasons and/or examples to support your views." The written prompt was as follows: "It is often necessary, even desirable, for political leaders to withhold information from the public". The prompt was read out by the experimenter for all participants in order to ensure they understood it correctly.

The prompt itself was taken from the issued topics for the Graduate Record Examinations (GRE) General Test, Analytical Writing Measure (Educational Testing Service, 2004). This is an exam currently used in the United States for the basis of graduate entry. As such it was deemed to provide a challenging topic for adults, but

one that did not require too much specialist knowledge. The topics have all been piloted as suitable, and a good body of published research is available on the validity and reliability of the topic prompts (Schaeffer, Briel, & Fowles, 2001).

Other Literacy-Related Measures

Reading task. Each participant completed the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999). The TOWRE is a speeded test of single-word (sight word efficiency) and nonword reading (phonemic decoding efficiency) for individuals from ages 6 to adulthood. The test was administered according the procedures in the manual. Each participant had to read a card with single words as quickly as they could in 45 sec. This was followed by a 45-sec period of the participant reading a card with nonwords as quickly as he or she could. Scores were given for each word or nonword read accurately in the time period.

Handwriting fluency task (based on Berninger, Mizokawa, & Bragg, 1991). This task involves the participant writing out the letters of the alphabet, in lowercase and in order, as quickly as possible in 1 min. Letters are only counted toward a total amount of letters per minute if the letters are in the correct order and legible. A letter is classed as legible if, in the marker's opinion, it would have been recognizable alone on the page, without cues from other letters in a word to help identify it. This task has been shown to have a very high interrater reliability (r = .97; Berninger et al., 1997). The task has also been used and cited in many large-scale handwriting studies on handwriting fluency (See Berninger, 1999, for a review) and has psychometric information available on test development and links to other writing skills.

Working-memory tasks. Three memory-span tasks assessed phonological short-term memory. One task was a simple working-memory task (forward digit span) and the other two were complex working-memory tests with a processing requirement calling for central executive resources on top of short-term storage (backward digit span and listening span). Forward and backward digit span were assessed using the relevant subtest from the Wechsler Memory Scale (Weschler & Stone, 1973). Both tests were administered according to the instructions in the manual, and raw scores were used to allow for individuals ages 16 and younger.

The listening span task was an adaptation of the classic Daneman and Carpenter (1980) task taken from Leather and Henry (1994) and involving listening rather than reading span. The test was selected as free of reading-related constraints and having high reliability. Participants heard short sentences that could be either true or false (e.g., "children go to school" or "grass grows in the house"). Sentences were presented in groups of one to four; the participant was asked to listen to each sentence, say whether it was true or false, and then recall the last word from each of

the sentences. The span score was the longest list length at which two trials were passed, plus an extra half-point credit if one list at the next list length was correctly recalled.

Visuo-spatial memory was assessed by the visual-sequential span test taken from the Tests of Memory and Learning (Reynolds & Bigler, 1994) and administered according to the manual.

Writing assessment. The essays produced by the participants were assessed using a standardized procedure from the Weschler Objective Language Dimensions (WOLD) written expression subscale (Rust, 1996). The WOLD was chosen so that aspects of text generation such as vocabulary use, ideas and development as well as spelling, grammar and punctuation could all be examined.

A holistic score with a maximum score of 6 is given to the overall quality of the essays, and a further set of 6 analytical scores was also produced. The analytic procedure obtains ratings in the following areas: ideas and development; organization, unity and coherence, vocabulary, sentence structure, and variety; grammar and usage; and capitalization and punctuation. There was a maximum possible score of 4 for each analytic element.

The scoring scheme for the GRE analytic writing was not used because this has a deliberate bias toward higher order skills in writing, such as argumentation, and we wished to also have the scope to rate lower order skills such as grammar and punctuation. The WOLD scoring criteria more closely fitted this intention.

Each essay was typed up (preserving spelling errors and cross-outs) to reduce bias from poor handwriting (Graham & Weintraub, 1996) and rated using the WOLD criteria by someone blind to the nature of the study. The rater carried out the full training and familiarization program for the WOLD scoring scheme according to the published manual. The 8 example scripts for the holistic scoring criteria and the 15 example scripts for the analytic scoring criteria were all studied from the manual. A sample of the essays (10%) was also marked by one of the authors, and the interrater reliability (Cronbach's alpha) for the analytic ratings was as follows: Ideas and Development = .84; Organization, Unity, and Coherence = .76; Vocabulary = .82; Sentence Structure and Variety = .71; Grammar and Usage = .83; Capitalization and Punctuation = 1. For the holistic score, reliability was .91. This is a very good reliability rating for an analysis of writing, and such reliabilities are not uncommon with the WOLD measure. Other scoring methods can produce more complex and subtle measures but show much lower reliabilities (see Westby & Clauser, 1999, for a review of writing assessment reliabilities).

The essays also yielded four other measures, word count to measure essay length, spelling errors, a measure of average sentence length, and a measure of number of different words used (lexical diversity).

RESULTS

Despite reporting that they found the task demanding, all students completed the task and produced essays in response to the prompt. The number of words produced in 30 min across the three groups was slightly less than for the narratives produced for the Sterling et al. (1997) study. This would be expected given the more difficult nature of our task.

The average sentence length in our results appears longer than the average length presented by the narrative task in the Sterling et al. (1997) article and the narrative task in the Hoskyn and Swanson (2003) article. This would be expected if participants were constructing sentences suitable for an argumentative type of text, not just a simple narrative.

The comparisons of the students with dyslexia and the age- and spelling-ability-matched groups are shown in Table 2 and 3, respectively. A series of one-way ANOVAs were performed on the measures of reading, handwriting, working memory, and writing quality. Table 2 shows the means and standard deviations of those measures on which the students with dyslexia and their age-matched peers differed significantly (assuming no a priori predictions of direction), and the comparison with the spelling-matched group can be seen in Table 3. Three measures are common to both tables; students with dyslexia performed at significantly lower levels to both comparison groups on one complex working-memory measure (listening span), on nonword reading, and in spellings generated in their essays. There were no other measures showing significant differences from the spelling-matched group. Reading the two tables together, it is clear that the students with dyslexia are closer in performance level to individuals matched

TABLE 2
Comparison of Students With Dyslexia and Age-Matched Controls

	Students With Dyslexia[a]		*CA Match*[b]		
Measure	*M*	*SD*	*M*	*SD*	*F*
Nonword reading	43.19	11.86	58.60	4.50	29.65
Handwriting fluency (letters per minute)	90.7	21.47	111.6	19.67	10.52
Forward digit span	9.14	1.62	10.65	2.53	5.18
Listening span	2.71	0.56	3.13	0.58	5.30
Holistic essay writing quality score	3.43	1.21	4.15	0.88	4.76
Spelling errors in essay	12.7	8.70	6.10	6.60	7.34
Essay word count	414	151	505	136	4.12

Note. Two-tailed $p < .05$.
[a]$n = 21$. [b]$n = 20$.

TABLE 3
Comparison of Students With Dyslexia and Spelling-Skill-Matched Controls

	Students With Dyslexia[a]		*SS Match*[b]		
Measure	*M*	*SD*	*M*	*SD*	*F*
Nonword reading	43.19	11.86	54.68	6.86	13.68
Listening span	2.71	0.56	3.68	0.90	17.07
Spelling errors in essay	12.7	8.70	7.21	6.10	5.19

Note. Two-tailed $p < .05$.
[a]$n = 21$. [b]$n = 19$.

on spelling ability than they are to their age-matched peers. However, the age-matched group performed at a higher level than the students with dyslexia on a number of other measures. We deal with each of these differences in turn.

Holistic Essay Quality Score

The WOLD holistic score for essay quality showed the dyslexic group achieving significantly lower scores than the chronological-age group but not significantly different from the spelling-skill-matched group. The mean score level for the students with dyslexia and the spelling-skill match was between 3 and 4 on a scale of 6 for the holistic score—in practice, this meant essays somewhere between an essay at Level 3, defined by the scoring manual as including "several extended, specific details with some elaboration," and a Level 4 response that is "generally well written and has many details with extension and elaboration." The chronological-age group was well within the Level 4 criteria on average.

Therefore, although there is a consistent difference between the groups the difference, in absolute terms, is not that large. The difference is also not less than one would predict given the spelling ability of the students with dyslexia.

Spelling Errors

Despite being matched for spelling ability, the students with dyslexia produced more spontaneous spelling errors during the essay task than the spelling-skill-matched group (and the chronological-age group). This direction was as we hypothesized, but it is interesting that the number of errors is significantly higher than that of the spelling-skill-matched group and hence not in accord with our initial prediction. However, the overall number of spelling errors produced was reasonably small, with the students with dyslexia producing on average 3% as a

proportion of the total text. The proportion of spelling errors produced by the chronological-age-matched group was very similar to the proportion of errors produced by the adults in the Hoskyn and Swanson (2003) study and the error rate of the students with dyslexia and the spelling-ability controls more closely resembles the adolescent sample in that study. The error rate for our group was much lower than the 8% found by Sterling et al. (1997) in their sample of students with dyslexia.

Essay Word Count

There was a difference between the number of words produced by the students with dyslexia and the chronological-age match, with the students with dyslexia writing less but a similar amount to the spelling-match group. This is in accord with previous research showing that the essays of students with dyslexia were shorter than comparable students' work and in line with our prediction.

Sentence Length

Our results show that there was no difference in sentence length between the groups. This confirms the Sterling et al. (1997) finding and indicates that sentence complexity is likely to be also similar between the groups.

Lexical Diversity

The students with dyslexia did not differ from the chronological-age group and the spelling-skill group on lexical diversity. We had hypothesized that the students with dyslexia would show less lexical diversity than the chronological-age controls.

Handwriting Fluency

Handwriting fluency and spelling constitute transcription in the writing process. We have seen that the students with dyslexia are impaired at spelling. In handwriting fluency the students with dyslexia were again significantly disadvantaged when compared with their chronological-age-matched peers. They were scoring at the same level as the spelling skill group. In effect, this makes the spelling-skill-matched group a transcription match group, as both spelling and handwriting are at the same level.

The average speed of handwriting fluency of the students with dyslexia is roughly equivalent to that produced by children in the United Kingdom approaching age 12 based on the same task performed by UK school children (Connelly &

Hurst, 2001). The average speed of the chronological-age group tends more toward adult norms for this task in the United Kingdom (Connelly et al., 2005).

Reading

There were no differences between groups in reading real words. Surprisingly individuals with dyslexia were poorer on nonword reading than both the age-matched and spelling-ability-matched groups. The level of speeded nonword reading ability shown by the students with dyslexia was equivalent, on average, to a 14-year-old whereas the spelling-skill and chronological-age controls showed scores associated with adults. This result confirms previous research showing a continuing phonological problem in students with dyslexia when dealing with print (Hatcher et al., 2002).

Working Memory

No differences were found between groups in the visuo-spatial memory task. The students with dyslexia had a shorter forward digit spans than the age-match group, as well as shorter listening span than both the chronological-age group and spelling-skill group. This also conforms to previous research where students with dyslexia were impaired in working memory span in comparison to reading and chronological-age-matched groups (Gathercole & Baddeley, 1993)

Variables Contributing to Overall Writing Quality

To find out which of the measures were associated with essay quality, Pearsons correlations between the main outcome measure (WOLD holistic score) and the other dependent measures were calculated separately for each group. The literature allows us to make some a priori predictions of direction, and so one-tailed correlations are appropriate in this case. The measures showing significant correlations for any of the three groups are shown in Table 4. For the students with dyslexia a complex memory measure (listening span), handwriting fluency, essay word count, and lexical diversity were all positively correlated with writing quality. In contrast, for the spelling-skills-matched group both word and nonword reading measures, essay word count, sentence length, lexical diversity, and handwriting fluency were positively correlated with the holistic writing measure. The only variable to correlate significantly with the holistic writing score for the chronological-age group was sentence length.

There was no significant correlation between number of spontaneously produced spelling errors and performance on the WRAT–3 spelling task for the dyslexic group. The poor spellers on the WRAT–3 were not necessarily the poor spell-

TABLE 4
Wechsler Objective Language Dimensions Essay Quality Correlations With Main Measures for Each Group

	Group		
Measure	*Students With Dyslexia*[a]	*CA Match*[b]	*SS Match*[c]
Listening span	.375*	.375	.351
Word reading	.004	.052	.414*
Nonword reading	.217	.350	.459*
Sentence length (from essay)	–.087	.42*	.393*
Essay word count	.486*	.348	.504*
Lexical diversity	.658*	.274	.549*
Handwriting fluency (letters per minute)	.578*	.056	.535*

[a]$n = 21$. [b]$n = 20$. [c]$n = 19$.
*$p < .05$ (one-tailed).

ers in the written composition task. This finding points to something else, in addition to poor spelling, feeding into the number of spelling errors in the texts.

To further investigate the potential predictive value of these measures for essay quality, we used regression analysis and an analysis strategy also used by Hoskyn and Swanson (2003). A series of hierarchical regressions with essay quality as the dependent measure allowed us to assess the unique contribution of a set of measures to essay quality. Age was entered as a first step for each regression, followed by one of the seven variables that had shown significant group differences (see Tables 2 and 3). With contrast measures defining group membership as the last step in the regressions (see Table 5), our analysis strategy allowed us to assess each measure on which the groups differed and then to see if group membership accounted for any additional variance in essay quality. Table 5 shows the R^2, R^2 change, F, and significance level for each step in the models. Our reasoning was that if the predictor variables were well selected, group membership should not account for any significant additional variance. A regression with age and the contrast measures as the two steps showed that group membership accounted for 7.9% of the variance in essay quality after controlling for age.

The eight models show that those measures on which the groups differed account for between 0.4% and 22.9% of the variance in essay quality. Spelling errors, forward digit span, and sentence length failed to account for a significant proportion of the variance in essay quality. Of the variables where there were differences between the students with dyslexia and their age- or spelling-matched peers, all except the spelling error measure successfully accounted for differences between the three groups. This is shown by the fact that in the final step, the contrast measures in regression models do not account for a significant proportion of the variance in essay qual-

TABLE 5
Hierarchical Regression Models on Wechsler Objective Language Dimensions Holistic Writing Scores

Independent Variables	R^2	R^2 *Change*	*F*	*df*	*p*
Model 1					
1. Age	.079	.079	4.99	1, 58	.029
2. Sentence length	.083	.004	0.25	1, 57	*ns*
3. AD vs SS & AD vs CA	.159	.076	2.48	2, 56	*ns*
Model 2					
2. Spelling errors	.093	.014	0.85	1, 57	*ns*
3. AD vs SS & AD vs CA	.215	.122	4.28	2, 56	.019
Model 3					
2. Forward digit span	.115	.036	2.34	1.57	*ns*
3. AD vs SS & AD vs CA	.171	.056	1.84	2, 55	*ns*
Model 4					
2. Listening span	.200	.121	8.64	1, 57	.005
3. AD vs SS & AD vs CA	.264	.063	2.37	2, 56	*ns*
Model 5					
2. Nonword reading	.218	.138	10.08	1, 57	.002
3. AD vs SS & AD vs CA	.225	.008	0.271	2, 55	*ns*
Model 6					
2. Essay word count	.263	.184	14.21	1, 57	.000
3. AD vs SS & AD vs CA	.300	.038	1.48	2, 55	*ns*
Model 7					
2. Handwriting fluency	.287	.208	16.61	1, 57	.000
3. AD vs SS & AD vs CA	.299	.012	0.49	2, 56	*ns*
Model 8					
2. Lexical diversity	.308	.229	18.89	1, 57	.000
3. AD vs SS & AD vs CA	.341	.032	1.34	2, 55	*ns*

Note. Step 1 is the same for each model. AD = individuals with dyslexia; CA = chronological controls; SS = spelling-matched controls.

ity scores. The two measures accounting for the highest proportions of the variance in essay quality were lexical diversity (22.9%) and handwriting fluency (20.8%).

These results are congruent with Hoskyn and Swanson's (2003) findings that handwriting speed explained a large proportion of variance in their measure of the structural complexity of writing. Working memory measures still account for a significant proportion of the variance, as do lexical diversity, handwriting, essay length, and nonword reading.

Analytical Scoring of the Essay

The WOLD scoring method allows a more detailed inspection of several aspects of essay quality, and these subscales may go some way to explaining differences in overall writing quality between the groups as just outlined. A series of one way

TABLE 6
Comparison of Students With Dyslexia and Age-Matched Controls: Wechsler Objective Language Dimensions Essay Quality Subscores

	Students With Dyslexia[a]		*Group CA Match*[b]			
Analytic Scoring Elements	*M*	*SD*	*M*	*SD*	*F*	*Typical Scoring Elements at the Mean Score Level*
Ideas and development	2.38	0.59	2.65	0.67	1.87	"Adequately supported ideas with some details extended or elaborated."
Organization, unity, and coherence	2.62	0.67	2.65	0.49	0.03	"Fairly well organised, with good unity of plan. Some transitions may be used. Little or no digression from main idea."
Vocabulary	2.76	0.54	3.30	0.47	11.56*	"Good word choices that are appropriate, specific and varied and have some appeal."
Sentence structure/variety	3.00	0.84	2.90	0.45	0.22	"Good mix of sentence lengths and structures."
Grammar	2.90	0.62	3.05	0.69	0.50	"Good grammar and word usage."
Capitalization/punctuation	2.95	0.86	3.60	0.68	7.05*	"Most punctuation and capitalisation correct."

Note. Maximum score = 4.
[a]$n = 21$. [b]$n = 20$.
*Differences significant at the 5% level.

ANOVAs showed that the group with dyslexia performed at a lower level than the chronological-age group in only two aspects of the analytic scoring—Vocabulary, and Capitalization and Punctuation (see Table 6).

This confirms our hypotheses derived from previous research that the vocabulary produced by the students with dyslexia in their writing would be poorer than their peers and that punctuation and capitalization would also be affected.

DISCUSSION

The results from this study imply (a) that the overall essay writing quality of students with dyslexia is generally poorer than chronological-age controls and is linked to their level of spelling accuracy and handwriting fluency; (b) that essays produced by students with dyslexia contain even more spelling errors than one

would predict given their dictated spelling skill; (c) that low-level transcription skills such as spelling and handwriting fluency continue to be important factors associated with essay writing in some undergraduates; (d) that reading skills and working memory continue to be associated with essay writing in some undergraduates; and (e) that dyslexic students' writing is poorer in spelling and punctuation than age-matched peers but, on a positive note, not lacking in ideas, organization, sentence structure, or even grammar.

Our study confirms that students with dyslexia do indeed have problems with writing academic essays. However, these problems seem, on the surface, relatively narrow in scope. Using the "simple view of writing," we can see that dyslexia impacts primarily on transcription skills during the writing process. This was as hypothesized and confirms previous research about problems in these students. Handwriting fluency accounted for a significant portion of the variance of overall writing quality and correlated with essay writing quality for both the students with dyslexia and their spelling-skills controls. This mirrors work on children, and though contributing slightly less here than in children's writing, it underlines the very important role handwriting fluency has in a timed writing assignment. The basic skill of physically getting the letters and words on the page quickly and efficiently is still important at university level. This confirms and extends the results of Connelly et al. (2005) and the work of Berninger (1999), among others. The role of transcription skills in the writing done by adults has been often overlooked, but we can see from this study that transcription skills continue to constrain writing in adults and particularly in vulnerable populations such as adults with dyslexia.

It was a surprise to us that the essays written by the students with dyslexia contained even more spelling errors than the essays written by the spelling-skills control group. This could have been due to a poor match between the groups, but as our other results fitted predictions, and as the spelling match was done on an individual basis, this seems unlikely. However, on consideration, the spelling results, though surprising, do also fit the simple model of writing (Berninger et al, 2002), which is modeled as a limited capacity system. The students with dyslexia have a more limited capacity working memory, both in terms of simple phonological memory span, which was lower than the age-matched controls, and complex verbal memory span, as measured by listening span, which was lower than both age- and spelling-matched controls. These memory constraints result in a reduction of their ability to cope with the same level of demand on writing processes that other students handle when producing text. This means that transcription processes such as spelling and handwriting fluency will potentially suffer. This is all the more so in students with dyslexia, as they have problems extracting accurate spellings in any case. It is interesting that the higher order aspects of writing such as ideas and organization do not appear to suffer.

Hoskyn and Swanson (2003) found a significant correlation between visual working memory and the same measure of writing quality, but we did not replicate

this in our sample. This could be due to our more limited testing of this aspect of working memory. Our measure was a single complex visuo-spatial memory measure, whereas they used two tests, one involving directional responses.

Our results do confirm previous research (Rice, 2004) showing that adult students with dyslexia continue to show problems with the direct phonological processing of print. Our sample of dyslexic students scored lower than even the spelling-skill controls on a measure of speeded nonword reading. This phonological problem was also illustrated in the significantly lower score on the phonological working-memory task measuring listening span for the students with dyslexia. Phonological knowledge used during nonword reading will also be used when spelling. The poor manipulation of phonological information when reading nonwords or spelling is a continuing problem for students with dyslexia that leads to difficulties with writing as well as the more commonly known problems with reading. Nonword reading speed also contributed toward overall writing quality beyond the group differences. This shows the continuing interaction between reading skills and writing and the close links between different aspects of literacy.

The essay topic we used was more ecologically valid than some previous studies have used, but it demanded little formal retrieval of knowledge, unlike many of the exams taken at university. The ability to retrieve key information from long-term memory and convert it into appropriate language for text via working memory is a key skill of exam writing. Therefore, we can expect the problems of the dyslexic adults' limited capacity system to be exacerbated in these cases. We might predict that spelling and vocabulary choice will suffer even more as the complex memory load increases, and for students with spelling difficulties, lexical diversity will be reduced with consequent effects on essay quality. It will also be likely that the writing effort will take more time, as the whole writing system comes under pressure. Therefore, it seems justified to give dyslexic students more time to complete exams while they are studying at university.

It may also be the case that writing interventions can be devised to reduce the burden on the limited working-memory capacity of the dyslexic students. Working memory itself is very difficult to improve using formal programs (Witruk, 2003). Therefore, it may be more useful to channel effort into further automating the processes involved in transcription. A recent UK-based intervention to improve the spelling of subject-specific words by students with dyslexia seems a step in the right direction (Sterling, Ertubey, Brownfield, O'Reilly, & Noyce, 2004). Automating spelling knowledge and giving students the confidence to use more complex words in their writing will reduce some of the effects of a limited working-memory capacity. Other schemes that have been used successfully with children could also be potentially adapted for use with adults (Berninger et al., 1997). Because we have shown that the writing produced by students with dyslexia is related directly to literacy level, schemes to improve literacy levels in dyslexia, particularly spelling, should also have a long-term benefit on the writing produced by these students.

It is common in universities for dyslexic students to be encouraged to use word processors to help them overcome spelling problems when writing. Although the spell checker is useful, we should be aware that the same fundamental constraints on writing processes will operate via the medium of the keyboard. For example, slow keyboarding will also contribute to writing problems as much as slow handwriting. Erskine (1999) found that a sample of university students with dyslexia keyboarded more slowly than controls in an essay-writing task. The number of spelling errors displayed by the students with dyslexia was similar to levels found in our data and was significantly more than Erskine's chronological-age controls.

Writing essays without having to recourse to spelling, keyboarding, or handwriting would, in theory, appear to be an ideal solution for students with dyslexia. However, essays written to dictation using either dictation software or scribes are not problem free. See Higgins and Raskind (2004) for a recent attempt to use speech recognition software. Modern dictation programs require considerable training and are not yet sufficiently accurate to be used successfully in constructing complex text with specialist terms. Using a scribe also has personal and interpretative costs in feeding complex ideas through another person (Scott, 1999). We may find in the future that the writing problems of students with dyslexia will lessen once speech recognition technology advances, but in the meantime we are left with the problems outlined and the potential solutions previously presented.

In conclusion, we have shown that the writing skills of students with dyslexia at university are poorer than age-matched peers and were highly tied to spelling and handwriting fluency levels. Their writing contained more spelling errors than would be expected given their dictated spelling-skill level. This is likely to be due to poorer transcription processes working within a more limited capacity system. However, on a positive note, the thinking and arguing skills of the students was no less that of their age-matched peers.

A larger scale study is required for more sophisticated modeling of the contributors to writing quality. Ideally this should be both a correlational and an intervention study to allow us to remediate and settle theoretical questions about the relative contributions of lower and higher order processes to the performance of students with dyslexia. We need to investigate more fully ways of improving poor spelling, slow handwriting, and less efficient memory skills in adults so that the academic potential of university students with dyslexia is fully unlocked.

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