Phonological and Orthographic Spelling in High-functioning Adult Dyslexics

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Despite a history of reading or spelling difficulties, some adults attain age-appropriate spelling skills and succeed at university. We compared the spelling of 29 such high-functioning dyslexics with that of 28 typical students, matched on general spelling ability, and controlling for vocabulary and non-verbal intelligence. Participants wrote derived real and pseudo words, whose spelling relationship to their base forms was categorized as phonologically simple (apt-aptly), orthographically simple (deceit-deceitful), phonologically complex (ash-ashen), or orthographically complex (plenty-plentiful). Dyslexic participants spelled all word and pseudoword categories more poorly than controls. Both groups spelled simple phonological words best. Dyslexics were particularly poor at spelling simple orthographic words, whose letter patterns and rules must likely be memorized. In contrast, dyslexics wrote more plausible spellings of orthographic than phonological pseudowords, but this might be an artefact of their more variable spelling attempts. These results suggest that high-functioning dyslexics make some use of phonological skills to spell familiar words, but they have difficulty in memorizing orthographic patterns, which makes it difficult to spell unfamiliar words consistently in the absence of sufficient phonological cues or orthographic rules. Copyright © 2008 John Wiley & Sons, Ltd.

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INTRODUCTION

Most studies of developmental dyslexia have focused on the causes and characteristics of childhood dyslexia. It is now well established that the primary deficit in dyslexia is poor phonological awareness (for recent reviews, see Shaywitz, 2003; Snowling, 2000; Vellutino, Fletcher, Snowling, & Scanlon, 2004). Poor phonological awareness then leads to difficulties in establishing reliable spelling–sound relationships and, further, to difficulties in decoding, single word reading, reading fluency, and spelling. Other deficits, for instance, in orthographic processing (Castles & Coltheart, 1993) or naming speed (Wolf & Bowers, 1999), may represent independent but overlapping sources of difficulty, or may derive from the primary phonological deficit.

Until recently, few studies had considered the outcome of a childhood diagnosis of dyslexia in adults. A small but increasing body of research now suggests that most individuals diagnosed with dyslexia as children remain diagnostically dyslexic throughout their lives (Bruck, 1985; Felton, Naylor, & Wood, 1990; Finucci, Gottfredson, & Childs, 1986; Labuda & DeFries, 1988; Pennington, Lefly, Van Orden, Bookman, & Smith, 1987; Pennington et al., 1986; Scarborough, 1984). The behavioural basis of reading problems for most adults with reading disabilities lies in deficient phonological decoding (often expressed in inaccurate and slow pseudoword reading), which persists even if reading comprehension problems are no longer detectable (e.g. Parrila, Georgiou, & Corkett, 2007; Pennington, Van Orden, Smith, Green, & Haith, 1990). Similarly, problems with spelling often accompany decoding problems (Gallagher, Laxon, Armstrong, & Frith, 1996).

Other studies have identified a group of ‘compensated dyslexics’ (Lefly & Pennington, 1991): adults who, despite a history of significant reading problems, now have word identification and reading comprehension levels within the normal range (e.g. Bruck, 1992, 1993; Deacon, Parrila, & Kirby, 2006; Gallagher et al., 1996; Hatcher, Snowling, & Griffiths, 2002; Miller-Shaul, 2005; Pennington et al., 1986; Snowling, Nation, Moxham, Gallagher, & Frith, 1997). Lefly and Pennington (1991) estimated that up to a quarter of individuals diagnosed with dyslexia in childhood will eventually ‘compensate’ for their early difficulties. Similarly, increasing numbers of students with diagnoses of dyslexia are attending universities where they are often offered help with note-taking and extra time for examinations. Whether all such students are ‘compensated’ in the sense that Lefly and Pennington (1991) intended is far from certain, but it seems reasonable to describe them as ‘high-functioning’, since they are coping with the demands of higher education.

Compensated or high-functioning adult dyslexics are an important group to investigate for both theoretical and practical reasons. For example, many theoretical models of reading development cannot explain how these dyslexics have reached their relatively high reading level in spite of poor phonological skills (e.g. Ehri, 1991, 1992; Frith, 1986; Share, 1995). Understanding how compensation occurs can provide important information about variability in adult reading strategies and in reading development. On theoretical grounds (see e.g. Coltheart, Curtis, Atkins, & Haller, 1993; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001), two obvious candidates for supporting spelling and word recognition are orthographic knowledge and semantic knowledge. The current
evidence on these is mixed. Several studies have reported that reading-disabled adults use phonologically based word recognition strategies similar to those used by normal readers (e.g. Ben-Dror, Pollatsek, & Scarpati, 1991; Watson & Brown, 1992), albeit with less efficiency. In contrast, Elbro (1993) reported that half of his adolescent dyslexic participants used more whole-word reading strategies, and several studies have reported orthographic knowledge as a relative strength (e.g. Miller-Shaul, 2005; Siegel, Share, & Geva, 1995) or as a possible compensatory tool (Leinonen et al., 2001; van der Leij & van Daal, 1999), although Meyler and Breznitz (2003) found that orthographic processing was particularly difficult for university students with dyslexia.

Other studies have indicated that the inconsistency between very poor phonological decoding and better word reading (Elbro & Arnbak, 1996) or spelling (Bruck, 1993) skills could be due to relatively intact morphological knowledge that compensates for poorer phonological skills. Morphology influences the spelling of many English words, so that, for example, the shared spellings of portions of words such as heal and health, or kissed and hugged, reveal their shared units of meaning, despite differing pronunciations. Sensitivity to such links of meaning might implicate the semantic route in Coltheart et al.'s (2001) Dual Route Cascaded model. Again, evidence is mixed, with some studies (e.g. Elbro & Arnbak, 1996; Leong, 1999) showing at least reading-age-appropriate performance levels in morphological awareness tasks and others finding poorer performance (e.g. Deacon et al., 2006; Joanisse, Manis, Keating, & Seidenberg, 2000).

In sum, there is little agreement as to how many adults with reading disabilities can or cannot bypass deficient phonology and which of the mechanisms discussed might differentiate these two groups. Also, there is even less evidence on how such adults deal with spelling despite the importance of both orthographic and morphological skills for correct spelling. Pennington et al. (1986, 1987) and Lefly and Pennington (1991) extended this line of research to spelling, and argued that while phonological coding skills are often poor in individuals with dyslexia, orthographic coding skills can exceed those of spelling-age controls. Working with compensated dyslexic adults, Lefly and Pennington (1991) found that these individuals were poorer at general spelling (although still within the average range) than typical readers matched for age, IQ, SES, and education and, further, that there were no significant differences in the patterns of spelling errors shown by the two groups. The compensated dyslexics, however, did spell significantly better than non-compensated dyslexic adults. Pennington et al. (1986), in turn, showed that non-compensated adult dyslexics had better knowledge of complex orthographic rules than of complex phonological rules, and that they were significantly better than a spelling-age matched control group on spelling items that required knowledge of complex orthographic rules. Pennington et al. concluded that adult dyslexics (a) achieved their similar overall spelling performance level by using more complex orthographic rules and (b) relied on larger units of sound-to-spelling correspondences as a partial means of compensating for their deficit in small unit phonological processing.

Pennington et al.'s (1986) findings are particularly important as they indicate a discrepancy between the development of phonological and orthographic processing (see also Pennington et al., 1987). Most models of reading
development suggest that orthographic processing develops through accurate and repetitive phonological decoding of regular graphemic units (e.g. Ehri, 1991, 1992; Frith, 1986; Share, 1995). These models predict that a phonological processing deficit hinders the development of orthographic processing. Readers with weak spelling–sound knowledge will have too few successful reading experiences to establish adequate orthographic knowledge and thus will not learn to reliably recognize words or parts of words visually, nor to spell them correctly on the basis of this knowledge. Pennington et al.’s findings with adult dyslexics challenge these dominant developmental models.

However, Pennington et al.’s (1986, 1987) and Lefly and Pennington’s (1991) results were based on post hoc error analyses of words from a standardized spelling achievement test, the Wide-Range Achievement Test (WRAT; Jastak & Jastak, 1978). The scoring procedure coded errors as showing simple phonological accuracy if all the consonant sounds were present in the correct order (vowel errors were ignored). Errors with complex phonological accuracy represented all vowel and consonant sounds. It was permissible for both types of phonological errors to be orthographically illegal (e.g. ‘hav’ for have; ‘cwantity’ for quantity). Errors coded as having simple orthographic accuracy had both initial and final letters correct, and no orthographically illegal letter sequences. Finally, spelling errors with complex orthographic accuracy were those that erred on one of the four orthographic patterns: single consonant alternations (e.g. c sometimes represents /s/, sometimes /k/), vowel clusters (e.g. ea for /e/), geminate consonants (doubled consonants such as exaggerate), and analogy words (e.g. the phys of physical and physician). However, the words on the WRAT were not designed to be analysed in this way, and so the numbers of words with the potential to be subject to these error types were uneven, and not matched for frequency or difficulty. For example, there were 23 potential consonant alternations, involving 4 different sounds (/k/, /s/, /z/, and /d/) and 4 different spellings (c, s, g, and d). There were 14 vowel clusters of 10 different types, some of which were determined by a preceding q (e.g. equipment, quantity), and some of which were not (e.g., believe, train). The 21 ‘analogy’ words involved orthographic rules ranging from the very simple (e.g. -x- in executive) to the more complex (e.g. court- in courteous), and others that also involve complex morphology-based patterns (e.g. phys- or -cian in physician).

In addition, the words in the WRAT spelling sub-test become progressively more difficult. Pennington and colleagues asked participants to spell all of the words, rather than using the standard termination rule, which might have led to frustration and sub-optimal performance on the later words. Further, the number and type of each of the spelling patterns are not represented consistently in the WRAT list. For example, if one particular spelling pattern were over-represented at the end (or start) of the list, it might appear that dyslexic spellers had particular difficulty (or facility) with this pattern.

The Present Study

To overcome these limitations, we decided to investigate high-functioning dyslexics’ spelling on a list of words specifically chosen to test simple phonological, simple orthographic, complex phonological, and complex orthographic spelling skills. We chose the words so that there would be equal numbers
of each type of word, matched for approximate length, phonetic complexity, and written frequency. The four types of word employed were all words derived from base words. Their spelling could be determined by either ‘simple’ or ‘complex’ rules, based on phonology or orthography. The spelling of both the derived forms and their base words was assessed. Their morphological relationships (shown by maintenance of the base spelling in the derived form, e.g. orphan-orphanage) also provided an opportunity to test the possibility that dyslexics, especially high-functioning ones, have intact morphological knowledge. Of course, writers do not always use a strategy to spell words; they may simply rely on rote knowledge. To control for this possibility, we also asked participants to spell a set of matched pseudowords, which would require the use of a spelling strategy, since they could not be spelled from memory.

We administered our word lists to two groups of participants. The first was a group of high-functioning, possibly compensated, university students with a significant history of reading problems, who had overcome their earlier reading difficulties to attend university. The second group were control university students, matched statistically on a variety of measures. Because both of these groups should have university-level reading and writing skills, scoring their spellings using Pennington et al.’s (1986) codes would be likely to place many of them at ceiling, and to miss distinctions between words or groups. For example, we might expect that all participants would be able to spell the consonants of a word in the correct order (simple phonological accuracy). The scoring system was thus designed to be more stringent, while continuing to follow the concepts of Pennington et al.’s system. The current study therefore aimed to compare the phonological and orthographic spelling of apparently compensated adults, and control adult spellers, on both real and pseudowords. As described, the evidence about the phonological, orthographic, and morphological processing strategies of adult dyslexics is very mixed when it comes to reading, and very limited when it comes to spelling. Both Ehri’s (1991, 1992) and Share’s (1995) theories would lead to an expectation that adults’ spelling (and orthographic knowledge) is restricted by their phonological knowledge; thus, we would not expect to see a difference across phonological and orthographic items. However, Pennington et al.’s (1986, 1987) results would lead us to hypothesize that these high-functioning dyslexic individuals might show relatively strong orthographic spelling strategies, by way of compensation for relatively poor phonological spelling strategies, even with more carefully selected words and a more stringent scoring system.

METHOD

Participants

Participants were recruited through letters sent through Student Support Services, class announcements, and campus posters. The initial sample consisted of 68 students at the University of Alberta, financially compensated for their time. There were 25 men and 43 women, with a mean age of 26 years, 3 months (SD=7.5 months, range=18–52 years). Participants visited the testing lab in the university 5 times, for sessions of approximately 60 min each as part of a larger study, and completed a battery of reading, spelling, and cognitive tests, described
below. In addition, participants completed the Adult Reading History Questionnaire—Revised (Parrila, Corkett, Kirby, & Hein, 2003), which provided an index of self-reported history of reading and spelling acquisition problems (for details, see Parrila et al., 2007). Twenty-nine participants, 10 male and 19 female, with a mean age of 28.9 years (SD=8.9), reported high levels of reading acquisition problems and were assigned to the dyslexic group. Of the 29 compensated dyslexics, 11 had a recent diagnosis of dyslexia or specific reading disability, and all 29 also showed current problems in word identification, decoding, and/or spelling (for individual-level data, see Parrila et al., 2007, Table 3). The remaining 39 participants reported no history of reading problems. Of these, we selected a control group of 28 participants, 9 male and 19 female, with a mean age of 25.0 years (SD=6.3), matched as closely as possible to the compensated dyslexic group on their raw scores on Raven’s (1976) Standard Progressive Matrices and on the spelling sub-test of the Wide-ranging achievement test—3 (WRAT-3; Wilkinson, 1993). This meant excluding some of the better spellers in the control group who could not be matched with any of the high-functioning dyslexic participants.

All participants reported English as their native language and normal or corrected-to-normal vision. Apart from Raven’s Matrices and the WRAT spelling sub-test, participants completed the spelling sub-test of the Peabody Individual Achievement Test—Revised (Markwardt, 1989) and the Peabody Picture Vocabulary Test—III (PPVT-III; Dunn & Dunn, 1997). The reading tests were the Word Identification and Word Attack sub-tests from the Woodcock (1998) Reading Mastery Test—Revised and the Comprehension sub-test from the Nelson–Denny Reading Test (Brown, Fishco, & Hanna, 1993). The latter test provided two standard indices: reading rate and timed reading comprehension (20-min time limit). Because many dyslexic participants failed to complete the test in 20 min, we also calculated the percentage correctness of attempted questions to remove the effect of unanswered questions. The phonological processing tests were the Rosner Auditory Analysis Test (Rosner & Simon, 1971) and rapid automatized naming of digits from the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999).

Table 1 reports the means, standard deviations, and F-values from one-way analyses of variance (ANOVAs) comparing the groups on general ability, spelling, reading, and phonological processing tests. The performance of the dyslexics was within the normal range in spelling and reading tasks, but still significantly poorer than that of the control group on all but three tasks: Raven’s Matrices and WRAT-3 spelling raw score (since groups were matched on these), and percentage of correct answers on the reading comprehension test. The Word Attack, Word Identification, and Auditory Analysis Tests showed negatively skewed distributions for the control group (with performances clustering close to the ceiling) and a nonparametric Mann–Whitney test was therefore used to verify the ANOVA results; all three tests showed highly significant differences between the groups (all p’s < 0.001).

In general, despite the removal of several good spellers of the control group, the results are similar to those of earlier studies that reveal continued differences between dyslexic and control participants. Although dyslexic participants can perform as well as control participants on reading comprehension measures, they continue to struggle on decoding, word reading, reading speed, and phonolo-
gical tasks (e.g. Aaron, 1989; Gallagher et al., 1996; Hatcher et al., 2002; Mosberg & Johns, 1994; Rack, 1997). The negatively skewed distributions for Word Attack, Word Identification, and Auditory Analysis may also have resulted in underestimation of the differences between the groups on these tasks.

**Stimuli**

The stimuli were 64 real words and 64 pseudowords, in base–derived word pairs (4 of the words actually had inflectional endings -er/-or or -est, but for efficiency, all are referred to as ‘derived’). The relationship between the spelling of each base word and its derived form was categorized as simple phonological, complex phonological, simple orthographic, or complex orthographic. There were eight real and eight pseudoword pairs of each category:

*Simple phonological pairs:* The base word had the same sound and spelling in both base and derived forms. The spelling of the base word was as phonetic as possible; we attempted to avoid sounds with more than one plausible spelling. **Examples:** bother-bothersome, mimber-mimbersome.

*Simple orthographic pairs:* The base word had the same sound and spelling in both base and derived forms, but the base word’s spelling contained some ambiguities: one or more of its sounds could plausibly be spelled with one or

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Table 1. Means and standard deviations for scores on the general ability, spelling, reading, and phonological processing tests

<table>
<thead>
<tr>
<th>Tests</th>
<th>Group</th>
<th>Group</th>
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<tbody>
<tr>
<td></td>
<td>Dyslexic (n=29)</td>
<td>Control (n=28)</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Raven’s Matrices</td>
<td>55.21</td>
<td>3.03</td>
</tr>
<tr>
<td>PPVT-III</td>
<td>183.62</td>
<td>7.29</td>
</tr>
<tr>
<td><strong>Spelling</strong></td>
<td></td>
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<tr>
<td>WRAT-3 raw</td>
<td>44.81</td>
<td>11.79</td>
</tr>
<tr>
<td>WRAT-3 ss</td>
<td>101.12</td>
<td>10.61</td>
</tr>
<tr>
<td>PIAT-R raw</td>
<td>88.76</td>
<td>4.83</td>
</tr>
<tr>
<td>PIAT-R ss</td>
<td>97.79</td>
<td>7.37</td>
</tr>
<tr>
<td><strong>Reading</strong></td>
<td></td>
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</tr>
<tr>
<td>WRMT-R Word Identification</td>
<td>94.66</td>
<td>6.25</td>
</tr>
<tr>
<td>WRMT-R Word Attack</td>
<td>32.97</td>
<td>6.57</td>
</tr>
<tr>
<td>ND rate</td>
<td>206.93</td>
<td>94.06</td>
</tr>
<tr>
<td>ND timed comp.</td>
<td>57.03</td>
<td>12.47</td>
</tr>
<tr>
<td>ND untimed comp.</td>
<td>85.03</td>
<td>10.36</td>
</tr>
<tr>
<td><strong>Phonological processing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AAT</td>
<td>30.55</td>
<td>8.04</td>
</tr>
<tr>
<td>RAN digits</td>
<td>15.91</td>
<td>2.51</td>
</tr>
</tbody>
</table>

Note: PPVT-III, Peabody Picture Vocabulary Test—Third Edition; WRAT-3, Wide-Range Achievement Test—3; PIAT-R, Peabody Individual Achievement Test—Revised, WRMT-R, Woodcock Reading Mastery Test—Revised; ND, Nelson-Denny; AAT, Rosner Auditory Analysis Test; RAN, rapid automatized naming (time in seconds to complete task).

*p < 0.05; **p < 0.01; ***p < 0.001.

F-Values report the main effect of group.
more letters/letter combinations that must simply be learned or guessed. Examples: deceit/deceitful, cirent/cirentful (which could also plausibly be spelled with an initial s-, or with two r’s rather than one). Spelling these words thus required more than a simple sound-to-letter mapping, because unless the spelling is already known by rote, a choice must be made between several plausible orthographic patterns. The greater range of plausible spellings for these words may make it harder to come up with a correct (for real words) or appropriate (for pseudowords) spelling than for simple phonological words.

Complex phonological pairs: A crucial portion of the base word (the ending) had the same spelling in base and derived forms to represent their shared meaning. In the base form, the spelling was unambiguously determined by the final sound of the word (e.g. ash, forate). However, in the derived form there were two (or more) plausible spellings for this crucial portion (e.g. ashen/achian; foration/foracian/forashion). If one does not already know how to write the derived word, the only clue to the spelling of this ambiguous portion is the spelling (or sound) of the base word. Examples: addict/addiction, imbuct/imbuction. The ending of both of these derived forms could be spelled either -ction or -xion. However, because the base forms end in -ct rather than -x, the spelling -tion is necessary to signal that these words are related. (It is true that on the basis of sound alone, crucifix could be written crucificks, but since it is a singular noun, not a plural, it requires -x, not -cks.)

Complex orthographic pairs: Following Pennington et al. (1986), we used four relatively complex orthographic patterns. If the spelling of these words is not already known, then knowledge of the underlying orthographic conventions is crucial for correct spelling.

(a) Single consonant alternations: A crucial portion of the base word had the same spelling in both base and derived forms, each with two or more plausible spellings. The spelling of the base form could be used to determine the spelling of the derived form. Examples: scarce/scarcity, preeze/preezily. The final /s/ in scarce could plausibly be spelled with either s or c, and the final /z/ in preeze could be spelled with either s or z. However, using the same letter for both members of a pair signals that these words are related in meaning.

(b) Geminate consonants: The base word ended in a single consonant that must be doubled in the derived form. Examples: slip/slippage, stron/stronnage

(c) y to i: The base word ended in a y that must be changed to i in its derived form. Examples: plenty/plentiful, shonty/shontiful

(d) Analogy: The word pairs followed a standard spelling pattern. For example, English base–derived pairs that change sound from /t/ to /ʃ/, change spelling from t to ss (e.g. submit-submission, emit-emission), even though the derived form’s /ʃ/ sound could plausibly be spelled in several ways (e.g. submishion, submician). These restrictions meant that participants would need to rely on analogy by thinking of the family of ‘-it to -ission’ words, rather than using their knowledge that the base spelling should be maintained, to spell the derived forms correctly. Examples: submit/submission, fulmit/fulmission.

Across categories, the base–derived pairs were matched as closely as possible for phonetic complexity, length, and type of ending (e.g. bother/bothersome was
matched with quarrel/quarrelsome). Each pseudoword pair was constructed to correspond to a real word pair in terms of phonetic complexity, length, and number of ambiguous sounds (e.g. regret/regretful was matched to impret/impretful), and all pseudowords complied with English phono- and orthotactic conventions. Within categories, the base and derived real words were matched as closely as possible for written frequency (Carroll, Davies, & Richman, 1971), and each derived word was chosen to be as similar as possible in frequency to its base form (see the Appendix for a list of words and further notes on matching). The experimental words were put into sentences that made clear the link of meaning between the base and derived forms. There was one sentence for the base form, and one for the derived form, of each word. For example, ‘Jennifer was going to astonish them all. She knew they would stare at her in astonishment’; ‘We thought we might imblinish the bathroom. It could do with a good imblinishment’.

Procedure

Standardized (WRAT-3) spelling and all other tasks reported in Table 1 were presented to the participants in Sessions 1 and 2. The experimental words, in their sentence contexts, were recorded by a female speaker of Canadian English, and presented to participants individually in a quiet room at their university. Participants wrote down each word as they heard it with no repetition allowed. In Session 3, participants heard the base and the derived word of each pair in their sentence contexts, but were asked only to write down the derived form (e.g. ‘We were all feeling a bit melli last night. Therefore, we put on some melliome music. Spell melliome’). In Session 4, they heard only the base form in its sentence context, and were asked to write just this base form (e.g. ‘We were all feeling a bit melli last night. Spell melli’). In both experimental spelling sessions, the real words were presented first and the pseudowords second. Participants were instructed to spell each word as best as they could, and then press a button on a keyboard to hear the next item. No time limits were imposed on the spelling performance.

RESULTS

Real Words

Words spelled correctly overall: We first looked at the number of 32 base and 32 derived words that the participants had spelled correctly overall. The means and standard deviations are shown in Figure 1.

Group by word type repeated-measures analyses of covariance (ANCOVA) were carried out on these data, controlling for factors that could have affected word spelling performance. The first ANCOVA had performance on Raven’s Progressive Matrices and the PPVT-III as covariates, controlling for general non-verbal and verbal ability. This analysis revealed a main effect of group, $F(1,51)=46.5, p<0.001$. The control group spelled more of the experimental words correctly than did the dyslexic group. There was a main effect of word type, $F(1,51)=4.87, p=0.032$, with more base than derived words spelled correctly overall. Finally, group and word type interacted significantly, $F(1,51)=18.2,$
Newman–Keuls post hoc tests showed that control spellers outperformed compensated dyslexic spellers on both base and derived words \( p<0.01 \), and that both groups did better on base than derived words \( p<0.01 \).

From the means in Figure 1, it seems that the significant interaction was due to the dyslexic participants showing a larger word type effect than the controls, in terms of relatively poorer performance on the derived than the base words compared with the controls. It is also clear that there was a ceiling effect for the control participants, particularly for the base words. The second ANCOVA, which controlled for WRAT-3 spelling, in addition to Raven’s and PPVT-III, revealed the same main effects of group, \( F(1,48)=9.92, p=0.003 \), and of word type, \( F(1,48)=11.8, p=0.001 \), although the group by word type interaction no longer reached significance. Again, it may be that derived words were especially difficult for the dyslexic participants, but again this interaction may be due largely to ceiling effects.

**Spelling of derived words:** The spelling of the ‘base’ section of the derived words was then examined, because this section is subject to the rules that were under investigation. For the simple phonological, simple orthographic, and complex phonological words, the base spelling needed to be maintained between the base and derived form of each word (e.g. *apt-aptly*). For the complex orthographic words, the relevant orthographic rules necessarily ‘overrode’ the requirement of maintaining the base spelling (e.g. the ‘y to i’ rule means that maintaining the *y* of *plenty* by writing ‘*plentyful*’ would not be correct). Errors in the spelling of the derived words’ endings were ignored (e.g. *orphanige* would still be counted as ‘correct’ for *orphanage*). We counted the number of base sections of the derived words spelled correctly overall. However, it is important to know whether participants were able to spell the derived words’ base forms: otherwise we could not necessarily expect participants to be able to spell derived forms correctly. Therefore, we also counted the number of derived words spelled correctly only when the base word was also spelled correctly. The means and standard deviations for each of these types of spelling are shown in Figure 2(a) and (b).
Overall, the participants seem to have written the base section of the derived forms correctly (and consistently with base forms) more often for the simple phonological words than for the other types of words, especially the simple orthographic words. Further, it appears that dyslexic spellers were less likely than the control spellers to write the base sections of the derived words correctly, especially if they also had to write the base word correctly. The control group’s performance was overall very good, and close to ceiling on the simple phonological words. This may limit the validity of parametric statistics, and should be borne in mind when interpreting the results.

The spelling of the base sections of the derived words written correctly, without regard to how the base words were spelled alone, was

![Graph showing mean and standard deviations for number of correct spellings for all derived words and for derived words with base forms also spelled correctly.](image)

Figure 2. Mean and standard deviations for number of correct spellings for all derived words (a) and for derived words with base forms also spelled correctly (b) (max.=8).
examined in a repeated-measures ANCOVA. Spelling complexity (simple, complex) and spelling type (phonological, orthographic) were the repeated measures and group was the between-subjects variable. To control for factors which may have contributed to spelling performance, we first included Raven’s Matrices and PPVT-III as covariates. This analysis revealed a main effect of group, $F(1,53)=50.4, p<0.001$. The control spellers wrote these words correctly more often than the dyslexic spellers. There was also a main effect of spelling complexity, $F(1,53)=5.55, p=0.022$. Overall, the simple words were spelled significantly better than the complex words. There was a significant interaction between group and spelling type, $F(1,53)=9.66, p=0.003$, and also between group and spelling complexity, $F(1.53)=4.16, p=0.046$. However, both of these were qualified by a three-way interaction of spelling type, spelling complexity, and group, $F(1,53)=8.96, p=0.004$. Newman–Keuls post hoc tests showed that control spellers produced more correct words than dyslexic spellers on all four word types ($p<0.01$). The control spellers performed significantly better on the simple phonological words than on all others ($p<0.05$), which did not differ significantly. The dyslexics also performed significantly better on the simple phonological words than on all others ($p<0.01$). Their spelling of the complex orthographic and complex phonological words did not differ significantly, but both were significantly better than their spelling of the simple orthographic words ($p<0.01$). The three-way interaction then would seem to be due to the low scores of dyslexics on simple orthographic words.

This ANCOVA was repeated, using only the derived words whose base forms had also been spelled correctly. Again, there were main effects of group, $F(1,53)=53.6, p<0.001$, and spelling complexity, $F(1,53)=5.20, p=0.027$. The interactions between group and spelling type, and between group and spelling complexity, no longer reached significance, but the three-way interaction between group, spelling type, and spelling complexity remained significant as before, $F(1,53)=8.04, p=0.006$, with the same pattern of significant differences revealed by Newman–Keuls post hoc tests as reported in the same three-way interaction described above. As can be seen by comparing Figure 2(a) and (b), most of the derived words whose base sections were spelled correctly also had their base forms spelled correctly when tested separately. Thus, it is not surprising that these results are so similar. Overall, it seems that both groups of spellers performed relatively well on words that could be spelled according to their sound (i.e. the simple phonological words). However, when it came to words that required the use of more complex spelling strategies—based on sound or orthographic conventions—both groups performed more poorly, with particular difficulties in the dyslexic group on simple orthographic words.

The ANCOVAs above were then repeated, with WRAT-3 general spelling ability, Raven’s, and PPVT-III as covariates to control for the possibility that the observed differences were related to the remaining differences in general spelling performance (see Table 1). These analyses were run both for all derived words spelled correctly ($F_1$), and for only those derived words whose base forms were also spelled correctly ($F_2$). For the analysis of all derived words, the main effect of spelling complexity remained significant, $F_1(1,50)=4.01, p=0.049$, but the interactions between spelling complexity and group, $F_1(1,50)=1.49, p=0.228$, and spelling type and group, $F_1(1,50)=2.93, p=0.093$, did not. For the analysis of only those
derived words whose base was spelled correctly, the main effect of spelling complexity was no longer significant, $F_2(1,50)=3.74$, $p=0.059$, but the interaction of spelling complexity and group remained non-significant, $F_2(1,50)=0.432$, $p=0.514$, and significant, $F_2(1,50)=4.82$, $p=0.033$, respectively. More importantly, however, for both analyses, the effect of group remained significant, $F_1(1,50)=13.5$, $p=0.001$, $F_2(1,50)=17.8$, $p<0.001$, as did the three-way interaction (and its post-hoc differences), $F_1(1,50)=16.3$, $p<0.001$, $F_2(1,50)=11.6$, $p=0.001$, as in the previous analyses.

The fact that this group difference, as well as the three-way interaction, remained significant even after controlling for general spelling performance (WRAT-3) indicates that the observed differences are due not to spelling ability per se, but to dyslexia and/or the experience of reading and spelling difficulties in childhood. Therefore, the salient results from the analyses of the real word spelling are that dyslexic participants were less accurate than the controls in spelling overall, and had particular difficulty with the simple orthographic words, which required memory for correct letter sequences within the base.

**Pseudowords**

Pseudowords spelled appropriately overall: The participants’ spelling of the pseudowords was also examined. Since there could be no ‘correct’ spelling for these stimuli, we based our scoring on whether or not a spelling was a plausible orthographic form of the pseudoword. Because we had been stringent in accepting only conventionally correct spellings for the real words, our analysis of the pseudowords was also a stringent one. As with the real words, we examined only the spelling of the ‘base’ section of the derived pseudowords and ignored the spelling of the endings. As with the real words, the use of orthographic rules under investigation in the complex orthographic words overrode the necessity of maintaining the exact spelling of the base section, so that, for example, *melly* to *mellisome* was scored as correct, although *mellysome* was not. We accepted phonologically plausible representations only as part of orthographically legal spelling sequences, taking into account within-word letter position. For example, before t in English, the sound /k/ can be represented with c (as in act or insect), but never with ck (the two exceptions are the compound words cocktail and necktie). For this reason, the *zecktly* was not considered a plausible spelling of *zectly*. This is a more rigorous coding scheme than that used by Pennington et al. (1986) for coding complex phonological accuracy, in which orthographically illegal spellings (e.g., *cquantity*) were accepted. It is more similar to their coding of simple orthographic accuracy, although this coding type did not take into account within-word position. Figure 3 shows the mean number of the 32 base and 32 derived pseudowords that the participants spelled appropriately overall.

Repeated-measures ANCOVAs were carried out on the data. The covariates in the first ANCOVA were scores on Raven’s Progressive Matrices and the PPVT-III. There was a main effect of group, $F(1,53)=25.9$, $p<0.001$. The control group spelled more of the pseudowords appropriately than did the dyslexic group. Group interacted significantly with pseudoword type, $F(1,53)=4.74$, $p=0.03$. Newman–Keuls post hoc tests showed that control spellers out-performed dyslexic spellers on both base and derived pseudowords ($p<0.01$), and that
both groups did better on base than derived pseudowords ($p < 0.01$). As with the real words, it seems from the means (Figure 3) that the significant interaction was due to the dyslexic participants’ poorer performance on the derived than the base pseudowords, relative to the Controls, but again this probably reflects the controls’ near-ceiling performance. The second ANCOVA, controlling for WRAT-3 spelling, Raven’s, and PPVT-III performance, also revealed a significant main effect of group, $F(1,50)=10.4, p=0.002$, but the group by pseudoword type interaction was no longer significant.

**Orthographically legal spelling of derived pseudowords:** We looked at the number of phonologically plausible, orthographically legal spellings of the base parts of the derived pseudowords. We first examined the number of derived pseudowords’ base sections that had been spelled orthographically legally overall, regardless of the spelling of the base forms in the other session. To be consistent with the real word scoring, we also counted the number of derived pseudowords whose base section participants spelled in the same way as the base form itself. For example, a participant who wrote *keet* and *keetest*, or *keat* and *keatest*, would receive one point under this scheme, whereas someone who wrote *keet* and *keatest* would not.

Figure 4(a) and (b) shows the number of orthographically legal spellings of derived pseudowords’ base sections produced overall, and the number produced when the spelling of base pseudowords was also taken into account.

As shown in Figure 4(a) and (b), the participants’ spelling of the derived pseudowords was often phonologically plausible, and sometimes consistent with their base spellings. The control spellers were much more likely to produce both legal and consistent spellings than their dyslexic peers. The number of legal spellings varied quite widely between different pseudoword types. These pseudowords clearly presented a challenge to both groups of spellers, but especially to the dyslexics. The responses (derived pseudowords overall, and with base consistent) were examined in separate repeated-measures ANCOVAs, with spelling complexity (simple, complex) and spelling type (phonological, orthographic) as the repeated measures and group as the between-subjects variable.

Figure 3. Mean and standard deviations for number of pseudowords spelled appropriately overall by the two groups (max.=32).
We first looked at the number of times that the participants spelled the base sections of the derived pseudowords in a phonologically plausible and orthographically legal way, without taking into account base spelling. Scores on Raven’s Matrices and the PPVT-III were first included as covariates. There was a main effect of group, $F(1,53)=30.1, p<0.001$. The control spellers were significantly more likely than the dyslexic spellers to produce spellings of the derived pseudowords that were both orthographically and phonologically appropriate. There was a main effect of spelling complexity, $F(1,53)=4.51, p=0.038$, with simple pseudowords spelled better than complex ones. There was

![Graph](image-url)

Figure 4. Mean and standard deviations for number of phonologically plausible, orthographically legal spellings of derived pseudowords overall (a) and with consistent base spellings (b) (max.=8).

We first looked at the number of times that the participants spelled the base sections of the derived pseudowords in a phonologically plausible and orthographically legal way, without taking into account base spelling. Scores on Raven’s Matrices and the PPVT-III were first included as covariates. There was a main effect of group, $F(1,53)=30.1, p<0.001$. The control spellers were significantly more likely than the dyslexic spellers to produce spellings of the derived pseudowords that were both orthographically and phonologically appropriate. There was a main effect of spelling complexity, $F(1,53)=4.51, p=0.038$, with simple pseudowords spelled better than complex ones. There was
also a trend towards a significant interaction between group and spelling type, $F(1,53)=3.49$, $p=0.067$. From the means, it seems that control spellers hardly differed in their spelling of orthographic (mean=6.91 out of 8) and phonological pseudowords (mean=6.70), while dyslexic spellers did relatively better on orthographic (mean=5.74) than phonological pseudowords (mean=4.57). In both cases, control spellers did better than dyslexic spellers. This ANCOVA was then re-run, with Raven’s, PPVT-III, and WRAT spelling performance as covariates. The pattern of significant results was the same as in the previous analysis, with a main effect of group, $F(1,50)=10.7$, $p=0.002$, of spelling complexity, $F(1,50)=5.56$, $p=0.022$, and the group by spelling type interaction reached significance, $F(1,50)=5.44$, $p=0.024$. The means for the group by spelling type interaction are shown in Figure 5.

Post hoc Newman–Keuls tests confirmed that the control spellers spelled both pseudoword types better than did the dyslexic spellers ($p<0.01$). The control participants did not differ significantly in their performance on the phonological and orthographic stimuli. However, the dyslexic participants spelled the orthographic pseudowords significantly better than the phonological pseudowords ($p<0.01$). By definition, the phonological pseudowords could be spelled according to their sound; there was little room for choice of spelling and, as a result, fewer letter combinations would be counted as appropriate. The orthographic pseudowords, however, could potentially be spelled with a number of different letter combinations (e.g. keetest, keatset, keitest). A group by pseudoword type repeated-measures ANOVA showed that the dyslexic participants used more varied spellings than the control participants, $F(1,30)=28.7$, $p<0.001$. Each pseudoword was spelled on average 5.03 different ways by the dyslexic group, compared with 3.75 ways by the controls. Thus, dyslexic writers may have more often ‘hit upon’ acceptable spellings for orthographic than for phonological stimuli. There is, however, some evidence of a ceiling effect for the control participants, especially with orthographic pseudowords. If more challenging items had been included, it is possible that their
advantage for orthographic pseudowords would have been as great as for phonological pseudowords.

The second group of analyses examined the phonologically plausible and orthographically legal spelling of the derived pseudowords with the base section spelled consistently in base and derived forms. When PPVT-III and Raven’s were controlled, the only significant effect was a main effect for group, with controls out-performing dyslexics, $F(1,53)=52.8, p<0.001$. When WRAT spelling was also controlled, controls again out-performed dyslexics, $F(1,50)=21.0, p<0.001$, and participants did significantly better overall on simple than on complex pseudowords, $F(1,50)=4.5, p=0.04$.

**DISCUSSION**

This study compared the spelling of phonologically and orthographically simple and complex words, both real and pseudo, by university students who reported childhood difficulties with reading and spelling, and students who reported no such early difficulties. Both the dyslexic students and the controls spelled the base words and pseudowords correctly significantly more often than their derived forms. Furthermore, even after controlling for non-verbal intelligence, vocabulary, and general spelling ability, the dyslexic spellers were poorer at spelling both real and pseudowords than the control spellers. This was true irrespective of whether words required simple phonological, simple orthographic, complex phonological, or complex orthographic spelling knowledge. Very similar patterns of results were obtained whether the spelling of all derived words was included in the analysis, or only those derived words whose base forms the participants had spelled correctly. It seems that these students’ ability to spell is fragile, and that even when general spelling ability is controlled, difficulties show up on a separate set of (pseudo)words. This supports findings by Lefly and Pennington (1991) with compensated adult dyslexics (see also Gallagher *et al.*, 1996). We found no convincing evidence for adult dyslexics compensating for their phonological deficits with relatively stronger orthographic spelling strategies, as suggested by Pennington *et al.* (1986; see below for a more detailed discussion). These results are in agreement with the developmental models assuming that phonological knowledge can act as a bottleneck for the development of orthographic knowledge. Nor did we find evidence of a relative advantage for the dyslexics in spelling morphologically complex forms (e.g. Bruck, 1993). The interactions that occurred in both the real word and pseudoword analyses appeared to show a relative difficulty for dyslexics with the morphologically complex forms (as suggested by Deacon *et al.*, 2006; Joanisse *et al.*, 2000), but in each case the interaction was more plausibly due to ceiling effects for the control participants.

Both groups performed best when spelling simple phonological derived real words, such as *aptly*, which even if unknown by rote provide strong clues to their spelling from their sound alone. Although the dyslexic group did not attain as many correct simple phonological spellings as their control-group peers, their relatively good performance on these words suggests that they had attained at least a reasonable level of phonological processing skill for real words. This result, in the domain of spelling, supports the findings of Ben-Dror *et al.* (1991)
and Watson and Brown (1992) in the domain of reading: that reading-disabled adults use phonology-based word recognition strategies that are similar to, but not as efficient as, those used by typical readers. The present spellers’ ability to rely on simple phonological knowledge (relative to their other spelling knowledge) might be an important factor in these individuals’ attainment of general literacy skills within the normal range.

Although both groups performed more poorly on the other three types of real words, the dyslexics’ particular weakness was on the simple orthographic words. These words, such as fiercest, ghostly, and deceitful, contain letter sequences representing sounds that are often represented by alternative letter sequences. Perhaps through lack of reading experience, or through lesser ability to retain orthographic representations, the dyslexics were less able to correctly produce these largely word-specific spellings. Furthermore, these are relatively infrequent words, and therefore less likely to have been memorized. The complex orthographic words, on the other hand, contain rule-based patterns, such as the y to i shift in worry/worrisome, or the consonant doubling of beg/beggar. These rules are more likely to have been memorized. It may be that the ‘complex orthographic rules’ investigated here are exactly the type of spelling rules that are memorized by individuals highly skilled at compensating for dyslexia. This might lead them to do better on such words than on simple orthographic words, which each have their own particular spelling patterns, and cannot be so easily learned according to rules. Perhaps the requirement for lexical-level orthographic processing posed an additional challenge for the compensated dyslexics in this study. Meyler and Breznitz (2003) reported similar problems in their sample, although their participants’ problems were not limited to tasks requiring lexical-level orthographic processing.

These results do not support claims that orthographic knowledge might be a relative strength, or even a compensatory tool, for dyslexic individuals (e.g. Leinonen et al., 2001; Miller-Shaul, 2005). More specifically, they do not support Pennington et al.’s (1986) finding of adult dyslexics having superior knowledge of complex orthographic rules than of complex phonological rules. In the present study, the most difficult task for the dyslexic participants seemed to be the production of letter strings that had no clear phonological rules to guide spelling, and whose orthographic structure had to be memorized (e.g. deceitful, villainous). These words apparently continue to present a challenge even for individuals who have reached reasonable levels of literacy.

Conclusions drawn from the spelling of real words are always limited by uncertainty about how much rote spelling knowledge participants bring to the task. The study therefore also included a matched set of ostensibly related base and derived pseudowords. As expected, the participants produced overall fewer ‘appropriate’ spellings of these pseudowords than they had for the real words, presumably because none could be spelled from memory, but instead through the use of strategies. As with the real words, the control participants wrote significantly more appropriate spellings than did the dyslexic participants. And as with the real words, both groups did significantly better on the base pseudowords than on their derived forms. Although the dyslexic participants may have been differentially disadvantaged by the derived pseudowords, it seems more likely that the group by word type interaction instead reflected ceiling effects in the control participants. When general spelling ability was
controlled statistically, this group by pseudoword type interaction was no longer significant, but the controls’ spelling of the pseudowords was still significantly better than that of the dyslexics. It seems that general spelling ability, as measured on the WRAT-3, does not fully reflect the ability to spell more complex and unfamiliar stimuli.

In terms of the spelling of the base portion of the derived pseudowords, the control spellers scored higher than the dyslexic spellers in every way we tried coding the data. We first considered derived pseudowords that were written in a way that was both phonologically plausible and orthographically legal. Overall, the pseudowords that could be spelled by a simple strategy were written better than those that required a complex strategy. However, even after overall spelling ability was controlled, different spelling patterns remained on the pseudoword types. The control spellers did not differ significantly in their spelling of phonological and orthographic pseudowords. In contrast, the dyslexic spellers did better on orthographic than phonological pseudowords. This result is somewhat at odds with the results from the real words, in which both groups found the phonological words easier. The dyslexic spellers’ apparently better performance on orthographic pseudowords may at least partially reflect the nature of the word categories used. The orthographic pseudowords could plausibly be spelled in more different ways than the phonological pseudowords, and the dyslexic spellers did produce more spellings of the orthographic pseudowords than did the controls. The dyslexic group may thus have ‘hit upon’ appropriate spellings for the orthographic pseudowords more often than for the phonological pseudowords. However, it is also possible that the compensated dyslexic spellers behave in a different way when word-specific knowledge is unavailable. Although their phonological skills may be strong enough to support spelling of phonologically simple real words, they may still be insufficient for dealing with completely unknown words. Dyslexic individuals may therefore need to rely also on a combination of memorizing word-specific letter patterns, and learning orthographic rules, such as consonant doubling rules.

Second, for consistency of comparison with real words, we examined the spelling of the pseudowords whose base portion had been spelled consistently, as well as phonologically plausibly and orthographically legally, from one session to the next. Both groups of participants performed significantly better on the simple than the complex pseudowords. This appeared to be largely driven by relatively good performance on the simple phonological pseudowords (although this effect did not reach significance). These pseudowords were presumably the easiest to spell consistently because their simple sound sequences made their spelling relatively easy to guess. Control spellers were more likely to be consistent than their compensated dyslexic counterparts in their spelling of all four pseudoword types, perhaps because they were better able to produce a stable mental representation of the base portion of a pseudoword when they first wrote it, which persevered when they went to spell it a week later. The decision to spell two apparently related pseudowords consistently might also depend on one’s understanding of derivational morphology, and its influence on the spelling of English words. There is evidence that those with dyslexia show levels of morphological understanding lower than that which would be expected based on their reading levels (e.g. Deacon et al., 2006; Joanisse et al., 2000), and this may
help to explain the dyslexic participants’ lower levels of spelling consistency. The current results also provide evidence that individuals with dyslexia are able to produce plausible spellings of words, but that they might find it difficult to choose the correct one, or to remember the one they chose before.

The present study has limitations that should be noted. As with any such group, the participants in this study are likely to represent a heterogeneous sample (for individual-level data across different task domains, see Parrila et al., 2007). All of our compensated dyslexic participants reported an early history of problems with reading/spelling, all showed current problems in word identification, decoding, and/or spelling, and, as a group, behaved very similarly to participants in earlier studies on high-functioning dyslexics (e.g. Gallagher et al., 1996; Hatcher et al., 2002). However, the results of the present research should still be interpreted with caution, because not all participants had a formal diagnosis of dyslexia. It is possible that some of the participants (had) also experienced co-morbid disorders such as attention deficit hyperactivity disorder (ADHD) or developmental dyspraxia. It is likely that for individuals with such co-morbidity, the difficulties experienced with spelling and reading are largely attributable to the dyslexia, rather than to the other disorder. However, co-morbid disorders could interact with the experience of dyslexia to make the process of learning to read and write even more difficult, and perhaps qualitatively different from that experienced by individuals without such co-morbidity. Future studies should screen for disorders such as ADHD and dyspraxia, and should employ a formal diagnosis of dyslexia in participant selection. Preliminary attempts to categorize the present participants into subtypes (such as phonological and surface dyslexics) and to compare their results were not successful, but future studies would do well to focus on differences between individuals or sub-types with larger samples than was available for the current study. It would also be informative to interview participants about their spelling strategies and their knowledge of English spelling rules to differentiate between application of memorized rules and implicit knowledge of orthographic conventions. Finally, the conclusions are drawn from the spelling of only 8 (pseudo)words per category (128 stimuli overall). It should be borne in mind that a more variable and/or representative range of spellings may have occurred if a greater number of words and pseudowords had been included per category. This might be an aim for future research.

Nevertheless, the present study provides insight into the spelling of individuals who, despite self-reported early difficulties, have managed to attain reading and spelling levels within the normal range. The dyslexic participants performed more poorly at spelling all experimental real and pseudowords than their typical peers, even when general spelling ability was controlled. It seems that many childhood problems with spelling can never be completely compensated for, and that a number of problems remain. However, it is encouraging that these individuals were able to make use of a number of strategies to support their spelling attempts. When writing real words, these participants appeared to use simple phonological strategies relatively well, although they had more difficulty using phonological and orthographic rules to guide their spelling, and the most difficulty with words whose letter strings had to be memorized. When spelling pseudowords, the dyslexic individuals continued to spell by sound, but also made use of a number of phonologically
and orthographically appropriate spellings to produce plausible spellings of a
number of orthographic sequences. From this evidence it seems that those
compensating for childhood literacy difficulties can make use of their existing
phonological skills, and that they do not have unexpectedly strong orthographic
skills to make up for any phonological processing problems, as suggested by
Pennington and colleagues. These results are thus in line with developmental
models suggesting that high-quality phonological representations are likely to
precede high-quality orthographic representations (e.g. Ehri, 1991, 1992; Frith,
1986; Share, 1995).

Although these students have achieved apparently normal reading and
spelling levels, and are managing at university, it seems that extra training and
practice might be of benefit. Many of these students might already have had extra
reading instruction during their schooling, and so it would be important to focus
any intervention in a way that would further improve the skills that these
individuals already possess. Specific instruction in the use of more complex
phonological and orthographic spelling rules, as well as targeted practice in the
memorization of letter sequences of common but irregular words, and in the use
of morphological links between words, might help these students to further
improve their reading and writing skills. Such instruction has been shown to
improve spelling in much younger children (e.g. Arnbak & Elbro, 2000; Nunes,
Bryant, & Olsson, 2003) and might also help these older students to struggle less
to attain literacy levels that other students achieve more easily. Ultimately, the
lessons learned from working with these students might also help to improve the
literacy skills of others with dyslexia who still find reading and spelling to be
difficult and challenging activities.

APPENDIX

Real word pairs: Mean written frequency for base and derived words shown for
each word category (expressed in terms of Standard Frequency Index (SFI),
related to frequency per million, e.g. a word with an SFI of 40 occurs
approximately once per one million tokens; Carroll et al., 1971): simple
phonological: blonde-blondest, apt-aptly, hermit-hermitage, adapt-adapter, both-
er-bothersome, regret-regretful, venom-venomous, astonish-astonishment (base:
6.6, derived: 3.0). Simple orthographic: fierce-fiercest, ghost-ghostly, orphan-
orphanage, conquer-conqueror, quarrel-quarrelsome, deceit-deceitful, villain-
villainous, acknowledge-acknowledgement (base: 6.5, derived: 2.4). Complex
phonological: ash-ashen, discreet-discretion, crucifix-crucifixion, addict-addiction,
electric-electrician, fruit-fruition, face-facial, part-partial (base: 124.8, derived:
4.25). complex orthographic: scarce-scarcity, sparse-sparsity, slip-slippage, beg-
beggar, worry-worrisome, plenty-plentiful, submit-submission, abolish-abolition
(base: 23.2, derived: 3.5).

Note: Real words were matched for frequency on the basis of their derived
forms. Word pairs were chosen so that base and derived forms were as similar as
possible in frequency, but this was not possible for two highly frequent base
forms: face and part. Nevertheless, the relative frequency of these words’ base
forms did not appear to confer any advantage to spelling these two base-derived
pairs more consistently than the rest.

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