Many Roads to Success: How High Functioning Adults with Phonological Difficulties Achieve Word Reading Success

by

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ABSTRACT

This dissertation examines the word reading skills of high-functioning adults with reading difficulties (HFRDs) in a sample of 145 college HFRDs who reported childhood or current reading difficulties and 70 controls. In the first part of this three-part study, the HFRDs were further categorized into compensated HFRDs, persistent HFRDs, and late-emerging HFRDs. The compensated HFRDs (*n* = 26) were students who reported childhood reading difficulties but no current reading difficulties. The persistent HFRDs (*n* = 104) were students who reported both childhood and current reading difficulties. The late-emerging HFRDs (*n* = 15) were students who reported no childhood reading difficulties but who did report current reading difficulties. The three HFRD subgroups were compared to each other and to the controls to determine whether residual reading weaknesses exist.

Results showed that the persistent HFRDs displayed continuing weaknesses in all reading skills examined when compared to the controls, except in sublexical orthographic processing skills and lexical access speed. The compensated HFRDs displayed persisting difficulties relative to the controls in word reading accuracy, decoding accuracy and speed, phonological awareness, rapid digit naming, word-level orthographic processing accuracy, and print exposure. When compared to the persistent HFRDs, the compensated HFRDs showed relative strengths in word reading efficiency and decoding efficiency. Finally, the late-emerging HFRDs resembled the compensated HFRDs in performance, except for a relative strength in decoding speed. They outperformed the persistent HFRDs in word reading accuracy and efficiency, irregular word reading speed, decoding speed, word-level orthographic processing accuracy, and orthographic processing speed. However, when compared to the controls, they showed relative difficulties in decoding accuracy, spelling accuracy, and print exposure.

In the second part of the study, all HFRDs were reclassified into groups based on the discrepancy between their word reading and phonological decoding skills. When examining accuracy dissociations (AD), the AD(+) group (*n* = 12) consisted of HFRDs whose standardized word reading accuracy skills were ≥ 1 SD above their standardized decoding accuracy skills, the AD(0) group (*n* = 67) consisted of HFRDs whose standardized word reading accuracy skills were within 0.5 SD of their standardized decoding accuracy skills, and the AD(-) group (*n* = 12) consisted of HFRDs whose standardized word reading accuracy skills were ≥ 1 SD below their

standardized decoding accuracy skills. Results revealed that the AD(+) group also had significantly better vocabulary, spelling accuracy, and print exposure skills than the AD(-) group. When examining efficiency dissociations (ED), the ED(+) group (*n* = 24) consisted of HFRDs whose standardized word reading efficiency skills were ≥ 1 SD above their standardized decoding efficiency skills, the ED(0) group (*n* = 60) consisted of HFRDs whose standardized word reading efficiency skills were within 0.5 SD of their standardized decoding efficiency skills, and the ED(-) group (*n* = 17) consisted of HFRDs whose standardized word reading efficiency skills were ≥ 1 SD below their standardized decoding efficiency skills. Results indicated that the ED(+) group was significantly more efficient at morphological parsing than the ED(-) group, and significantly faster at choosing correct spelling and naming objects than the ED(0) group. In contrast, the ED(+) group was less accurate in decoding than both the ED(-) and ED(0) groups.

In the third part of the study, the individual profiles of the HFRDs in the AD(+) and ED(+) groups were detailed in relation to the controls. Many of these surprisingly good word readers displayed print exposure levels comparable to the controls or better. Many ED(+) individuals also showed naming speed skills comparable to the control group. Some individuals in both the AD(+) and ED(+) groups also exhibited the double deficit profile of phonological awareness and naming speed deficits, but with varying word reading skills rather than the expected poor reading prognosis.

PREFACE

This thesis is an original work by Sandy Lai. The research project, of which this thesis is a part, has received approval from the University of Alberta Research Ethics Board: Project Name "Word Recognition in Post-secondary Students with Reading Disabilities", ID Pro00000330, Approved June 2008. The secondary analysis of the collected data, which comprises this thesis, has also received approval from the University of Alberta Research Ethics Board: Project Name "How High Functioning Adults with Phonological Difficulties Achieve Word Reading Success", ID Pro00058913, Approved August 2015.

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CHAPTER I: INTRODUCTION

Most of the literature on reading difficulties have focused on child populations (e.g., Adams, 1990; Snowling, 2000), examining their development and characteristics. However, there is also an increasing need for research on these individuals as they become adults. In particular, a growing subset of individuals with reading difficulties are entering postsecondary education. For example, in 2011, the Canadian University Survey Consortium surveyed 25 postsecondary institutions and found that approximately 3% of the student population reported learning disabilities (Canadian University Survey Consortium, 2011). Similarly, in 2012, a Canadian-wide survey of 122 postsecondary institutions revealed that 2-5% of postsecondary students register with student disability services, with 74% of the institutions reporting that 25% or more of the students receiving disability services have Learning Disability or Attention Deficit Hyperactivity Disorder diagnoses (Harrison & Wolforth, 2012). Moreover, a significant number of students with reading difficulties do not officially report their disabilities. Therefore, postsecondary institutions admit a substantial number of students who require support to continue academic success.

These adults with reading difficulties who nevertheless become eligible to attend postsecondary education, can be termed high-functioning adults with reading difficulties (HFRDs). These HFRDs may be “compensated dyslexics” (Lefly & Pennington, 1991), defined as adults who had childhood reading difficulties but currently read at normal reading levels. HFRDs may also be readers with residual reading and spelling difficulties who have developed functional coping strategies. Regardless of whether they have obtained normal reading levels by adulthood, HFRDs have managed their childhood reading difficulties to the point where they are able to achieve higher education (i.e., post-secondary education).

To date, a handful of studies have examined the HFRD population, but have mostly focused on their residual difficulties when compared to typical readers. From a practical perspective, it is essential to identify the persisting difficulties displayed by HFRDs in order to accommodate them appropriately to facilitate postsecondary academic success. However, from a theoretical perspective, it is also interesting to examine the HFRD population because of the implications for theoretical models of reading. For example, most models of reading development posit phonological skills as the primary route to word reading (e.g., Snowling, 2001). In these models, reading difficulties therefore result primarily from phonological deficits, referring to difficulties in manipulating, storing, and/or retrieving phonological units. However, many HFRDs have word reading accuracy skills that fall in the average range despite persistent phonological deficits (e.g., Law, Wouters, & Ghesquière, 2015), suggesting that they may be using cognitive processes other than phonological skills when reading. Such findings may indicate that single-route models of reading (e.g., Snowling, 2001) may be insufficient in explaining reading processes in all populations, and that more comprehensive models (e.g., Castles & Coltheart, 1993) may be required.

Therefore, my dissertation attempts to disentangle the word reading process in HFRDs and profile their strengths and weaknesses. In doing so, I aim to examine cognitive processes that may be used by HFRDs as alternatives to phonological skills. The first part of this dissertation compares three different groups of HFRDs to each other and to a group of typical college readers on a variety of reading skills. The first HFRD group consists of individuals who report both childhood and current reading difficulties, and are similar to the uncompensated HFRDs in previous studies. The second HFRD group consists of individuals who report childhood reading difficulties but no current reading difficulties. This second group is analogous to the compensated dyslexics in previous research. The third HFRD group consists of individuals who report no childhood reading difficulties but who do report current reading difficulties. The identification and analysis of these individuals has not previously occurred in the HFRD literature. Through the group comparisons, I examine whether persisting reading difficulties exist in each HFRD group and whether the three HFRD groups display different reading profiles.

In the second part of this dissertation, I identify a subset of HFRDs whose word reading accuracy skills are stronger than expected from their phonological decoding accuracy skills, a subset whose word reading accuracy skills are weaker than expected from their phonological decoding accuracy skills, and a subset whose word reading accuracy skills are at the level expected from their phonological decoding accuracy skills. I subsequently compare the three subsets on a variety of reading skills. Similarly, I identify a subset of HFRDs whose word reading efficiency (i.e., accuracy under time pressure) skills are stronger than expected from their phonological decoding efficiency skills, a subset whose word reading efficiency skills are weaker than expected from their phonological decoding efficiency skills, and a subset whose word reading efficiency skills are at the level expected from their phonological decoding efficiency skills. These three subsets are also compared on a variety of reading skills. Through the two sets of analyses, I examine whether the HFRDs whose word reading skills exceed the level expected from their decoding skills also display strengths in other reading processes, as these relative strengths may point towards possible compensatory mechanisms for decoding difficulties in these individuals.

Finally, in the third part of this dissertation, I analyze individual profiles of the HFRDs whose word reading accuracy skills surpass their decoding accuracy skills and the HFRDs whose word reading efficiency skills surpass their decoding efficiency skills. The detailing of these HFRDs' strengths and weaknesses, as compared to their typically reading peers, further serves to identify the possible compensatory mechanisms that enable these individuals to achieve word reading success despite phonological difficulties. If the potential compensatory mechanisms identified in the individual profiles echo the findings of the previous group comparisons, the results will further support the role of particular skills as alternative routes to word reading.

The next chapter reviews the literature on the HFRD population's abilities in word reading and various related reading processes. Namely, I will discuss previous HFRD research in the areas of word reading, phonological processing, orthographic processing, and morphological processing. I will also examine the few studies that have investigated possible compensatory mechanisms in HFRDs. As the reading process varies across different languages, the current study will focus on readers of the English language to maintain consistency.

CHAPTER II: LITERATURE REVIEW

Word Reading

Word Reading Accuracy

Most studies have found word reading accuracy deficits in HFRDs when compared to typical college readers. For example, Bruck (1990) examined a group of 20 HFRDs who were diagnosed with dyslexia in childhood, and a group of 20 typical college readers who were matched to the HFRDs on sex, educational level, and age. The HFRDs were significantly less accurate than the typical college readers on both a standardized and an experimental word reading task, despite having average or above average verbal and nonverbal intelligence. Similarly, Wilson and Lesaux (2001) recruited a group of 28 HFRDs who had been diagnosed with learning disabilities within 3 years of entering university and a group of 31 typical college readers. The two groups did not differ significantly in age, receptive vocabulary, verbal intelligence, or nonverbal intelligence. The HFRDs were significantly less accurate than the controls on a standardized measure of word reading accuracy. The authors also administered Bruck's (1990) experimental word reading task, and again found that the HFRDs made significantly more errors than the controls.

In a more recent study, Parrila, Georgiou, and Corkett (2007) recruited a group of 28 HFRDs who self-reported childhood reading problems and a group of 27 typical college readers. The HFRDs were significantly less accurate both when reading words in a standardized task and when reading irregular words in an experimental task. Similarly, Deacon, Cook, and Parrila (2012) examined a group of 20 HFRDs with diagnosed dyslexia, 31 HFRDs who self-reported childhood reading problems, and 33 typical college readers. The controls outperformed both HFRD groups on a standardized measure of word reading accuracy, whereas the two HFRD groups did not differ from each other. Moreover, Law et al. (2015) also administered a standardized word reading accuracy measure to a group of 54 typical college readers and 36 HFRDs with diagnosed dyslexia. The HFRDs were significantly less accurate than the controls, despite being comparable in age, gender, and nonverbal intelligence. One interesting finding in this study, however, is that the HFRD group mean fell within the normal range of performance

(M = 91.7, SD = 10.1, on a standardized scale with M = 100 and SD = 15), along with the control group mean.

In comparison to studies comparing HFRDs and typical college readers, only one study has compared word reading accuracy in HFRDs and younger typical readers. Bruck's (1990) study also recruited a group of 15 Grade 6 typical readers, in addition to the 20 HFRDs and 20 typical college readers. The author found that the HFRDs performed comparably to the younger typical readers in word reading accuracy on both the standardized and experimental measures.

Some studies have also examined word reading differences between compensated and uncompensated HFRDs. For example, Birch and Chase (2004) recruited a group of 28 HFRDs who had been previously diagnosed with reading disabilities and a group of 13 typical college readers. The authors then classified the 28 HFRDs into compensated and uncompensated HFRDs based on their performance on word reading and spelling tasks. The 14 compensated HFRDs' reading and spelling accuracy scores fell in the average range and within one standard deviation of their intelligence scores. In contrast, the 14 uncompensated HFRDs' reading and spelling accuracy scores fell below the average range and more than one standard deviation below their intelligence scores. The three participant groups differed significantly in verbal intelligence, with the typical college readers having the highest scores and the uncompensated HFRDs having the lowest scores, but not in nonverbal intelligence. The authors subsequently administered an experimental regular and irregular word reading task to the participants. Regular words are words that can be pronounced by applying spelling-sound correspondences (e.g., must), whereas irregular words are words that cannot be accurately pronounced by applying spelling-sound correspondences (e.g., does). The three groups were equally accurate when reading regular words. However, when reading irregular words, the uncompensated HFRDs were significantly less accurate than the compensated HFRDs, who in turn were significantly less accurate than the controls. Unfortunately, the authors did not control for verbal intelligence when comparing the three groups; thus it is unclear whether the significant differences are due to differences in verbal intelligence between the groups.

In another study, Lefly and Pennington (1991) administered a standardized oral reading task to a group of 20 uncompensated HFRDs, 20 compensated HFRDs, and 19 typical college readers. The uncompensated HFRDs were individuals who self-reported childhood reading difficulties and also showed current difficulties on standardized measures of reading and spelling accuracy. The compensated HFRDs were individuals who self-reported childhood reading difficulties but did not show current difficulties on standardized measures of reading and spelling accuracy. The three groups were matched on age, socioeconomic status, intelligence, and education. The oral reading task consisted of reading passages arranged in increasing difficulty, and participants started with a passage they could read with no errors and were stopped after having made seven or more errors in a passage. The authors then calculated a word reading accuracy score by averaging the number of errors in the final three passages read by each participant. Similar to Birch and Chase's (2004) study, the uncompensated HFRDs made significantly more errors than both the compensated HFRDs and the typical college readers. However, in contrast to the previous study, the compensated HFRDs were comparable to the controls in accuracy.

Therefore, both studies (Birch & Chase, 2004; Lefly & Pennington, 1991) showed that the uncompensated HFRDs were significantly less accurate word readers than the typical college readers. However, the results differ when comparing the compensated HFRDs to typical college readers. One main discrepancy between the two studies is that Birch and Chase's study examined isolated word reading accuracy, whereas Lefly and Pennington's study examined contextual word reading accuracy. Thus it is possible that word reading in context facilitates accuracy for some HFRDs, particularly the compensated HFRDs.

Word Reading Speed

The persisting word reading difficulties in HFRDs are also apparent when measuring word reading speed or fluency. For example, in Bruck's (1990) study, the HFRDs were not only less accurate in naming words than the typical college readers, but also significantly slower. Wilson and Lesaux's (2001) study replicated Bruck's findings with the same experimental word reading task, and also with another standardized word reading task. Similarly, Parrila et al. (2007) found the HFRDs were significantly slower than the controls to name both regular and irregular words.

In another study, Kirby, Silvestri, Allingham, Parrila, and La Fave (2008) examined a group of 36 HFRDs with current reading disability diagnoses and 66 typical college readers. The participants completed a silent passage reading task and marked their progress in the first passage after 1 minute. The authors then counted the number of words read in the first passage within 1 minute. On average, the HFRDs read 44 fewer words than the controls. Administering the same task, Deacon et al. (2012) also found that the typical college readers read significantly more words than both the diagnosed HFRDs and the self-reported HFRDs. However, the self-reported HFRDs also read significantly more words than the diagnosed HFRDs. In this study, the controls read on average 39 more words than the self-reported HFRDs, who in turn read on average 31 more words than the diagnosed HFRDs.

The word reading fluency deficits in HFRDs appear to be more pervasive than the word reading accuracy deficits. For example, even though Bruck's (1990) HFRDs were equally accurate at reading words as the Grade 6 typical readers, they were significantly slower. Similarly, other studies have also found that even compensated HFRDs are impaired in word reading speed when compared to typical college readers. In particular, two studies (Birch & Chase, 2004; Lefly & Pennington, 1991) have found that the uncompensated HFRDs were significantly slower than the compensated HFRDs, who in turn were significantly slower than the typical college readers. In Birch and Chase's study, this pattern occurred both when reading irregular words and when reading regular words, despite no group differences in regular word reading accuracy. In Lefly and Pennington's study, the same pattern was found in a standardized oral reading task for which the authors calculated a word reading speed score by timing the last three passages read by each participant. Therefore, it appears that HFRDs display robust deficits in word reading speed, with uncompensated HFRDs showing the largest deficits.

Context Effects

Some studies have also examined the effect of context on word reading speed. In Bruck's (1990) study, the author first presented 64 target words in sentences with neutral context (e.g., *When I press the button, you will see the word* ____.). The same target words were subsequently embedded within a prose passage. Both the typical college readers and HFRDs read the target words significantly faster in the prose passage when they were previously embedded in meaningful context than in neutral context, but the facilitation effect was much larger for the HFRDs. There was no facilitation effect for the Grade 6 typical children.

Similarly, Ben-Dror, Pollatsek, and Scarpati (1991) recruited a group of 20 HFRDs who had been diagnosed with dyslexia and performed below the 40th percentile on a standardized word reading accuracy measure. They administered a task which placed the 30 easy target words and 30 difficult target words as the last words in sentences. The difficult words were longer (Word length = 4.5 vs 8.0) and less frequent (Kucera-Francis Index = 108 vs. 9.4) than the easy words. The sentences had congruous context (e.g., *The reader opened the* ***book****.*), neutral context (e.g., *The next word will be* ***book****.*), or incongruous context (e.g., *The plane flew above the* ***book****.*). The authors calculated the facilitation effect as being the difference between the congruous and neutral conditions. The HFRDs showed a significant facilitation effect for the difficult words, meaning that they read difficult words significantly faster in sentences with congruous context than in sentences with neutral context. The authors also calculated the inhibition effect as being the difference between the incongruous and neutral conditions. The HFRDs showed no significant inhibition effects for either the easy or the difficult words. Thus their target word reading speed was not reduced when the words were embedded in incongruous contexts. Finally, the authors calculated an overall context effect as being the difference between the congruous and incongruous conditions. The overall context effect was significant for the HFRDs for both easy and difficult words, indicating that they were significantly faster at reading target words embedded in congruous sentences than those embedded in incongruous sentences. Therefore, the authors concluded that HFRDs were able to use context to facilitate word reading speed.

In a more recent study, Corkett and Parrila (2008) examined a group of 24 HFRDs and 31 typical college readers. The HFRDs were college students who self-reported a history of reading difficulties. The HFRDs and controls were comparable in untimed reading comprehension accuracy, but the HFRDs performed significantly worse in verbal intelligence, nonverbal intelligence, spelling accuracy, reading accuracy, decoding, reading rate, and timed reading comprehension. In Experiment 1, the authors presented the participants with target words embedded in neutral sentences (e.g., *The stuff was placed near the* ***decanter*****)** and congruent sentences (e.g., *The wine was served from the* ***decanter*****)**. The overall facilitation effect was significant, but did not interact significantly with group and did not remain significant when accounting for reading speed. Similarly, the authors presented target words embedded in neutral sentences and incongruent sentences (e.g., *The politician appealed to the* ***decanter***). The overall inhibition effect was significant, and significantly stronger for the HFRDs than for the controls even after accounting for reading speed. Therefore, HFRDs were significantly more affected by incongruous context than the controls.

In Experiment 2 of the study, Corkett and Parrila (2008) presented the same participants with sentences ending with a homograph (i.e., a word with two meanings). The sentences biased either dominant meanings (e.g., *He heard a* ***bark***) or subordinate meanings (e.g., *He bought a* ***chest***) of the homographs. The participants named a target word after reading a sentence aloud. The target words were either semantically related to the biased meaning of the homographs in a salient way (e.g., *bark* → *dog*), semantically related to the biased meaning of the homographs in a nonsalient way (e.g., *bark* → *animal*), or semantically unrelated to the biased meaning of the homographs (e.g., *organ* → *book*). The results revealed a significant inhibition effect for the HFRDs. Specifically, after being primed with the dominant meanings of the homographs, the HFRDs were significantly slower at naming target words that were semantically related in a nonsalient way to the dominant meaning of the homographs than target words unrelated to the dominant meaning of the homographs. In other words, priming the dominant meanings of the homographs subsequently slowed the HFRDs at reading distantly related target words, indicating that the HFRDs were sensitive to sentence context. The inhibition effect did not occur after reading sentences priming subordinate meanings of the homographs. The controls also displayed a significant inhibition effect, but with a contrasting pattern. After being primed with the subordinate meanings of the homographs, the controls were significantly slower to name target words semantically related in a salient way to the subordinate meaning of the homographs than target words unrelated to the subordinate meaning of the homographs. The controls displayed no significant inhibition effects after reading sentences priming dominant meanings of the homographs. Both inhibition effects remained significant even after controlling for sentence reading speed. The authors concluded that the presence of the context effects in both Experiments 1 and 2 supported the argument that HFRDs use an interactive reading process in which context influences word reading performance.

Regularity and Frequency Effects

In addition to context effects, some studies have examined whether word regularity and word frequency affect HFRDs and typical college readers in similar ways. To examine regularity effects, researchers generally explore performance differences between regular and irregular words. To examine frequency effects, researchers generally examine performance differences between high frequency and low frequency words.

In Bruck's (1990) study, the participants named 15 regular high frequency words, 15 regular low frequency words, 15 irregular high frequency words, and 15 irregular low frequency words. The typical college readers read regular and irregular words equally quickly in both high frequency and low frequency conditions, which is expected for skilled readers. The Grade 6 typical readers read regular and irregular words equally quickly for high frequency words, but were slower to read low frequency irregular words than low frequency regular words. This pattern is also expected for their reading level, as they can recognize familiar (i.e., high frequency) words by sight but must apply sounding out strategies for unfamiliar (i.e., low frequency) words. Thus when reading low frequency words, they were slower to read irregular words than regular words because irregular words cannot be sounded out entirely. In contrast, the HFRDs were slower to read irregular words than regular words for both high frequency and low frequency words. Hence the author suggested that HFRDs must apply sounding out strategies for all words, which is similar to the immature word reading processes found in beginning readers and dyslexic children (e.g., Backman, Bruck, Hebert, & Seidenberg, 1984). Moreover, considering that HFRDs have impaired phonological processes (e.g., Aaron & Phillips, 1986), relying on sounding out strategies may be particularly detrimental to HFRD word reading performance.

The regularity effect exhibited in Bruck's (1990) study appears to affect both compensated and uncompensated HFRDs. Birch and Chase (2004) also found that both the compensated and uncompensated HFRDs were significantly slower and less accurate when reading irregular words than when reading regular words. However, in contrast to Bruck's (1990) study, the typical college readers also showed the same regularity effect.

The presence of the regularity effect may also depend on whether accuracy or response times are examined. For example, in addition to the 20 HFRDs, Ben-Dror et al. (1991) also recruited 20 younger typical readers (mean age = 11.7) and 20 typical college readers. The younger readers were matched individually to the HFRDs on a standardized word reading accuracy measure. In an experimental task, the participants read 39 regular words and 39 irregular words. When examining accuracy, all three groups made significantly more errors when naming irregular words than when naming regular words. When examining response time, however, there was no significant regularity effect. Therefore, HFRDs appear to display regularity effects across different studies, but the effect is inconsistently manifested in accuracy, speed, or both.

Phonological Processing

Due to phonological skills' prominent role in reading ability (e.g., Adams, 1990), many studies have examined phonological processes in HFRDs. Phonological processing generally refers to the recognition, manipulation, and retrieval of sound units (Wagner & Torgesen, 1987). Phonological decoding refers to the ability to convert print into sound through the use of letter-sound conversion rules. Readers must recognize that printed letters represent sound, and systematically translate letters or letter clusters into sound units in order to pronounce a word. Phonological awareness refers to the ability to orally perceive and manipulate sound components in words, which can range from whole word units to phonemes (i.e., single speech sounds). For example, the word *cat* can be orally decomposed into its three phoneme units of */k/*, */a/*, and */t/*. Phonological memory refers to the storage of phonological units in short-term or working memory. Finally, naming speed refers to the speed at which readers can name a set of stimuli (see Kirby, Georgiou, Martinussen, & Parrila, 2010, for a review).

Phonological Decoding

Examining a group of 20 college dyslexics, Aaron and Phillips (1986) found that, although their reading profiles varied greatly, they all displayed deficits in grapheme-phoneme conversion in the absence of oral language difficulties. These residual phonological difficulties seem to be most apparent when they were required to read nonwords, which are made-up words that conform to the grapheme-phoneme conversion rules of the English language (e.g., *wuck*, *slome*).

Nonword reading accuracy. Many other studies have also found HFRDs to be impaired in nonword reading when compared to typical college readers, even when controlling for background variables. For example, by computing reading quotients from childhood assessment records, Felton, Naylor, and Wood (1990) identified a group of 37 HFRDs and a group of 40 typical adult readers. Although the participants were not recruited through postsecondary institutions, the average years of education exceeded high school for both groups. The HFRDs were significantly less accurate than the controls on a standardized nonword reading measure, even after controlling for childhood socioeconomic status and childhood intelligence. The result was also significant after controlling for adult intelligence and education.

Similarly, Gallagher, Laxon, Armstrong, and Frith's (1996) study examined a group of 10 HFRDs with diagnosed dyslexia and a group of 10 typical sixth-form (i.e., Grade 12) readers. Although the two groups were comparable in academic grades and word reading accuracy, the HFRDs were significantly less accurate than the controls when reading nonwords in an experimental task. In a subsequent study, Snowling, Nation, Moxham, Gallagher and Frith (1997) recruited a group of 14 self-reported HFRDs and 19 typical college readers. The HFRDs were also significantly less accurate than the controls on the same nonword reading task, even after controlling for verbal and nonverbal intelligence. In a more recent study, Wilson and Lesaux (2001) also found that the HFRDs were significantly less accurate than the controls in nonword reading, even though the groups were comparable in age, verbal intelligence, and nonverbal intelligence. Similarly, Kemp, Parrila, and Kirby (2008) also found nonword reading deficits in their HFRDs when compared to typical college readers who were matched on nonverbal intelligence and spelling ability.

Other studies have compared HFRDs to both typical college readers and reading-level controls. For example, Pennington, Lefly, van Orden, Bookman, and Smith (1987) examined 18 HFRDs who reported childhood reading difficulties and showed current reading difficulties, 18 typical adult readers, and 18 reading-level controls. The reading-level controls were matched to the HFRDs based on grade equivalent scores on a measure of word reading accuracy, and were typical readers for their grade level. The HFRDs performed significantly worse on a standardized nonword reading measure than both the typical adult readers and the reading-level controls. Similarly, in Bruck's (1990) study, the participants were administered an experimental nonword reading task consisting of 40 nonwords. The HFRDs were significantly less accurate than both the typical college readers and the Grade 6 typical readers, even though the HFRDs were comparable to the younger readers in word reading accuracy, reading comprehension accuracy, and spelling.

Finally, Birch and Chase (2004) examined nonword reading accuracy in uncompensated HFRDs, compensated HFRDs, and typical college readers. The uncompensated HFRDs were significantly less accurate at reading nonwords than the compensated HFRDs, who were in turn significantly less accurate than the controls. Interestingly, these differences occurred even though there were no accuracy differences between the groups when reading regular words, which also require using similar grapheme-phoneme conversions.

Nonword reading speed. In addition to nonword reading inaccuracies, HFRDs also display deficits in nonword reading speed or fluency when compared to typical adult readers. For example, in Bruck's (1990) study, the HFRDs were significantly slower at reading nonwords than the typical college readers. Similarly, Leong (1999) recruited nine HFRDs with diagnosed dyslexia and nine typical college readers. He administered a nonword decision task in which participants decided which nonword in a pair sounded like a real word (e.g., *kake* in the *dake-kake* pair), and measured response latency. The results also showed that the HFRDs responded significantly slower than the controls.

On the other hand, the results are more inconclusive when comparing HFRDs and reading-level controls. In Bruck's (1990) study, in addition to being less accurate, the HFRDs were also significantly slower than the Grade 6 typical readers at reading nonwords. In Leong's (1999) study, the nine reading-level controls were Japanese English-as-a-Second-Language (ESL) college students who performed comparably to the HFRDs on a contextual word naming measure and a standardized spelling measure. In contrast to Bruck's (1990) study, he found that the HFRDs and the reading-level controls responded equally quickly on the nonword decision task. However, it is difficult to directly compare the two studies as Leong's reading-level controls were not native English speakers.

Moreover, nonword reading speed deficits are also apparent in both uncompensated HFRDs and compensated HFRDs. In Birch and Chase's (2004) study, similar to the pattern for nonword reading accuracy, the uncompensated HFRDs were significantly slower to read nonwords than the compensated HFRDs. The compensated HFRDs were, in turn, significantly slower than the typical college readers.

Nonword versus real word reading. Another way to examine HFRDs' decoding skills is to compare their real word and nonword reading performance. For example, in Bruck's (1990) study, the experimental task also included 40 real words that were similar to the 40 nonwords in length, syllable structure, and orthographic structure. The HFRDs were significantly slower and less accurate at reading nonwords than real words.

Similarly, in Ben-Dror et al.'s (1991) study, the HFRDs, typical college readers, and reading-level controls read both words and nonwords in the same task. The HFRDs and reading-level controls were matched on word reading accuracy. The HFRDs were not only significantly slower and less accurate than the two control groups when reading both words and nonwords, but also significantly more impaired when reading nonwords (compared to real words) than the other two groups. More specifically, the HFRDs were 615 ms slower at reading nonwords than real words, whereas the typical college readers were only 66 ms slower and the reading-level controls were only 78 ms slower. The HFRDs' error rates also increased from 6.1% on real words to 36.4% on nonwords, whereas the typical college readers' error rates increased from 4.8% to 12.2% and the reading-level controls' error rates increased from 4.9% to 24.6%. Therefore, the HFRDs were more negatively impacted by the nonwords than the other groups.

A similar finding also occurred in Birch and Chase's (2004) study with both compensated and uncompensated HFRDs. The uncompensated HFRDs performed significantly worse than the compensated HFRDs and typical college readers when reading 30 regular words, 30 irregular words, and 30 nonwords. However, the uncompensated HFRDs' accuracy and speed were the most impaired when reading nonwords. More specifically, the uncompensated HFRDs scored 17 points lower than the typical college readers when reading irregular words and 4 points lower when reading real words, but they scored 29 points lower than the controls when reading nonwords. Likewise, the uncompensated HFRDs were 536 ms slower than the typical college readers when reading nonwords, but only 384 ms slower when reading irregular words and 346 ms slower when reading regular words. Therefore, the uncompensated HFRDs were most impaired when reading nonwords.

Phonological Awareness

Besides decoding deficits, HFRDs also show difficulties with more basic sound skills, particularly when manipulating small sound segments such as phonemes. For example, Felton et al. (1990) administered a standardized measure of phonetic discrimination and sound analysis skills to 37 HFRDs and 40 typical adult readers, who were identified based on reading quotients calculated from childhood records. The HFRDs performed significantly worse than the controls, even after controlling for intelligence and education. In another study, Kitz and Tarver (1989) administered a phoneme reversal task to a group of 10 HFRDs and 10 typical college readers. In this task, participants heard words consisting of 3 phonemes, and were required to pronounce each word backwards (e.g., *pat* → *tap*). The mean response time across the 15 items was 5 seconds slower for the HFRDs than the controls.

Some studies have used nonword tasks to examine phonological awareness. For example, Snowling et al. (1997) required 14 self-reported HFRDs and 19 typical college readers to delete phonemes in nonwords. The HFRDs were significantly less accurate than the controls, even after controlling for verbal and nonverbal intelligence. Using the same task, Wilson and Lesaux (2001) also found that their HFRDs were significantly less accurate than their typical college readers at deleting phonemes in nonwords, despite no group differences in age, verbal intelligence, and nonverbal intelligence.

In another study using nonwords, Bruck (1992) examined a group of 39 adults who were diagnosed with dyslexia in childhood and a group of 20 typical college readers. The participants were administered three nonword tasks requiring them to count syllables, count phonemes, and delete initial or final phonemes. The dyslexic adults made significantly more errors in counting syllables, counting phonemes, and deleting final phonemes, but were comparable to the controls in deleting initial phonemes. Subsequently, the author compared the 26 highest-performing adult dyslexics to a group of 15 Grade 3 typical readers. Although the Grade 3 typical readers had lower reading and spelling levels than the adult dyslexics, the adult dyslexics nevertheless made more errors in counting phonemes and deleting final phonemes. One caveat, however, is that the dyslexic group in this study consisted of 19 adults in college programs and 20 adults who did not enter postsecondary education after high school. Therefore, it is uncertain whether all the dyslexic participants can be considered high functioning.

Because the HFRDs were comparable to the controls at deleting initial phonemes, Bruck (1992) argued that adult dyslexics can obtain normal levels of phonological skills at larger phonological units (i.e., onset-rime) despite persisting phoneme-level deficits. In support of this argument, Snowling et al.'s (1997) study also found that their HFRDs were comparable to their typical college readers in a rhyme production task, both in accuracy and rate. Therefore, HFRDs' phonological weaknesses may be limited to phoneme level processes.

Other studies have also examined phonological awareness skills using spoonerism tasks. Spoonerisms are produced by exchanging the beginning sounds of two words (e.g., *Walt Disney* → *Dalt Wisney*). For example, Gallagher et al. (1996) examined spoonerisms in a group of 16 diagnosed sixth-form HFRDs and a group of 16 typical sixth-form readers. The HFRDs were also significantly slower than the controls but comparable in accuracy when creating spoonerisms. The results were replicated with a subset of 10 HFRDs and 10 controls who were comparable in academic grades and word reading accuracy. However, Snowling et al. (1997) found that the HFRDs were slower and less accurate than the typical college readers on the same spoonerism task, even after accounting for verbal and nonverbal intelligence. Also using the same spoonerism task, Wilson and Lesaux (2001) similarly found that their HFRDs were slower and less accurate than their controls on a spoonerism task. In a more recent study and with a different task, Law et al. (2015) showed that their HFRDs produced spoonerisms at a significantly lower rate than their controls.

Two studies have also compared phonological awareness skills in compensated HFRDs and uncompensated HFRDs. Birch and Chase (2004) administered a Pig Latin task to their uncompensated HFRDs, compensated HFRDs, and typical college readers. The task required participants to translate words into Pig Latin by moving the initial phoneme to the end of the word and adding a syllable (e.g., *count* → *ount-cay*). The uncompensated HFRDs were significantly slower and less accurate than both the compensated HFRDs and the controls, who did not differ from each other. In another study, Law et al. (2015) further classified their 36 previously diagnosed HFRDs into compensated HFRDs and uncompensated HFRDs based on their current word reading accuracy scores. In contrast to the previous study, however, the two HFRD groups were comparable in a spoonerism task. As the authors did not compare the HFRD groups separately with the controls, it is unknown how the two HFRD groups performed relative to the typical college readers.

Finally, some studies have also examined HFRDs' phonological awareness skills when compared with reading-level controls. For example, Pennington, van Orden, Smith, Green, and Haith (1990) administered a Pig Latin task to a sample of 30 HFRDs who reported childhood reading difficulties and showed current reading difficulties, 30 typically reading age-matched controls, and 30 reading-level controls. The reading-level controls were comparable to the HFRDs on a measure of word reading accuracy. The authors found that the HFRDs were significantly less accurate and slower than both control groups, even though the three groups were comparable in a phoneme perception task. In addition to oral tasks, the phonological deficits of HFRDs are also apparent in spelling measures. Examining spelling errors in HFRDs, typical adult readers, and spelling-level controls, Pennington et al. (1987) also found that the HFRDs had significantly more difficulty than both control groups at representing all the sounds in words and at representing the consonant sounds in words. However, in contrast to these two studies, Leong (1999) found that the HFRDs were significantly slower than typical college readers at deciding whether a pair of words rhymed, but were comparable to the ESL college students acting as reading-level controls.

Phonological Memory

A handful of studies have examined HFRDs' phonological memory, which refers to memory for phonological units. To measure phonological memory, some studies have administered repetition tasks requiring participants to repeat words or nonwords. For example, Snowling et al. (1997) found that their HFRDs and typical college readers accurately repeated comparable numbers of both words and nonwords. In contrast, however, Parrila et al. (2007) found that the HFRDs accurately repeated significantly fewer nonwords than the controls.

Some studies have also examined HFRDs' ability to recall increasingly longer lists of nonwords. For example, Snowling et al. (1997) required participants to remember lists of nonwords with one, two, or three syllables. The HFRDs showed significantly smaller nonword memory spans than the controls for nonwords of all syllable lengths, even when controlling for speech rate. In a more recent study, Law et al. (2015) also found that the HFRDs performed significantly worse than the typical college readers on a standardized nonword recall task.

In addition to words and nonwords, some studies have examined HFRDs' ability to recall series of digits. In Snowling et al.'s (1997) study, the HFRDs showed significantly smaller digit memory spans than the controls, but the difference did not remain after controlling for vocabulary and nonverbal intelligence. On the other hand, using the same digit span task, Wilson and Lesaux (2001) found that their HFRDs showed significantly smaller digit spans than the controls, even though the two groups were comparable in age, verbal intelligence, and nonverbal intelligence. Similarly, Hanley (1997) found that his 33 HFRDs performed significantly worse than the eight typical college readers on a similar digit span task. Law et al. (2015) also found that their HFRDs had significantly smaller digit memory spans than their controls on another similar task. Therefore, HFRDs generally appear to exhibit poorer phonological memory than typical college readers.

Naming Speed

In naming speed tasks, digits, letters, words, colours, or objects are repeated multiple times to form an array. Readers must successively name the stimuli in the array as quickly as they can, and the time to name the array is recorded. For example, Felton et al. (1990) created a composite naming speed measure by averaging performance across colour, object, digit, and letter naming tasks. The HFRDs were significantly slower on this composite measure than the typical college readers, both after controlling for intelligence and education and after controlling for childhood intelligence and socioeconomic status. However, because the authors only examined the composite naming speed measure, it is unclear where the HFRDs' specific deficits occurred. The HFRDs' raw score naming times were slower than the controls for all four types of stimuli, but it is unclear which differences were statistically significant.

Some studies have examined rapid naming of specific stimuli in HFRDs and controls, with mixed results. For example, Parrila et al. (2007) found that their self-reported HFRDs were significantly slower than their typical college readers at naming digits and colours. Similarly, Law et al. (2015) also found that their HFRDs were significantly slower than the controls at naming colours and objects. On the other hand, Everatt (1997) found no significant differences between their diagnosed HFRDs and typical college readers in the rapid naming of colours, objects, and words. The only significant rapid naming difference in his study was that the HFRDs were significantly slower than controls at nonword naming.

Some studies have examined naming speed differences in both compensated and uncompensated HFRDs, also with inconclusive findings. Kinsbourne, Rufo, Gamzu, Palmer, and Berliner (1991) recruited 23 uncompensated HFRDs, 11 compensated HFRDs, and 21 typical adult readers. The uncompensated HFRDs were individuals whose reading comprehension, word reading, and spelling skills were significantly discrepant from their intelligence scores, following Finucci et al.'s (1984) criteria. The compensated HFRDs were individuals who had a childhood history of dyslexia but no longer met Finucci criteria for dyslexia. Although the authors did not specifically recruit participants from postsecondary programs, the mean years of education for all groups exceeded high school. The results indicated that the uncompensated HFRDs were significantly slower at naming objects than the compensated HFRDs, who were in turn significantly slower than the controls. Both the uncompensated and compensated HFRDs were slower than the controls at naming colours, but were comparable to each other. In contrast, Birch and Chase (2004) found that both compensated HFRDs and uncompensated HFRDs were significantly slower at naming objects than the controls, but were comparable to each other. As well, the uncompensated HFRDs were slower than both the controls and compensated HFRDs at naming letters and digits, whereas the compensated HFRDs were comparable to the controls. The uncompensated HFRDs were also slower at naming colours than the compensated HFRDs, whereas the two groups were not significantly different from the controls. Therefore, it appears that residual naming speed deficits in HFRDs are inconsistently manifested across different types of stimuli.

Orthographic Processing

In light of research showing persistent phonological deficits in HFRDs, some researchers have examined other reading processes to determine whether similar deficits exist. Orthographic processing refers to the ability to visually or holistically recognize whole words and letter patterns (e.g., Stanovich & West, 1989), which allows readers to immediately recognize familiar words without laboriously sounding out the letters. Orthographic processing also refers to the awareness of orthographic constraints and regularities in print, such as being able to recognize common orthographic units (e.g., *tion*), and identify legal and illegal letter patterns (e.g., *thr* is a permissible letter pattern in English, whereas *yhr* is not).

One way to examine orthographic skills is by administering spelling tasks. Studies have generally found that HFRDs demonstrate spelling deficits when compared to typical college readers. For example, Everatt (1997) administered an 85-word experimental spelling task to a group of 44 HFRDs with diagnosed dyslexia and a group of 71 typical college readers. The HFRDs produced on average 30 more errors than the controls. In another study, Wilson and

Lesaux (2001) also found that their 28 HFRDs were significantly less accurate than their 31 typical college readers on a standardized spelling task. Similarly, Parrila et al. (2007) found that their 28 HFRDs who self-reported childhood reading difficulties were significantly less accurate than their 27 typical college readers on two standardized spelling measures. In fact, the HFRDs' spelling skills were at a Grade 10 level, whereas the controls' spelling skills were at a Grade 12.9 level. Kemp et al. (2008) then compared the same group of HFRDs to another group of 28 typical college readers who were matched to the HFRDs on nonverbal intelligence and general spelling ability. Despite being matched on a standardized spelling measure, the HFRDs were nevertheless significantly less accurate than the controls on a second standardized spelling measure. In a recent study, Law et al. (2015) also found that the HFRDs were significantly less accurate than the typical college readers on a standardized spelling measure. However, in contrast to Parrila et al.'s study, both the controls' and HFRDs' scores fell within the normal range, despite being discrepant from each other. Specifically, the HFRD group mean was 90.8 (*SD* = 10.31) on a standardized scale with a mean of 100 and a standard deviation of 15. When the HFRDs were further classified into compensated and uncompensated HFRDs, the two HFRD groups did not show any significant differences in spelling accuracy.

Moreover, to examine both regular and irregular word spelling. Hanley (1997) recruited a group of 29 HFRDs and 13 typical college readers. The participants were classified as HFRDs if they scored more than two standard deviations below the mean on both a standardized reading measure and a standardized spelling measure. The HFRDs were significantly less accurate than the controls on both regular and irregular word spelling. Both the HFRDs and controls were also significantly better at spelling regular words than irregular words.

In two other studies (Lefly & Pennington, 1991; Pennington et al., 1987), the authors examined not only overall spelling accuracy, but also types of spelling errors. The authors coded the errors made on a standardized measure of spelling in both studies. Each error was coded as a simple phonologically accurate misspelling (SPA; i.e., all consonant sounds represented), a complex phonologically accurate misspelling (CPA; i.e., all consonant and vowel sounds represented), a simple orthographically accurate misspelling (SOA; i.e., initial and final letters correct with no illegal letter sequences), or a complex orthographically accurate misspelling (COA; i.e., having at least four correct spelling patterns in the word). As these types of errors represent phonological or orthographic knowledge of the target word, more occurrences of these errors were considered to reflect better spelling ability.

Pennington et al. (1987) recruited a group of 32 HFRDs who were classified as dyslexic based on self-reported childhood reading difficulties and a reading quotient, and a group of 35 typical adult readers. Although the participants were not recruited through colleges, the mean years of education were 14.1 for the HFRDs and 15.7 for the controls. Overall, the HFRDs were significantly less accurate in spelling than the controls. When examining the spelling errors, the controls showed significantly higher proportions of SPA, CPA, and COA errors than the HFRDs. In addition to the typical adult readers, the study also included a group of 32 spelling-level controls. These spelling-level controls were matched to the HFRDs on accuracy on the standardized spelling measure, and scored within the normal range for their own grade level. The spelling-level controls also showed significantly higher proportions of SPA and CPA errors than the HFRDs. However, the HFRDs showed significantly higher proportions of SOA and COA errors than the spelling-level controls.

Using the same spelling error coding system, Lefly and Pennington (1991) recruited a sample of 57 uncompensated HFRDs, 25 compensated HFRDs, and 56 typical college readers. The uncompensated HFRDs were individuals who self-reported childhood reading difficulties and also showed current reading problems on standardized achievement tests. The compensated HFRDs were individuals who self-reported childhood reading difficulties but did not show current reading problems. Overall, the typical college readers were significantly more accurate than the compensated HFRDs, who in turn were more accurate than the uncompensated HFRDs. When comparing spelling errors, the controls and compensated HFRDs showed comparable proportions of all four types of spelling errors. Both groups displayed significantly higher proportions of CPA and COA errors than the uncompensated HFRDs. The controls also had significantly higher proportions of SPA errors than the uncompensated HFRDs.

The analyses were then replicated with a subset of the sample of 25 uncompensated HFRDs, 25 compensated HFRDs, and 24 typical college readers, who were matched on age, socioeconomic status, intelligence, and education. The results held for overall spelling accuracy: the controls were more accurate than the compensated HFRDs, who in turn were more accurate than the uncompensated HFRDs. The results were also similar when examining spelling errors: the controls and compensated HFRDs had significantly higher proportions of CPA and COA errors than the uncompensated HFRDs, and were comparable to each other. Therefore, it appears that uncompensated HFRDs continue to lack spelling accuracy when compared to typical college readers. On the other hand, although compensated HFRDs also fall behind typical college readers in overall spelling accuracy, their spelling errors indicate a better grasp of complex phonological and orthographic spelling rules than those of the uncompensated HFRDs.

Some studies have also examined nonword spelling abilities in HFRDs. In Hanley's (1997) study, the 33 HFRDs performed significantly worse than the 52 typical college readers in nonword spelling. In a more recent study, Kemp et al. (2008) administered an experimental spelling task involving both real words and nonwords to a group of 29 HFRDs and 28 typical college readers. The task consisted of 64 real words and 64 nonwords, which formed base-derived word pairs. There were eight real word pairs and eight nonword pairs in each of four categories: simple phonological pairs, simple orthographic pairs, complex phonological pairs, and complex orthographic pairs. The simple phonological pairs were ones in which the base form had the same sound and spelling as the derived form (e.g., *bother – bothersome* for real words, *mimber – mimbersome* for nonwords). The simple orthographic pairs were ones in which the base and derived forms had the same sound and spelling, but both forms contained some ambiguities in how the sound could be represented (i.e., more than one possible representation of the sound; e.g., *deceit – deceitful* for real words, *cirent – cirentful* for nonwords). The complex phonological pairs were ones in which the base and derived forms had the same spelling, but the final sound of the base had an ambiguous spelling in the derived form (e.g., *ash – ashen* for real words, *forate – foration* for nonwords). The complex orthographic pairs were ones in which the base form changed its spelling in the derived form (e.g., *plenty – plentiful* for real words, *fulmit – fulmission* for nonwords).

When examining the real words and controlling for nonverbal intelligence and receptive vocabulary, the HFRDs were overall significantly less accurate than the typical college readers. Both groups had more difficulty spelling derived forms than base forms, with the HFRDs being significantly more impaired than the controls. When examining the spelling of derived forms, both the HFRDs and controls were better at spelling simple phonological derived words than other categories. The HFRDs also spelled complex orthographic and phonological derived words better than simple orthographic derived words. The results were replicated when examining only derived words for which the base words were also spelled correctly. The authors then conducted the same analyses while also controlling for general spelling ability. The interaction effect between group and word type (base/derived) was no longer significant. The three-way interaction between group, spelling type (phonological/orthographic), and spelling complexity (simple/complex) did not remain significant when including all derived words, but remained significant when including only derived words with correct base form spelling. Therefore, the HFRDs generally had more difficulty than the controls, and had particular difficulty spelling simple orthographic derived words.

When examining the nonwords and controlling for nonverbal intelligence and receptive vocabulary, the HFRDs were also significantly less accurate overall than the controls. Both groups also had more difficulty spelling derived forms than base forms, with the HFRDs being more impaired than controls. As there was no correct spelling of the nonwords, the authors investigated phonologically plausible and orthographically legal spellings of the nonwords. The typical college readers produced significantly more appropriate spellings of nonwords than the HFRDs. When examining derived forms, the HFRDs were significantly better at spelling orthographic derived nonwords than phonological derived nonwords, whereas the controls' performance did not differ between the nonword types. When examining derived forms for which the base form was spelled consistently, only the main effect of group was significant. The authors then conducted the same analyses while also accounting for general spelling ability. Only the main effects of group and spelling complexity remained significant.

Some studies have argued that HFRDs may rely more on their orthographic processing skills to compensate for their phonological processing deficits. For example, in Bruck's (1990) study, participants were instructed to identify English words embedded in nonwords, with some words embedded in more obvious ways than others (e.g., finding *aim* in *straim* is easier than finding *ice* in *baicer*). The HFRDs (as well as the controls) were significantly affected by the difficulty of the items, indicating that they were sensitive to the orthographic properties of words.

Moreover, Pennington et al.'s (1987) study also examined the complex orthographically accurate (COA) errors in more detail. Specifically, they analyzed four types of orthographic patterns: single consonant alternations (phonemes represented by more than one grapheme), vowel clusters (letter clusters that represent one phoneme), geminate consonants (consonant doubling), and analogy words (words analogous to other morphologically related words). The results showed that the typical adult readers showed significantly more single consonant alternations and consonant doublings in their errors than the HFRDs. On the other hand, the HFRDs showed significantly more vowel clusters and analogies in their errors than the spelling-level controls. Therefore, the authors suggested that HFRDs may rely on larger units of spelling-sound correspondences (e.g., spelling patterns) to compensate for their difficulties decoding smaller units of sound.

This suggestion is also supported by Hanley's (1997) observation that many HFRDs in his study reported that they attempted to read nonwords through analogies to real words. They were also significantly worse at reading nonwords with no available analogies (e.g., *svik*) than nonwords with available analogies (e.g., *plave*). As well, although not directly analyzed in the study, the HFRDs seemed to spell regular real words better than nonwords (which are also regular). The HFRDs' mean proportion correct was .92 on the regular words, whereas their mean proportion correct on the nonwords was .76. Thus it is possible that HFRDs use orthographic knowledge in their spelling instead of solely relying on sounding out strategies. However, Kitz and Tarver's (1989) study indicates that although HFRDs may be able to use orthographic strategies such as analogy to assist in word reading, their ability to do so may nevertheless fall behind their typically reading peers. In this study, the authors recruited a group of 10 HFRDs from a language remediation program and a group of 10 typical college readers. The authors administered a task in which participants read nonwords and real words. The nonwords contained the same orthographic patterns as the real words, such as that participants could read the nonwords by transferring their knowledge of the real words (e.g., *hit* as the real word, *jit* as the nonword). The task allowed for the calculation of a Phonic Transfer Index, which reflects the participants' ability to read nonwords through analogy. The results indicated that the HFRDs were significantly less able to do so than the controls, for both monosyllabic and multisyllabic words. In sum, although evidence suggests that HFRDs exhibit orthographic processing abilities, it is unclear as to whether their orthographic skills may be strong enough to truly compensate for their phonological deficits.

Morphological Processing

Of the different reading component skills, perhaps the most understudied in the HFRD literature is morphological processing. Morphological processing (see Amenta & Crepaldi, 2012, for a review) refers to the recognition that words contain meaningful units (i.e., morphemes), such as recognizing that the word *cats* can be decomposed into two morphemes of *cat* and *–s*, with the *cat* morpheme indicating the animal and the *–s* morpheme indicating the plural. Morphological processing also refers to the ability to recognize and manipulate those units, such as changing the word *grow* into *growth* and *growing* by adding appropriate morphemes.

To date, only a few studies have examined morphological processing skills in HFRDs. Leong (1999) found that the HFRDs were significantly slower than typical college readers to produce derived forms of words when provided with the base forms (e.g., *finally* from *final*), and to produce base forms when provided with the derived forms (e.g., *grow* from *growth*). However, the HFRDs performed comparably to a group of college ESL students acting as reading-level controls.

In another study, Deacon, Parrila, and Kirby (2006) recruited a group of 27 HFRDs who self-reported childhood reading difficulties and a group of 28 typical college readers. The authors presented the participants with target words that were either true derived forms of words (e.g., *reader*, in which the *–er* is a meaningful unit) or pseudo-derived forms of words (e.g., *offer*, in which the *–er* is not a meaningful unit). The target words included eight derived words and eight pseudo-derived words that had no orthographic or phonological change between the base and the derived form (e.g., *shipment*, with *ship* as the base, for derived words; *topic*, with *top* as the base, for pseudo-derived words). The target words also included eight derived words and eight pseudo-derived words that had an orthographic change between the base and the derived form (e.g., *central*, with *centre* as the base, for derived words; *gravy*, with *grave* as the base, for pseudo-derived words). The target words were embedded among other words, nonwords, and letter strings, and participants were asked to decide whether each presented item was a word or not. Morphological complexity affected the controls' response times such that they were faster to read derived words that were orthographically identical to their bases, and slower to read derived words that were orthographically different from their bases. On the other hand, morphological complexity did not affect the HFRDs' response times. Therefore, the authors concluded that HFRDs did not show the same morphological sensitivity as typical college readers.

Moreover, in a recent study, Law et al. (2015) examined morphological processing in a group of 36 HFRDs and 54 typical college readers. Participants were required to apply a suffix to a target root word that would be placed in a sentence (e.g., *The secret police arrested the ____ before he could give his speech*, with the target word *act*), and to complete a sentence by choosing one of four nonwords with real English suffixes (e.g., choosing from *credenthive*, *credenthification*, *credenthicism*, and *credenthify*). The HFRDs performed significantly worse than the controls, even after controlling for vocabulary and phonological skills. The authors then used hierarchical regression analyses to determine whether morphological awareness skills contributed significantly to word reading skills. After controlling for vocabulary and phonological skills, morphological awareness skills independently predicted 16.5% of the variance in word reading skills for the HFRDs, but did not independently predict word reading skills in the controls.

The authors then further classified the HFRDs into compensated and uncompensated HFRDs. When controlling for vocabulary, the controls showed significantly better morphological processing skills than the compensated HFRDs, who in turn were better than the uncompensated HFRDs. When controlling for both vocabulary and phonological skills, the controls and compensated HFRDs were comparable to each other, and both groups significantly outperformed the uncompensated HFRDs. From these findings, the authors argued that HFRDs may have shifted away from using phonological skills in word reading, unlike the typical college readers. In particular, compensated HFRDs, whose morphological processing skills were more similar to those of typical college readers, may have relied on morphological processes to compensate for their phonological deficits.

Other Compensatory Mechanisms

To date, most of the HFRD literature has focused on examining the residual skill deficits in HFRDs when compared to various control groups. In addition to profiling their strengths and weaknesses, it is also important to examine the ways in which HFRDs have managed their reading and spelling difficulties in order to cope with higher academic demands. However, very few studies have examined coping or compensatory skills in HFRDs. As previously discussed, some researchers have suggested that orthographic processing skills (e.g., Bruck, 1990; Hanley, 1997; Pennington et al., 1987) and morphological processing skills (e.g., Law et al., 2015) may serve as alternative reading processes for HFRDs. However, HFRDs may not be able to fully compensate for their phonological deficits through orthographic or morphological routes, as they display difficulties in both areas when compared to typical college readers (see Kitz & Tarver, 1989, for orthographic processing, and Deacon et al., 2006, for morphological processing)

Some studies have also found evidence for the role of vocabulary as a compensatory mechanism for HFRDs. For example, Bruck (1990) found that HFRDs with high reading comprehension scores (i.e., ≥ 50^{th} percentile and overlapping with typical college readers' scores) also had higher receptive vocabulary skills and higher childhood intelligence than HFRDs with low reading comprehension scores (i.e., ≤ 25^{th} percentile). Hanley (1997) also found that vocabulary significantly predicted 44% of the variance in a word reading measure. Interestingly, the vocabulary measure did not significantly predict variance in a nonword reading measure. Moreover, although it is unclear whether their sample of adult dyslexics could be considered high functioning, Gottardo, Siegel, and Stanovich (1997) found that vocabulary significantly predicted 14% of the variance in word reading ability, even after controlling for age, listening comprehension, phonological processing, verbal short-term memory, nonverbal intelligence, and syntactic processing.

Other studies have pointed to the role of HFRDs' personal characteristics and study/learning strategies as compensatory mechanisms. For instance, Corkett et al. (2006) examined study strategies (i.e., activities that increase familiarity and recall of material) and learning strategies (i.e., active learning activities) in a sample of 29 HFRDs who self-reported childhood reading difficulties and 38 typical college readers. The HFRDs reported using significantly more types of study strategies than the controls, and in particular using flash cards more than the controls. The HFRDs also reported using significantly more types of organization strategies than the controls, and in particular writing outlines for textbook chapters more than the controls. Finally, the HFRDs also reported participating in classroom discussions significantly more than the controls.

In another study, Kirby et al. (2008) also examined learning strategies and study approaches in a group of 36 HFRDs with diagnosed dyslexia and 66 typical college readers. The participants completed a self-report scale examining deep and surface approaches to learning, and a self-report scale examining various learning and study strategies. The HFRDs reported more use of time management strategies and study aids, and less use of strategies for selecting main ideas and test-taking. Interestingly, the 26 HFRDs attending university (vs. the 10 HFRDs attending vocational college programs) also reported a deeper approach to learning than the control group, even though they reported less use of strategies generally thought to indicate deeper learning (e.g., selecting main ideas). The authors suggested that the findings indicate the presence of compensatory mechanisms, albeit imperfect ones, in HFRDs. Specifically, HFRDs' word reading difficulties "drive the students in two directions: (a) toward deeper learning, use of study aids, and time management, perhaps because the details of what they read are too difficult to obtain and retain and because they feel that they have too much to do; but (b) these challenges drive them toward relatively impoverished learning and test taking strategies" (p. 94).

Summary

The HFRD literature remains relatively sparse compared to the vast literature on reading abilities and disabilities in younger populations. Most of the HFRD studies have focused on examining the residual deficits in HFRDs. Researchers have generally agreed that HFRDs exhibit residual difficulties in word reading accuracy when compared to typical college readers (e.g., Bruck, 1990; Deacon et al., 2012; Law et al., 2015; Parrila et al., 2007; Wilson & Lesaux, 2001). In fact, HFRDs' word reading accuracy levels are comparable to that of Grade 6 typical readers (Bruck, 1990). When comparing uncompensated HFRDs and compensated HFRDs, Lefly and Pennington (1991) found that uncompensated HFRDs were less accurate than compensated HFRDs and typical college readers, but that compensated HFRDs and controls performed comparably. However, word type may affect HFRDs' word reading accuracy. For example, Birch and Chase (2004) found that uncompensated HFRDs, compensated HFRDs, and controls were equally accurate when reading regular words. In contrast, when reading irregular words, the uncompensated HFRDs were less accurate than the compensated HFRDs, who were in turn less accurate than the typical college readers.

The literature has also shown HFRDs to display deficits in word reading speed or fluency, whether they are reading words in isolation (Bruck, 1990; Parrila et al., 2007; Wilson & Lesaux, 2001) or in context (e.g., Deacon et al., 2012; Kirby et al., 2008). The impairments in word reading speed appear to be more pervasive than the deficits in accuracy. For example, Bruck (1990) found HFRDs to be slower than Grade 6 typical readers, even though the two groups were comparable in accuracy. Measuring word reading speed also differentiates between compensated HFRDs and uncompensated HFRDs when accuracy does not. More specifically, uncompensated HFRDs are slower than compensated HFRDs, who in turn are slower than typical college readers (Birch & Chase, 2004; Lefly & Pennington, 1991), for both regular and irregular words (Birch & Chase, 2004).

Some studies have also examined factors that affect word reading performance in HFRDs. One factor affecting word reading speed appears to be context, with studies showing that HFRDs tend to be faster when reading words in congruous context than when reading words in neutral or incongruous contexts (Ben-Dror et al., 1991; Bruck, 1990). Other studies examining regularity and frequency effects generally show that HFRDs are slower and less accurate when reading irregular words than when reading regular words (Birch & Chase, 2004; Bruck 1990). They are particularly affected when reading irregular words that are also of low frequency (Bruck, 1990).

When examining reading component skills in HFRDs, many studies have focused on phonological skills. Researchers have generally agreed that HFRDs display residual phonological deficits. When reading nonwords, HFRDs are significantly less accurate than typical college readers (e.g., Felton et al., 1990; Gallagher et al., 1996; Snowling et al., 1987; Wilson & Lesaux, 2001) and reading-level controls (e.g., Bruck, 1990; Pennington et al., 1987). HFRDs are also significantly slower at reading nonwords than typical college readers (e.g., Bruck, 1990; Leong, 1999). Bruck (1990) also found HFRDs to be significantly slower than reading-level controls, but Leong found the two groups to be comparable. Moreover, uncompensated HFRDs are significantly less accurate and slower in decoding nonwords than compensated HFRDs, who in turn are significantly less accurate and slower than typical college readers (Birch & Chase, 2004). Furthermore, studies have also shown HFRDs to be more impaired in nonword reading than in real word reading (e.g., Ben-Dror et al., 1991; Birch & Chase, 2004; Bruck, 1990).

In addition to decoding deficits, HFRDs also show difficulties manipulating sound segments when compared to typical college readers (Birch & Chase, 2004; Bruck, 1992; Felton et al., 1990; Gallagher et al., 1996; Kitz & Tarver, 1989; Law et al., 2015; Snowling et al., 1997; Wilson & Lesaux, 2001). Some studies have also shown HFRDs to be impaired in phonological awareness when compared to reading-level controls (e.g., Pennington et al., 1987, 1990) while others have not (e.g., Leong, 1999). Similarly, some researchers have found uncompensated and compensated HFRDs to differ in phonological skills (e.g., Birch & Chase, 2004) while others have not (e.g., Law et al., 2015).

Moreover, HFRDs also appear to display difficulties with phonological memory, but the conclusions vary with different tasks. Studies examining nonword repetition tasks have shown mixed results, with some researchers finding typical college readers to outperform HFRDs (e.g., Parrila et al., 2007) and others finding that the two groups are comparable (e.g., Snowling et al., 1997). On the other hand, studies examining nonword recall have consistently shown HFRDs to have smaller nonword memory spans than typical college readers (e.g., Law et al., 2015), even when controlling for speech rate (Snowling et al., 1997). Similarly, researchers have also consistently shown HFRDs to have smaller digit memory spans than typical college readers (e.g., Hanley, 1997; Law et al., 2015; Snowling et al., 1997; Wilson & Lesaux, 2001).

In addition to phonological processing skills, some studies have examined HFRDs' naming speed abilities. Some studies have found significant impairments in HFRDs' ability to name digits (Parrila et al., 2007), colours (Law et al., 2015; Parrila et al., 2007), and objects (Law et al., 2015). In contrast, Everatt (1997) found no significant differences in colour naming, and only found HFRDs to be impaired in nonword naming. Studies examining uncompensated and compensated HFRDs have also produced mixed results. For example, Kinsbourne et al. (1991) found that uncompensated HFRDs were more impaired in object naming than compensated HFRDs, whereas Birch and Chase (2004) found the two groups to be comparable. In contrast, Birch and Chase found that uncompensated HFRDs were more impaired in colour naming than the compensated HFRDs, whereas Kinsbourne et al. found no differences between the two groups.

Other studies have examined HFRDs' orthographic processing skills. These studies have generally shown HFRDs to display residual spelling deficits when compared to typical college readers (e.g., Everatt, 1997; Hanley, 1997; Kemp et al., 2008; Law et al., 2015; Parrila et al., 2007; Wilson & Lesaux, 2001). These spelling difficulties are also apparent when spelling nonwords (e.g., Hanley, 1997; Kemp et al., 2008). Moreover, some studies examining spelling errors have found uncompensated HFRDs to generally show poorer orthographic skills than typical college readers (e.g., Lefly & Pennington, 1991; Pennington et al., 1987), whereas compensated HFRDs perform similarly to the controls (Lefly & Pennington, 1991). Despite their orthographic deficits relative to typical college readers, some researchers have nevertheless suggested that HFRDs can use their orthographic skills to compensate for their phonological processing deficits, as they appear to be sensitive to orthographic properties of words (e.g., Bruck, 1990), and to use analogies to read (e.g., Hanley, 1997) and spell (Pennington et al., 1987).

Furthermore, a reading component skill that has been investigated only recently is morphological processing. Compared to typical college readers, HFRDs display less sensitivity to morphological complexity (Deacon et al., 2006) and have more difficulty choosing and producing derived forms of words (Law et al., 2015; Leong, 1999). Interestingly, after controlling for both vocabulary and phonological skills, Law et al. found compensated HFRDs and controls to perform comparably, whereas the uncompensated HFRDs performed significantly worse than the other two groups. Law et al. also posited morphological processing skills as a possible compensatory mechanism, as morphological processing skills independently predicted word reading accuracy in HFRDs (but not controls), after controlling for vocabulary and phonological skills.

Finally, a handful of studies have investigated the ways in which HFRDs have coped with their reading difficulties. In addition to the previously discussed roles of orthographic processing (e.g., Bruck, 1990; Hanley, 1997; Pennington et al., 1987) and morphological processing (e.g., Law et al., 2015), some studies have pointed to vocabulary as being a possible compensatory mechanism (Bruck, 1990; Gottardo et al., 1997; Hanley, 1997). Other studies examining study and learning strategies (Corkett et al., 2006; Kirby et al., 2008) have suggested that HFRDs use more time management strategies (Kirby et al., 2008), organization strategies

(Corkett et al., 2006), and study aids (Corkett et al., 2006; Kirby et al., 2008) than typical college readers.

In conclusion, compared to other populations, the literature on HFRDs' reading abilities remains relatively sparse. Although some of the research has reached a general consensus, as in the persistence of phonological deficits, the evidence remains largely inconclusive as to whether HFRDs display persisting difficulties in other reading processes. Moreover, even fewer studies have examined the ways in which HFRDs have managed to cope with or compensate for their reading difficulties in order to attain academic success. Therefore, it is imperative that future research continue to disentangle the reading process in HFRDs, and to investigate their coping mechanisms in more detail.

Current Study

The current study aims to contribute to the HFRD literature in three ways. First, I will examine group differences between HFRDs and typical college readers in their word reading, spelling, phonological processing, naming speed, orthographic processing, and morphological processing skills. One difference between my study and previous studies is that I will examine three types of HFRD groups. In the past, studies that have recruited participants based on self-report have used either past or current reading difficulties as criteria for inclusion in the HFRD group (e.g., Deacon et al., 2012). However, this study attempts to examine whether subgroups of HFRDs that show reliable differences exist. The first group consists of HFRDs who report both a history of reading difficulties and current reading difficulties; this group can be considered the Persistent HFRDs and are similar to the uncompensated HFRDs in previous studies. The second group consists of HFRDs who report a history of reading difficulties but do not report current reading difficulties; this group can be considered the Compensated HFRDs. The third group consists of Late-emerging HFRDs who do not report a history of reading difficulties but report current reading difficulties. In previous studies, this final group would have been subsumed under the same group as the uncompensated HFRDs, as both groups show current reading difficulties; or they would have been excluded from the HFRD group if the inclusion criteria was a history of reading difficulties. Therefore, this study investigates whether these three HFRD subgroups differ reliably from typical college readers and from each other.

Second, I will further explore group comparisons by examining subsets of HFRDs who display significantly better word reading skills than expected from their phonological skills. Specifically, I will identify a subset of HFRDs whose word reading accuracy skills are significantly better than their decoding accuracy skills. I will compare this subset to another two subsets of HFRDs: one whose word reading accuracy skills are significantly poorer than their decoding accuracy skills, and one whose word reading accuracy and decoding accuracy skills are comparable. Similarly, I will identify a subset of HFRDs whose word reading efficiency skills significantly surpass their decoding efficiency skills, and compare this subset to one whose word reading efficiency skills are significantly poorer than their decoding efficiency skills and one whose word reading efficiency and decoding efficiency skills are comparable. By investigating these individuals whose word reading and decoding skills appear disconnected, I will attempt to reveal possible mechanisms through which some HFRDs have compensated for their decoding struggles to achieve word reading success.

Finally, I will explore individual profiles of HFRDs belonging to the aforementioned remarkable HFRD groups: the HFRDs whose word reading accuracy skills significantly exceed their decoding accuracy skills, and the HFRDs whose word reading efficiency skills significantly surpass their decoding efficiency skills. Therein, I will attempt to determine whether individual profiles also reveal the same compensatory mechanisms as the group results.

CHAPTER III: METHOD

Participants

The current sample included 215 university students recruited from the University of Alberta, Dalhousie University, and Saint Mary's University. The Adult Reading History Questionnaire – Revised (Parrila, Corkett, Kirby, & Hein, 2003) was widely administered as a screening measure to undergraduate first-year psychology classes at the three universities. Individuals who scored .37 or higher on either the Elementary or Current section (see Group Formation section in the next chapter for scoring details) were invited to participate in the study as HFRDs. At Dalhousie University, individuals who scored lower than .37 on both the Elementary and Current sections were also invited to participate as controls. Subsequently, 219 participants accepted the invitation to participate in the study and completed all tasks. The 219 participants were then classified into one of four participant groups based on their ARHQ-R scores (see Group Formation section in Results). Four participants did not meet classification criteria for any group, resulting in a final sample of 215 participants. The final sample consists of 154 females and 61 males. The females had a mean age of 22 years and 4 months (*SD* = 4 years 8 months), whereas the males had a mean age of 21 years and 4 months (*SD* = 2 years 6 months). All participants reported English as their preferred spoken and written language.

Measures

Screening

Adult Reading History Questionnaire – Revised (ARHQ-R). The ARHQ-R (Parrila et al., 2003; see Parrila et al., 2007 for details; Appendix A) asked participants to report on their reading and spelling experiences on paper. The ARHQ-R included 8 items asking participants to report on their elementary school (i.e., past) reading experiences, and 12 items asking participants to report on their university (i.e., current) reading experiences. Participants responded to each item on a Likert scale ranging from 0 to 4. The ARHQ-R Elementary variable refers to the participants' score on the elementary items, and the ARHQ-R Current variable refers to the participants' score on the university items (see Group Formation section in Results for scoring details). In the current sample, Cronbach's α was .95 for the ARHQ-R Elementary scale, and .90 for the ARHQ-R Current scale.

Cognitive Ability

Vocabulary. This task included 18 items (Items 25 – 42) from the Vocabulary subtest of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). Participants saw the words presented in groups of four or six items (as in the WASI stimuli booklet), in sequential order, on the computer screen, and provided an oral definition for each word. The experimenter recorded the responses on both paper and a sound recorder, and queried responses according to the WASI manual. The Vocabulary variable refers to the total number of points awarded on this task according to the WASI manual. In the current sample, Cronbach's α was .80.

Matrix Reasoning. This computer task included a practice item (Practice Item A) and 25 items (Items 11 – 35) from the Matrix Reasoning subtest of the WASI (Wechsler, 1999). Participants saw the items presented one at a time, in sequential order, on the computer screen, and chose their answers by pressing the corresponding number keys. The Matrix Reasoning variable refers to the total number of correct responses on this task. In the current sample, Cronbach's α was .72.

Word Reading

Word Identification. This computer task included 54 items (even-numbered items from Items 30 – 76, and Items 77 – 106) from the Word Identification subtest of the Woodcock Reading Mastery Tests – Revised (WRMT-R, Form H; Woodcock, 1987). Participants saw the words presented one at a time in sequential order and read each word aloud. The Word Identification variable refers to the total number of words read correctly on this task. In the current sample, Cronbach's α was .84.

Sight Word Efficiency. This computer task included the 104 words from the Sight Word Efficiency subtest of the Test of Word Reading Efficiency (TOWRE, Form A; Torgesen, Wagner, & Rashotte, 1999). Participants first read a practice screen with the eight practice items from the subtest. Then participants saw the words presented simultaneously on one screen (six columns of sixteen words, one column of eight words), and read the words in order as quickly as they could without making errors. The Sight Word Efficiency variable refers to the number of words correctly read within 45 seconds. The reported test-retest reliability in the manual is $r = .91$.

Regular and Irregular Word Reading. This computer task included the 60 words from Castles and Coltheart's (1993) study, consisting of 15 regular high frequency words, 15 regular low frequency words, 15 irregular high frequency words, and 15 irregular low frequency words. The high frequency words had a Kucera-Francis Index > 20 and the low frequency words had a Kucera-Francis Index < 20. Participants saw the words presented one at a time in random order, and read the words aloud as quickly as they could without making errors. The accuracy scores are not analyzed due to ceiling effects (Regular High Frequency Word Reading mean proportion correct = .99; Regular Low Frequency Word Reading mean proportion correct = .98; Irregular High Frequency Word Reading mean proportion correct = .95; Irregular Low Frequency Word Reading mean proportion correct = .80). The Regular High Frequency Word Reading RT, Regular Low Frequency Word Reading RT, Irregular High Frequency Word Reading RT, and Irregular Low Frequency Word Reading RT variables refer to the response times for correct responses to the items in each of the four word groups. The correlations between the four variables in this study ranged from .81 to .90.

Phonological Decoding

Word Attack. This computer task included the 45 nonword items from the Word Attack subtest of the WRMT-R (Form H; Woodcock, 1987). Participants saw the nonwords presented one at a time in sequential order, and read each nonword aloud. The Word Attack variable refers to the total number of nonwords read correctly on this task. In the current sample, Cronbach's α was .81.

Phonemic Decoding Efficiency. This computer task included the 63 nonwords from the Phonemic Decoding Efficiency subtest of the TOWRE (Form A; Torgesen et al., 1999). Participants first read a practice screen with the six practice items from the subtest. Then participants saw the nonwords presented simultaneously on one screen (four columns of thirteen nonwords, one column of eleven nonwords), and read the nonwords in order as quickly as they could without making errors. The Phonemic Decoding Efficiency variable refers to the number of nonwords correctly read within 45 seconds. The reported test-retest reliability in the manual is $r = .90$.

Phonological Choice. This computer task (Parrila et al., 2007) included 20 pairs of nonwords, with each pair consisting of orthographically similar nonwords with different pronunciations (e.g., *klass*, *cliss*). Participants saw the pairs presented one pair at a time in random order, and chose the nonword in each pair that was a pseudohomophone of a real word (i.e., sounded like a real word when pronounced) by pressing one of two keys. The accuracy scores were not analyzed due to ceiling effects (mean proportion correct = .90). The Phonological Choice RT variable refers to the response times for correct responses to the items on this task. As an estimate of reliability for the current sample, the correlation between the median RTs of the two halves of items (items with left-key target responses and items with right-key target responses) was .82, after removing within-individual outliers (see Data Transformation section for details).

Phonological Awareness

Elision. This computer task included 17 items (Items 4 to 20) and 3 practice items (Items d to f) from the Elision subtest of the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999). The items required the participants to remove single phonemes from a target word (e.g., Say *cup* without the */k/*.) Participants heard the pre-recorded items one at a time in sequential order through the computer, and responded aloud. The Elision Accuracy variable refers to the total number of correct responses on this task. In the current sample, Cronbach's α was .73. The Elision RT variable refers to the response times for correct responses to the first 10 items in this task (mean proportion correct for the first 10 items = .92).

Naming Speed

Rapid Automatized Naming (RAN) Letters. This computer task included the RAN Letter subtest of the Rapid Automatized Naming and Rapid Alternating Stimulus Tests

(RAN/RAS; Wolf & Denckla, 2005). The task repeatedly presented the letters, *a*, *d*, *o*, *p*, and *s*, randomly in a 50-letter array (five rows of ten letters). Participants first read a practice array (two rows of five letters) consisting of the same letters, and then read the 50-letter array in order as quickly as they could without making errors. The RAN Letters RT variable refers to the total time taken to read the 50 letters.

Rapid Automatized Naming (RAN) Digits. This computer task included the RAN Numbers subtest of the RAN/RAS (Wolf & Denckla, 2005). The task repeatedly presented the digits, *2*, *4*, *6*, *7*, and *9*, randomly in a 50-digit array (five rows of ten digits). Participants first read a practice array (two rows of five digits) consisting of the same digits, and then read the 50-digit array in order as quickly as they could without making errors. The RAN Digits RT variable refers to the total time taken to read the 50 digits. In the current sample, the correlation between the RAN Letters RT and RAN Digits RT raw score naming times was .78.

Orthographic Processing

Wordlikeness (Parts A and B). This computer task (adapted from Conrad, Harris, & Williams, 2013, to increase difficulty; Appendix B) included 43 pairs of nonwords, with each pair consisting of phonologically identical nonwords with different spellings (e.g., *dake*, *daik*). Part A consisted of 20 pairs and Part B consisted of 23 pairs. In each part, participants saw the pairs presented one pair at a time in random order, and chose the nonword in each pair that looked more like a real word by pressing one of two keys. In Part A, participants were asked to respond as quickly as possible. The accuracy scores in Part A were not analyzed due to ceiling effects (mean proportion correct = .91). The Wordlikeness RT variable refers to the response times for correct responses to the items in Part A. As an estimate of reliability for the current sample, the correlation between the median RTs of the two halves of items (i.e., items with left-key target responses and items with right-key target responses) in Part A was .75, after removing within-individual outliers (see Data Transformation section for details). In Part B, participants were asked to be as accurate as possible. The Wordlikeness Accuracy variable refers to the total number of correct responses in Part B. In the current sample, Cronbach's α was .53.

Spelling Choice (Parts A and B). This computer task previously administered in Barber's (2009) thesis included 50 pairs of words and their pseudohomophones (i.e., nonwords that are pronounced identically to the real word; e.g., *take*, *taik*; Appendix C). Parts A and B each consisted of 25 pairs. In each part, participants saw the pairs presented one pair at a time in random order, and chose the correctly spelled word in each pair by pressing one of two keys. In Part A, participants were asked to respond as quickly as they could. The accuracy scores for Part A are not analyzed due to ceiling effects (mean proportion correct = .97). The Spelling Choice RT variable refers to the response times for correct responses to the items in Part A. As an estimate of reliability for the current sample, the correlation between the median RTs of the two halves of items (i.e., Items 1 – 12 and Items 13 – 25) in Part A was .89, after removing within-individual outliers (see Data Transformation section for details). In Part B, the pairs consisted of words from the list of most commonly misspelled words (YourDictionary). In Barber's (2009) pilot study, at least 5 out of 15 typical college readers showed incorrect answers on each pair. In Part B, participants were asked to be as accurate as possible. The Spelling Choice Accuracy variable refers to the number of correct responses in Part B. In the current sample, Cronbach's α was .55 for the Spelling Choice Accuracy variable.

Dictated Spelling. This task included 30 items (Items 11 – 40) from the Wide Range Achievement Test – 3rd Edition (WRAT-3, Blue Form; Wilkinson, 1993). Ten other commonly misspelled words were added (i.e., *benign*, *itinerary*, *alcove*, *oligarchy*, *egregious*, *unanimous*, *pseudonym*, *discretionary*, *omniscient*, and *strategem*) to increase difficulty. Participants heard the pre-recorded items one at a time in sequential order through the computer, and wrote their responses on paper. For each item, the participants heard the word, then a sentence with the word in it, and then the word repeated. The Dictated Spelling variable refers to the total number of words spelled correctly on this task. In the current sample, Cronbach's α was .89.

Morphological Processing

Morphological Parsing Accuracy. This pencil and paper task presented 44 words to the participant on a single sheet of paper (Appendix D). Participants were asked to segment the words into smaller meaningful components with slashes. After three practice items, participants were asked to complete the page of 44 words without time constraints. Each item was scored such that missed slashes and incorrectly placed slashes were deducted from the maximum number of correct slashes allowed for the item. For example, the correct parsing for *semicircles* would consist of two slashes (i.e., *semi/circle/s*). Thus a participant who responds with *semi/circles* would have one missed slash deducted from the maximum number of two correct slashes, and a resulting item score of 1. The Morphological Parsing Accuracy variable is a proportion derived by dividing the sum of the item scores by the maximum number of correct slashes across all items. To calculate reliability for this task, the item scores were recoded into correct and incorrect responses, with correct responses referring to responses with no deductions for omitted or incorrect slashes. Cronbach's alpha in the current sample was .66.

Morphological Parsing Efficiency. This pencil and paper task presented 44 words to the participant on a single sheet of paper (Appendix D). Participants were asked to segment the words into smaller meaningful components with slashes. They were asked to complete as many as possible within 45 seconds. Similar to the Morphological Parsing Accuracy task, each item was scored such that missed slashes and incorrectly placed slashes were deducted from the maximum number of correct slashes allowed for the item. The Morphological Parsing Efficiency variable is a proportion derived by dividing the sum of the item scores by the maximum number of correct slashes across all items attempted within the time limit.

Print Exposure

Author Recognition Test. This computer task (adapted from Stanovich & West, 1989; Appendix E) included 130 names of people: 65 real authors and 65 foils. Participants saw the names presented one at a time in random order, and responded YES (if they thought the name was an author) or NO (if they thought the name was not an author) by pressing one of two keys. The Author Recognition variable refers to the total number of authors correctly selected minus the total number of foils selected on this task. In the current sample, Cronbach's α was .83.

Lexical Access

Picture Naming. This computer task included 40 pictures of common items. The pictures were presented one at a time in random order, and participants named each picture as quickly as they could. The accuracy scores are not analyzed due to ceiling effects (mean proportion correct

= .98). The Picture Naming RT variable refers to the response times for correct responses to the items on this task. As an estimate of reliability for the current sample, the correlation between the median RTs of the two halves of items (i.e., Items 1 – 20 and Items 21 – 40) was .89, after removing within-individual outliers (see Data Transformation section for details).

Procedure

Participants were individually administered all the measures in two separate sessions, each lasting approximately an hour. All computer tasks were administered using DirectRT (Jarvis, 2009). In the first session, the experimenter first administered the Matrix Reasoning, Vocabulary, and Dictated Spelling tasks, in fixed order. Then the experimenter administered the Author Recognition Test, Word Identification, Word Attack, RAN Letters, RAN Digits, Spelling Choice (Parts A & B), and Picture Naming tasks, in random order. In the second session, the experimenter administered the Regular and Irregular Word Reading, Morphological Parsing Accuracy, Morphological Parsing Efficiency, Sight Word Efficiency, Phonemic Decoding Efficiency, Elision, Phonological Choice, and Wordlikeness (Parts A & B) tasks, in random order. However, the Regular and Irregular Word Reading, Morphological Parsing Accuracy, and Morphological Parsing Efficiency tasks were always administered as a block in fixed order. As well, the Sight Word Efficiency and Phonemic Decoding Efficiency tasks were always administered as a block in fixed order.

CHAPTER IV: GROUP COMPARISONS

Group Formation

First, I categorized the 215 participants into four groups based on their responses on the Adult Reading History Questionnaire – Revised (ARHQ-R; Parrila et al., 2003). To create the groups, I first calculated two scale scores for each participant to represent their elementary and current reading experiences. I calculated the ARHQ-R Elementary score by dividing the sum of scores on the eight elementary reading experience items by the maximum possible score (i.e., 8 x 4 = 32). Similarly, I calculated the ARHQ-R Current score by dividing the sum of scores on the 12 current reading experience items by the maximum possible score (i.e., 12 x 4 = 48). For participants with missing responses, I prorated the ARHQ-R Elementary and ARHQ-R Current scores based on the number of items answered. For example, a participant with a missing response on the elementary items would have an ARHQ-R Elementary score calculated by dividing the sum of scores by 28 (i.e., 7 x 4) instead of 32. There were four participants with one missing response (two participants with one missing response in the elementary reading experience items and two participants with one missing response in the current reading experience items), and one participant with two missing responses (both in the current reading experience items).

Subsequently, I classified the participants into one of four groups based on their ARHQ-R Elementary and ARHQ-R Current scores. The ARHQ-R Elementary scores were classified according to the same cutoff scores as in Deacon et al. (2012), with scores falling at .37 or higher indicating reading problems and scores falling at .25 or lower indicating no reading problems. As previous research has not examined the ARHQ-R Current scores, a single cutoff score of .37 was used in order to retain all participants categorized by the Elementary scores. Therefore, participants whose ARHQ-R Elementary scores were ≤ .25 and whose ARHQ-R Current scores were < .37 were classified as the Control group. Participants whose ARHQ-R Elementary scores were ≥ .37 but whose ARHQ-R Current scores were < .37 were classified as the Compensated RD group (CRD). Participants whose ARHQ-R Elementary scores were ≤ .25 but whose ARHQ-R Current score was ≥ .37 were classified as the Late-emerging RD (LRD) group. Participants whose ARHQ-R Elementary and ARHQ-R Current scores were both ≥ .37 were classified as the Persistent RD (PRD) group.

In other words, the Control group (*n* = 70) consisted of participants who did not report elementary or current reading difficulties. The Control group had a mean age of 22 years and 1 month (*SD* = 3 years 11 months), and included 53 females and 17 males. The CRD group (*n* = 26) consisted of participants who reported elementary reading difficulties but no current reading difficulties (i.e., the compensated dyslexics). The CRD group had a mean age of 20 years and 11 months (*SD* = 1 year 10 months), and included 21 females and 5 males. The LRD group (*n* = 15) consisted of participants who reported no elementary reading difficulties but reported current reading difficulties (i.e., late-emerging reading difficulties). The LRD group had a mean age of 21 years and 3 months (*SD* = 3 years 5 months), and included 12 females and 3 males. The PRD group (*n* = 104) consisted of participants who reported both elementary and current reading difficulties (i.e., persistent dyslexics). The PRD group had a mean age of 22 years and 5 months (*SD* = 4 years 10 months), and included 68 females and 36 males. An analysis of variance (ANOVA) revealed no significant age differences between the four groups, $F(3, 211) = 1.04$, $p > .05$. Similarly, a χ^2 test found no differences in gender distribution across the four participant groups, $\chi^2(3, n = 215) = 4.16$, $p > .05$.

Table 1 shows the mean ARHQ-R Elementary scores of the four groups. As expected, the main effect of group was significant, $F(3, 211) = 336.11$, $p < .001$. As the groups showed unequal variances, I used post-hoc Games-Howell to examine the pairwise differences between the four groups. The ARHQ-R Elementary scores of the Control group and the LRD group were similar to each other, and (by design) significantly lower than the scores of the CRD and PRD groups. The scores of the CRD group and the PRD group were similar to each other. Likewise, Table 1 also shows the mean ARHQ-R Current scores of the four groups. The main effect of group was also significant, $F(3, 211) = 193.14$, $p < .001$. The post-hoc Games-Howell analysis showed that all four groups were significantly different from each other, with the Control group having the lowest scores (i.e., reported the least difficulty), followed by the CRD group, in turn followed by the LRD group, and finally followed by the PRD group. Thus the compensated HFRDs reported more current reading problems than the controls, and the late-emerging HFRDs reported fewer current reading problems than the persistent HFRDs.

Table 1. Descriptives and pairwise differences between the four participant groups on the ARHQ-R Elementary and Current scores.

	Control (n = 70)		CRD (n = 26)		LRD (n = 15)		PRD (n = 104)		ANOVA (df = 3, 211)	
Measure	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***F***	η_p^2
Elem.	$.08_{12}$	.09	$.54_{13}$	.12	$.12_{34}$	.08	$.60_{24}$	.14	336.11^{***}	.83
Current	$.23_{123}$	.07	$.28_{145}$	.06	$.44_{246}$	.05	$.56_{356}$	.12	193.14^{***}	.73

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

Note: Subscripts denote pairwise differences significant at the $p < .05$ level for each variable. For example the subscript *1* on the ARHQ-R Elementary variable indicates a significant difference between the Control and CRD groups.

To provide a frame of reference for the remaining analyses, I also estimated a grade equivalent for each participant based on their scores on the Word Identification[1], Word Attack, Sight Word Efficiency, and Phonemic Decoding Efficiency measures. On the Word Identification measure, the Control group had the highest mean grade equivalent (M = 16.3, SD = 1.8, range = 8.8 to 16.9), followed by the LRD group (M = 14.6, SD = 2.9, range = 9.9 to 16.9), the CRD group (M = 13.7, SD = 3.5, range = 7.8 to 16.9), and the PRD group (M = 12.5, SD = 3.2, range = 7.8 to 16.9). The percentage of participants who scored at the Grade 12 level or higher also followed the same pattern: 93% in the Control group, 67% in the LRD group, 62% in the CRD group, and 45% in the PRD group. On the Sight Word Efficiency measure, interestingly, the LRD group had the highest mean grade equivalent (M = 11.8, SD = 1.9, range = 5.4 to 12.6), followed by the Control group (M = 11.5, SD = 1.6, range = 5.4 to 12.6), the CRD group (M = 11.3, SD = 1.7, range = 5.8 to 12.6), and the PRD group (M = 9.5, SD = 2.6, range = 3.4 to 12.6). The percentage of participants who scored at the Grade 12 level or higher followed the same pattern: 80% in the LRD group, 61% in the Control group, 46% in the CRD group, and

[1] An extrapolated Word Identification raw score was calculated by (1) multiplying the score on the first 23 items (which were the even-numbered items from Item 30-75 in the original task) by two, (2) adding the score on the remaining 31 items (Items 77-106 in the original task), and (3) adding a basal score of 29.

23% in the PRD group. Therefore, although many HFRDs were able to achieve word reading levels at the Grade 12 level or higher, the typical college readers remained at an advantage. The persistent HFRDs are also particularly disadvantaged when comparing word reading efficiency.

On the decoding measures, the typical college readers displayed an even greater advantage. On the Word Attack measure, the Control group had the highest mean grade equivalent (*M* = 15.6, *SD* = 2.7, range = 6.9 to 16.9), followed by the LRD group (*M* = 11.9, *SD* = 4.0, range = 6.9 to 16.9), the CRD group (*M* = 11.4, *SD* = 4.2, range = 4.0 to 16.9), and the PRD group (*M* = 11.2, *SD* = 4.2, range = 3.8 to 16.9). In the Control group, 89% of the participants scored at the Grade 12 level or higher, compared to 47% in the LRD group, 39% in the CRD group, and 38% in the PRD group. Similarly, on the Phonemic Decoding Efficiency measure, the Control group had the highest mean grade equivalent (*M* = 12.1, *SD* = 1.1, range = 7.2 to 12.6), followed by the CRD group (*M* = 11.2, *SD* = 2.0, range = 5.0 to 12.6), the LRD group (*M* = 10.7, *SD* = 2.1, range = 6.8 to 12.6), and the PRD group (*M* = 9.3, *SD* = 2.7, range = 2.8 to 12.6). In the Control group, 84% of the participants scored at the Grade 12 level or higher, compared to 58% in the CRD group, 40% in the LRD group, and 26% in the PRD group. Therefore, the typical college readers showed a greater advantage over the HFRDs in decoding abilities than in word reading skills.

Data Transformations

Within-Individual Reaction Times

As previously mentioned, the reaction time (RT) variables included only reaction times to correct responses for all measures, and the reaction times to incorrect responses were excluded. Including only reaction times to correct responses ensures that the response time measured reflects the time taken by the participants during the target reading process. Next, I cleaned the RT variables from the Spelling Choice (Part A), Picture Naming, Phonological Choice, Wordlikeness (Part A), Regular and Irregular Word Reading, and Elision tasks by removing within-individual outliers for each participant. Within-individual outliers were defined as RTs lying beyond 2 standard deviations from the individual's mean RT.

For the Spelling Choice (Part A) and Picture Naming tasks, I split the items in half (i.e., odd-numbered items and even-numbered items). For each half, I removed within-individual outliers and calculated a new median RT. Then I averaged the two median RTs for each task to form the resulting Spelling Choice RT and Picture Naming RT variables.

For the Phonological Choice and Wordlikeness (Part A) tasks, I split the items into those with correct responses presented on the left and those with correct responses presented on the right. For each half, I removed within-individual outliers and calculated a new median RT. Then I averaged the two median RTs for each task to form the resulting Phonological Choice RT and Wordlikeness RT variables.

Finally, I cleaned the within-individual outliers from the Regular High Frequency Word Reading RT, Regular Low Frequency Word Reading RT, Irregular High Frequency Word Reading RT, Irregular Low Frequency Word Reading RT, and Elision RT variables. Then I calculated the new median RTs for each variable.

Within-Variable Outliers and Transformations

After removing within-individual outliers, I assessed all the variables for normality, separately for each of the four groups. Then I corrected the violations through transformations and by reducing the influence of outliers (i.e., changing them to be 1 unit more than the next highest data point or 1 unit less than the next lowest data point), following Tabachnick and Fidell’s (2007) guidelines. Although I assessed normality separately for each of the four groups, I applied transformations to all groups for the same variable, in order to maintain the same scale for all groups.

Consequently, I applied square root transformations to the Word Identification, Sight Word Efficiency, Regular High Frequency Word Reading RT, Regular Low Frequency Word Reading RT, Irregular High Frequency Word Reading RT, Word Attack, Phonemic Decoding Efficiency, Elision Accuracy, and Author Recognition Test variables. I applied a logarithmic transformation to the Phonological Choice RT and RAN Letters RT variables. I applied inverse transformations to the RAN Digits RT, Wordlikeness RT, and Spelling Choice RT variables. I reduced one outlier (belonging to the Control group) and then applied a square root transformation to the Elision RT variable.

Results

After transforming the data, I conducted several multivariate analyses of variance (MANOVAs) and univariate analyses of variance (ANOVAs) to examine whether the four participant groups differed on the various measures. For the MANOVAs, I report Pillai's Trace instead of Wilks' λ when the homogeneity of variances was not assumed. Following each significant MANOVA, I examined the corresponding ANOVAs to determine whether the four groups differed on each variable. For each significant ANOVA, I examined pairwise differences among the four groups using the Tukey's honest significant difference (HSD) test when the groups showed equal variances and the Games-Howell test when the groups showed unequal variances. Tables 2 to 4 show the results of the pairwise comparisons, as well as the group means and standard deviations. Although the transformed variables were used in the analyses, the raw score descriptives are reported in the tables to allow for direct comparisons. For the RT variables, the reaction times are reported with within-individual outliers removed and should be interpreted such that lower values indicate faster responses. Moreover, multivariate analyses of covariance (MANCOVAs) controlling for cognitive ability (i.e., Vocabulary and Matrix Reasoning) were also conducted for all measures, as the groups differed significantly on the two measures (see section below). Finally, a MANCOVA controlling for print exposure (i.e., Author Recognition Test) was conducted for the orthographic processing measures, in order to measure group differences in orthographic processing skills beyond those acquired through reading experience.

Cognitive Ability

First, I conducted a MANOVA to examine whether the four groups differed on the two measures of cognitive ability: Vocabulary and Matrix Reasoning. The overall effect was significant, Wilks' $\lambda = .77$, $F(6, 420) = 9.78$, $p < .001$. The ANOVAs revealed that the groups differed significantly on both measures (Table 2). On the Vocabulary measure, the post-hoc Tukey's HSD analysis indicated that the Control group scored significantly higher than the CRD and PRD groups. Similarly, on the Matrix Reasoning measure, the post-hoc Games-Howell analysis indicated that the Control group scored significantly higher than the CRD and PRD groups. The LRD group did not differ significantly from the three other groups.

Table 2. Raw score descriptives and pairwise differences between the four participant groups on the cognitive ability and word reading measures.

Measure	Control (n = 70)		CRD (n = 26)		LRD (n = 15)		PRD (n = 104)		ANOVA (df = 3, 211)	
	M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***F***	η_p^2
<u>*Cognitive Ability*</u>										
Vocabulary	21.49_{12}	4.58	15.96_{1}	6.53	18.20	4.13	16.08_{2}	5.14	17.28^{***}	.20
Matrix Reasoning	17.73_{12}	3.10	14.69_{1}	3.59	16.47	3.29	15.69_{2}	4.00	6.30^{***}	.08
<u>*Word Reading*</u>										
Word Identification	49.76_{12}	3.22	44.42_{1}	5.31	47.33_{3}	3.89	43.40_{23}	4.60	37.01^{***}	.35
Sight Word Efficiency	96.64_{1}	8.27	94.58_{2}	7.86	98.33_{3}	8.71	86.65_{123}	11.05	20.79^{***}	.23
Regular High Frequency Word Reading RT	561_{1}	77	599	87	580	79	635_{1}	117	8.22^{***}	.11
Regular Low Frequency Word Reading RT	582_{1}	77	622	97	610	90	686_{1}	144	11.99^{***}	.15
Irregular High Frequency Word Reading RT	583_{1}	77	624	91	595	92	670_{1}	129	9.95^{***}	.12
Irregular Low Frequency Word Reading RT	612_{1}	84	682	131	657_{2}	102	748_{12}	157	15.40^{***}	.18

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

Note: Subscripts denote pairwise differences significant at the $p < .05$ level.

Word Reading

Previous research has generally agreed that HFRDs display residual word reading deficits, both in accuracy and speed (e.g., Bruck, 1990; Deacon et al., 2012; Law et al., 2015; Parrila et al., 2007; Wilson & Lesaux, 2001), when compared to typical college readers. To examine whether the current sample also revealed similar deficits, I conducted a MANOVA to examine whether the four groups differed on the six measures of word reading: Word Identification, Sight Word Efficiency, Regular High Frequency Word Reading RT, Regular Low Frequency Word Reading RT, Irregular High Frequency Word Reading RT, and Irregular Low Frequency Word Reading RT. The overall effect was significant, Pillai's Trace = .50, $F(18, 624) = 7.01$, $p < .001$, $\eta_p^2 = .17$. The ANOVAs revealed significant effects for all six measures (Table 2). On the Word Identification measure, the post-hoc Tukey's HSD analyses indicated that the Control group scored significantly higher than the other three groups, and that the LRD also scored significantly higher than the PRD group. On the Sight Word Efficiency measure, the post-hoc Tukey's HSD analyses demonstrated that the PRD group scored significantly lower than the other three groups. On the remaining four measures, the post-hoc Games-Howell analyses indicated that the Control group was significantly faster than the PRD group. The LRD group was also significantly faster than the PRD group on the Irregular Low Frequency Word Reading RT measure. The multivariate and univariate effects remained significant after entering the Vocabulary and Matrix Reasoning measures as covariates.

In summary, it appears that the Control group consistently outperformed the PRD group, indicating continuing word accuracy and speed deficits in the Persistent HFRDs. On the other hand, the Control group only performed better than the CRD and LRD groups on the Word Identification measure, showing that the compensated HFRDs and late-emerging HFRDs were similar to the typical college readers in efficiency and speed. Moreover, the CRD group performed better than the PRD group on the Sight Word Efficiency measure. The LRD group also performed better than the PRD group on word reading accuracy, word reading efficiency, and irregular low frequency word reading speed.

Phonological Decoding

In the HFRD literature, studies have also generally shown HFRDs to be less accurate (e.g., Felton et al., 1990; Gallagher et al., 1996; Snowling et al., 1987; Wilson & Lesaux, 2001) and slower (e.g., Bruck, 1990; Leong, 1999) than typical college readers when reading nonwords. Thus I used a MANOVA to determine whether the four groups differed on the three decoding measures: Word Attack, Phonemic Decoding Efficiency, and Phonological Choice RT. The overall effect was significant, Pillai's Trace = .43, $F(9, 633) = 11.78$, $p < .001$, $\eta_p^2 = .14$. The ANOVAs also revealed significant effects for all three measures (Table 3). On the Word Attack measure, the post-hoc Tukey's HSD analyses revealed that the Control group scored significantly higher than the other three groups. On the Phonemic Decoding Efficiency measure, the post-hoc Tukey's HSD analyses revealed that the Control group scored significantly higher than the LRD and PRD groups, and the CRD group scored significantly higher than the PRD group. On the Phonological Choice RT measure, the post-hoc Games-Howell analyses showed that the Control and LRD groups both performed significantly faster than the CRD and PRD groups. The multivariate and univariate effects remained significant even after controlling for the Vocabulary and Matrix Reasoning measures.

In summary, the Control group consistently read nonwords more accurately, efficiently, and quickly than the PRD group, highlighting the enduring decoding difficulties in persistent HFRDs. The Control group also outperformed the CRD group in decoding accuracy and speed, but the two groups were comparable in decoding efficiency. Therefore, even the compensated HFRDs show some persisting decoding difficulties compared to typical college readers. The CRD group only outperformed the PRD group on the Phonemic Decoding Efficiency measure. Interestingly, the LRD group was significantly less accurate and less efficient than the Control group but was comparable in speed. The LRD group also outperformed the CRD and PRD groups on the Phonological Choice RT measure.

Phonological Awareness

In addition to decoding difficulties, previous studies have also shown HFRDs to have deficits in phonological awareness (e.g., Birch & Chase, 2004; Bruck, 1992; Felton et al., 1990; Gallagher et al., 1996; Kitz & Tarver, 1989; Law et al., 2015; Snowling et al., 1997; Wilson & Lesaux, 2001). Therefore, I used separate ANOVAs to determine whether the four groups differed on the two phonological awareness measures: Elision Accuracy and Elision RT. The groups differed significantly on both measures (Table 3). On the Elision Accuracy measure, the post-hoc Games-Howell analyses showed that the Control group scored significantly higher than

Table 3. Raw score descriptives and pairwise differences between the four participant groups on the phonological decoding, phonological awareness, and naming speed measures.

	Control **(n = 70)**		**CRD** **(n = 26)**		**LRD** **(n = 15)**		**PRD** **(n = 104)**		**ANOVA** **(df = 3, 211)**	
Measure	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***F***	η_p^2
Decoding										
Word Attack	42.11_{123}	2.56	37.88_{1}	4.82	39.00_{2}	4.19	37.49_{3}	4.51	23.09^{***}	.25
Phonemic Decoding Efficiency	58.51_{12}	4.38	55.00_{3}	6.77	53.67_{1}	6.77	48.77_{23}	8.54	30.21^{***}	.30
Phonological Choice RT	1753_{12}	486	2213_{13}	568	1694_{34}	560	2567_{24}	1318	12.28^{***}	.15
Phonological Awareness										
Elision Accuracy	15.43_{12}	1.20	13.38_{1}	3.02	14.93	1.49	13.52_{2}	2.55	12.52^{***}	.15
Elision RT	916_{12}	227	1124_{1}	354	968	337	1150_{2}	356	8.18^{***}	.10
Naming Speed										
RAN Letters RT	17424_{1}	3249	18792	2835	18066	4682	20456_{1}	3707	12.09^{***}	.15
RAN Digits RT	17668_{12}	3069	18986_{1}	2543	18134	4257	20541_{2}	5288	7.33^{***}	.09

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

Note: Subscripts denote pairwise differences significant at the $p < .05$ level.

the CRD and PRD groups. On the Elision RT measure, the post-hoc Tukey's HSD analyses also demonstrated that the Control group performed significantly faster than the CRD and PRD groups. Both univariate effects remained significant even after controlling for the Vocabulary and Matrix Reasoning measures. Hence, the Control group was significantly more accurate and faster at manipulating sound segments than the CRD and PRD groups, even after controlling for cognitive ability. The LRD group was also more accurate than the PRD group.

Naming Speed

In contrast to the literature on HFRDs' phonological processing skills, previous studies have produced mixed results regarding their naming speed abilities. To further examine this construct, I used a MANOVA to assess whether the four groups differed on the two measures of naming speed: RAN Letters RT and RAN Digits RT. The overall effect was significant, Pillai's Trace = .15, $F(6, 422.00) = 5.80$, $p < .001$, $\eta_p^2 = .08$. The ANOVAs revealed that the groups differed significantly on both measures (Table 3). For both measures, the post-hoc Games-Howell analyses indicated that the Control group were significantly faster than the PRD group. The Control group also named digits significantly faster than the CRD group. The multivariate and univariate effects remained significant even after accounting for the Vocabulary and Matrix Reasoning measures.

Orthographic Processing

Some previous studies have found orthographic deficits in HFRDs, using mostly spelling measures (e.g., Everatt, 1997; Hanley, 1997; Kemp et al., 2008; Law et al., 2015; Parrila et al., 2007; Wilson & Lesaux, 2001). The current study expands on this construct by including not only spelling measures but also tasks measuring sublexical orthographic knowledge. I used a MANOVA to investigate whether the four groups differed on the five measures of orthographic processing: Wordlikeness RT, Wordlikeness Accuracy, Dictated Spelling, Spelling Choice RT, and Spelling Choice Accuracy. The overall effect was significant, Wilk's $\lambda = .48$, $F(15, 572) = 11.61$, $p < .001$. The ANOVAs also revealed significant effects for all measures except on the Wordlikeness Accuracy measure (Table 4), and I used post-hoc Tukey's HSD analyses to determine pairwise group differences for the significant univariate effects. On the Wordlikeness

Table 4. Raw score descriptives and pairwise differences between the four participant groups on the orthographic processing, morphological processing, print exposure, and lexical access measures.

Measure	**Control (n = 70)** *M*	*SD*	**CRD (n = 26)** *M*	*SD*	**LRD (n = 15)** *M*	*SD*	**PRD (n = 104)** *M*	*SD*	**ANOVA (df = 3, 211)** *F*	η_p^2
Orthographic Processing										
Wordlikeness RT	1136	498	1246	502	1018_1	525	1291_1	621	3.71^{*}	.05
Wordlikeness Accuracy	19.46	2.05	18.96	2.51	18.27	2.22	18.46	2.69	2.62	.04
Dictated Spelling	29.74_{123}	4.35	22.69_1	4.99	25.40_{24}	3.66	20.69_{34}	4.55	58.01^{***}	.45
Spelling Choice RT	779_1	147	858	139	747_2	131	929_{12}	268	11.17^{***}	.14
Spelling Choice Accuracy	20.37_{12}	2.53	16.81_1	2.53	18.67_3	2.35	16.69_{23}	2.65	30.84^{***}	.31
Morphological Processing										
Morphological Parsing Accuracy	31.97_1	5.23	30.85	5.15	29.53	4.09	29.38_1	4.81	4.04^{**}	.05
Morphological Parsing Efficiency	$.68_1$	.12	.62	.12	.65	.13	$.62_1$	.13	2.89^{*}	.04
Print Exposure										
Author Recognition Test	37.11_{123}	9.20	31.08_1	8.82	30.27_2	8.07	27.01_3	7.93	19.96^{***}	.22
Lexical Access										
Picture Naming RT	777	118	821	95	796	142	840	203	2.14	.03

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

Note: Subscripts denote pairwise differences significant at the $p < .05$ level. For example, the subscript *1* on the Wordlikeness RT measure indicates a significant difference between the LRD and PRD groups.

RT measure, the LRD group was significantly faster than the PRD group. On the Dictated Spelling measure, the Control group scored significantly higher than the other three groups, and the LRD group scored significantly higher than the PRD group. On both the Spelling Choice RT and Spelling Choice Accuracy measures, the Control and LRD groups performed significantly better than the PRD group. The Control group also scored significantly higher than the CRD group on the Spelling Choice Accuracy measure. The multivariate and univariate effects remained significant both after controlling for the Vocabulary and Matrix Reasoning measures, and after controlling for the Print Exposure measure.

In summary, the Control group performed better than the PRD group on measures of word-level orthographic processing (i.e., Dictated Spelling and Spelling Choice) but not on measures of sublexical processing (i.e., Wordlikeness). Thus the persistent HFRDs appear to show some orthographic processing strengths, but their sublexical orthographic processing skills do not allow them to perform comparably to their typically reading peers at the word level. The Control group also performed better than the CRD group on the two measures of word-level spelling accuracy (i.e., Dictated Spelling and Spelling Choice Accuracy). Therefore, it appears that compensated HFRDs also show weaker spelling skills when compared to typical college readers. In fact, the compensated HFRDs and persistent HFRDs were not significantly different on any measure. On the other hand, the LRD group was comparable to the Control group on all measures except for the Dictated Spelling measure. The LRD group also performed better than the PRD group on all measures except for the Wordlikeness Accuracy measure. Interestingly, all significant differences remained even after controlling for cognitive ability or print exposure. Therefore, the groups show differences in orthographic processing skills beyond their differences in general knowledge and reading experience.

Morphological Processing

Although the HFRD literature has rarely examined morphological processing, a few studies have identified morphological processing deficits in HFRDs (e.g., Deacon et al., 2006; Leong, 1999). To further explore this process, I used a MANOVA to determine whether the four groups differed on the two measures of morphological processing: Morphological Parsing Accuracy and Morphological Parsing Efficiency. The overall effect was significant, Wilk's $\lambda = .92$, $F(6, 422.00) = 2.56$, $p < .05$. The ANOVAs revealed that the groups differed significantly on both measures (Table 4). For both measures, post-hoc Tukey's HSD analyses indicated that the Control group scored significantly better than the PRD group. When controlling for the effects of Vocabulary and Matrix Reasoning, the multivariate effect became nonsignificant, Wilk's $\lambda = .97$, $F(6, 416.00) = 1.08$, $p > .05$. The results were similar when controlling for either the Vocabulary measure, Wilk's $\lambda = .96$, $F(6, 418.00) = 1.34$, $p > .05$, or the Matrix Reasoning measure, Wilk's $\lambda = .95$, $F(6, 418.00) = 1.75$, $p > .05$.

In summary, the Control group performed better than the PRD group on both measures of morphological processing, showing morphological processing deficits in persistent HFRDs when compared to typical college readers. These differences become nonsignificant, however, when controlling for vocabulary, nonverbal reasoning, or both skills. Therefore, the morphological processing weaknesses of persistent HFRDs may be attributed to weaker verbal and nonverbal cognitive skills overall.

Print Exposure and Lexical Access

The current study also included measures of print exposure and lexical access, which have not been previously examined in the HFRD literature. I conducted an ANOVA to investigate whether the four groups differed on the Author Recognition Test, a commonly used print exposure measure. The groups differed significantly (Table 4). The post-hoc Tukey's HSD analysis showed that the Control group scored significantly higher than the other three groups. The univariate effect also remained significant after controlling for the Vocabulary and Matrix Reasoning measures. I also used an ANOVA to examine whether the four groups differed on the lexical access speed measure, Picture Naming RT. The results were nonsignificant (Table 4).

In summary, the Control group outperformed the PRD, CRD, and LRD groups on the measure of print exposure, even after controlling for vocabulary. Therefore, it appears that typical college readers read more than all HFRDs. The groups, however, did not differ in their ability to label pictorial stimuli.

Discussion

The group comparison analyses in this section served to examine whether HFRDs exhibit residual difficulties when compared to typical college readers, and to investigate whether the three HFRD groups display reliable differences from each other. The following sections will discuss the current findings with respect to the various research questions examined in this section.

Persistent HFRDs and Typical College Readers

The PRD group in this study consisted of individuals who reported childhood reading difficulties and who continue to report reading difficulties in their post-secondary studies. Therefore, the PRD group can be considered similar to the self-reported uncompensated HFRDs in previous studies. Consequently, comparing the Control and PRD groups allows for detection of continuing deficits in Persistent HFRDs.

In the current study, the persistent HFRDs showed weaknesses in all measures of word reading compared to the typical college readers. The persistent HFRDs were significantly less accurate in untimed word reading tasks, consistent with previous research (e.g., Bruck, 1990; Deacon et al., 2012; Law et al., 2015; Parrila et al., 2007; Wilson & Lesaux, 2001). They were also significantly less accurate in a timed word reading task (Sight Word Efficiency), which was not used in previous research. Moreover, the persistent HFRDs were significantly slower at reading both high and low frequency regular and irregular words out of context, also replicating previous results (e.g., Bruck, 1990; Parrila et al., 2007; Wilson & Lesaux, 2001).

The persistent HFRDs in the current study also exhibited pervasive phonological processing difficulties when compared to typical college readers. The persistent HFRDs were significantly less accurate at reading nonwords, replicating the findings of many studies (e.g., Felton et al., 1990; Gallagher et al., 1996; Kemp et al., 2008; Snowling et al., 1987; Wilson & Lesaux, 2001). They were also significantly slower at decoding nonwords, similar to previous findings (Bruck, 1990; Leong, 1999). Also echoing previous results (e.g., Bruck, 1992; Felton et al., 1990; Gallagher et al., 1996; Law et al., 2015; Snowling et al., 1997; Wilson & Lesaux, 2001), the persistent HFRDs were significantly less accurate and slower at manipulating sound units. In addition to phonological processing difficulties, the persistent HFRDs were significantly slower at naming digits and letters, also replicating previous findings (e.g., Parrila et al., 2007).

On the other hand, the persistent HFRDs displayed mixed performance in the orthographic processing tasks. They performed significantly worse than their typically reading peers in word-level orthographic processing skills, but were not significantly different from the controls in sublexical orthographic processing skills. The persistent HFRDs made significantly more errors when spelling to dictation, mirroring previous research (e.g., Everatt, 1997; Hanley, 1997; Kemp et al., 2008; Law et al., 2015; Parrila et al., 2007; Wilson & Lesaux, 2001). They were also significantly less accurate and slower in choosing correct spellings of words (Spelling Choice). However, the persistent HFRDs were not significantly different from the controls in accuracy or speed when identifying orthographic conventions (Wordlikeness). These results generally support previous studies suggesting that HFRDs may be able to rely on orthographic strategies to compensate for their phonological deficits (e.g., Bruck, 1990; Pennington et al., 1987), but that their orthographic processing skills nevertheless remain below those of their typically reading peers (e.g., Kitz and Tarver, 1989).

Furthermore, the persistent HFRDs were significantly less accurate than the controls on both the timed and untimed morphological processing tasks. These findings also echo previous literature showing that HFRDs were less sensitive to morphological complexity (e.g., Deacon et al., 2006) and were less able to produce derivations of base words (e.g., Leong, 1999) than typical college readers. However, the group differences in the current study disappeared for both measures when controlling for vocabulary, nonverbal intelligence, or both. Therefore, the morphological processing weaknesses in the persistent HFRDs may reflect an overall weakness in cognitive ability. Finally, the persistent HFRDs and typical college readers were comparable on a measure of lexical access speed, but the controls exhibited significantly better print exposure than the persistent HFRDs.

In summary, the typical college readers in this study generally outperformed the persistent HFRDs in all examined cognitive and reading skills, except on measures of sublexical orthographic processing and lexical access speed. These findings largely replicate previous studies showing that HFRDs display residual difficulties in many reading skills.

Compensated HFRDs and Typical College Readers

The CRD group consisted of individuals who reported reading difficulties in elementary school, but no post-secondary reading difficulties. Therefore, this CRD group can be considered self-reported compensated HFRDs. The comparison between the CRD and Control groups allows for comparison of compensated HFRDs and typical college readers.

In the current study, the compensated HFRDs' performance on word reading tasks only partially support previous findings in the literature. For example, Lefly and Pennington (1991) found that the compensated HFRDs and controls were comparable in word reading accuracy. In the current study, the compensated HFRDs were as accurate as the controls in a timed task (Sight Word Efficiency), but were significantly less accurate than the controls in an untimed task (Word Identification). On the other hand, previous studies (Birch & Chase, 2004; Lefly & Pennington, 1991) have found compensated HFRDs to be significantly slower at reading words than typical college readers. However, in the current study, the compensated HFRDs and controls were equally fast at reading both regular and irregular words.

One caveat hindering direct comparison of the current results to those of previous studies, however, is that the current study used isolated word reading measures whereas the previous studies used contextual word reading measures. Specifically, Lefly and Pennington (1991) and Birch and Chase (2004) both administered an oral passage reading measure, whereas the participants in the current study read words presented one at a time with no context. Therefore, contextual influences may have also affected the HFRDs' performance in the previous studies.

A second methodological discrepancy between the current study and the previous studies is the criteria for selecting compensated HFRDs. Lefly and Pennington (1991) recruited compensated HFRDs who reported childhood reading difficulties but showed no current reading difficulties on standardized achievement tests. Similarly, Birch and Chase (2004) recruited compensated HFRDs who were previously diagnosed with dyslexia but showed standardized reading scores within the normal range. In contrast, the current study identified compensated HFRDs as individuals who reported childhood reading difficulties but who did not report any current reading difficulties. Therefore, the compensated HFRDs may not be fully compensated individuals as measured by standardized reading tests, but instead could include individuals who have developed excellent coping mechanisms for their reading difficulties.

As well the compensated HFRDs' performance on phonological tasks in the current study mirror only some previous results. The compensated HFRDs were significantly less accurate and slower than the controls at decoding nonwords, similar to the findings in Birch and Chase's (2004) study. However, Birch and Chase found that their compensated HFRDs and controls performed comparably in a phonological awareness task, whereas the compensated HFRDs in the current study were significantly less accurate and slower at manipulating phonological units than the controls. One possible explanation for this discrepancy could be in the task demands of the two studies. Birch and Chase administered a Pig Latin task requiring participants to segment the initial phoneme in a word and subsequently add the phoneme to a fixed syllable (e.g., count → ount-cay), whereas the Elision task in the current study required participants to segment phonemes in initial, medial, and final positions. Therefore, it is possible that compensated HFRDs are able to perform phonological manipulation at a simple level, such as initial phoneme segmentation, but have difficulty at more complex levels. Moreover, Birch and Chase found that their compensated HFRDs and controls were equally fast at naming letters and digits. In the current study, the two groups were equally fast at naming letters, but the compensated HFRDs were significantly slower than the controls at naming digits.

On the other hand, the compensated HFRDs in the current study showed spelling weaknesses similar to those found in previous literature. The compensated HFRDs were significantly less accurate than the controls in spelling dictated words and choosing correct spellings of words. These results echo Lefly and Pennington's (1991) finding that the typical college readers outperformed the compensated HFRDs in spelling accuracy. Lefly and Pennington also found that their compensated HFRDs and controls showed similar types of spelling errors, suggesting similar sublexical orthographic processing skills. Although the current study used different tasks, preventing a direct comparison, the compensated HFRDs and controls also showed no significant differences in identifying orthographic conventions (Wordlikeness). Perhaps the most interesting finding in both Lefly and Pennington's study and the current study, is that the compensated HFRDs were able to demonstrate sublexical orthographic knowledge on par with the controls, but were nevertheless weaker at spelling real words than the controls.

Furthermore, the compensated HFRDs and typical college readers displayed similar morphological processing abilities in the current study. These findings are in contrast to Law et al.'s (2015) findings that their controls performed better than their compensated HFRDs. One possible reason may be the differences in task demands between the two studies. Specifically, Law et al. administered morphological processing tasks that required participants to convert root words into derived forms and to choose appropriate derivations of nonwords. In contrast, the participants in the current study performed a morphological parsing activity.

Finally, in the current study, the compensated HFRDs and typical college readers performed comparably on a measure of lexical access speed, but the controls displayed significantly better print exposure than the compensated HFRDs. However, the orthographic processing differences between the two groups remained significant even after controlling for print exposure differences. Thus it appears that even HFRDs who perceive themselves as compensated continue to display orthographic processing weaknesses, and that these weaknesses may reflect an inherent insensitivity to orthographic properties rather than a lack of reading experience.

In summary, the compensated HFRDs in the current study were generally comparable to the typical college readers in word reading efficiency and speed, decoding efficiency, rapid letter naming, sublexical orthographic processing, word-level orthographic processing speed, morphological processing, and lexical access speed. In contrast, the compensated HFRDs showed relative weaknesses in word reading accuracy, decoding accuracy and speed, phonological awareness, rapid digit naming, spelling accuracy, word-level orthographic processing accuracy, and print exposure. Therefore, the compensated HFRDs in the current study also displayed some persistent deficits when compared to typical college readers, despite reporting no current reading difficulties. The discrepancies found between the current results and those of previous studies may be at least partially attributable to differences in selection criteria for compensated HFRDs and to differences in task demands.

Compensated HFRDs and Persistent HFRDs

In addition to comparing compensated HFRDs to typical college readers, the comparison between the CRD and PRD groups in the current study also mimics the comparison of compensated and uncompensated HFRDs in previous literature. When examining word reading skills, the compensated HFRDs in the current study only outperformed the persistent HFRDs on a measure of timed word reading accuracy (i.e., Sight Word Efficiency). The compensated and persistent HFRDs were comparable on the untimed measure of word reading accuracy (Word

Identification), which contradicts previous results (e.g., Birch & Chase, 2004; Lefly & Pennington, 1991). The two groups were also comparable on the measures of word reading speed (Regular High Frequency Word Reading RT, Regular Low Frequency Word Reading RT, Irregular High Frequency Word Reading RT, and Irregular Low Frequency Word Reading RT), which also contradicts previous findings (e.g., Birch & Chase, 2004; Lefly & Pennington, 1991).

When examining decoding skills, the compensated HFRDs were significantly more accurate at decoding nonwords than the persistent HFRDs on a timed measure (Sight Word Efficiency), but were comparable on an untimed measure (Word Attack). These results only partially mimic the pattern in Birch and Chase's (2004) study, in that the typical college readers were more accurate than the compensated HFRDs, who were in turn more accurate than the uncompensated HFRDs. The compensated HFRDs and persistent HFRDs in the current study also performed comparably in nonword reading speed (Phonological Choice RT), in contrast to Birch and Chase's results. However, Birch and Chase's nonword reading measure required participants to read nonwords aloud, whereas the current participants were required to choose between pseudohomophones. Therefore, the decision task with more complex task demands (i.e., reading two nonwords and making a decision) may have been more difficult for both groups.

Moreover, the compensated HFRDs and persistent HFRDs in the current study also showed no significant differences in their phonological awareness skills. The two groups exhibited similar accuracy and speed when manipulating sound units (Elision), which contradicts Birch and Chase's (2004) results. As previously mentioned, the current study required manipulating phonemes in different positions, which may be a more problematic task for compensated HFRDs than Birch and Chase's task requiring manipulation of only initial position phonemes. The two groups also displayed similar letter and digit naming speeds (RAN Letters RT and RAN Digits RT), again contradicting Birch and Chase's findings.

The compensated HFRDs and persistent HFRDs also performed comparably in all measures of orthographic processing skills in the current study. They showed no significant differences in spelling ability (Dictated Spelling and Spelling Choice), contrary to Lefly and Pennington's (1991) findings. They also showed equal ability in identifying orthographic conventions (Wordlikeness). Similarly, the compensated HFRDs and persistent HFRDs showed comparable morphological processing skills in the current study. These results contrast Law et al.'s (2015) findings that their compensated HFRDs displayed better morphological processing skills than their uncompensated HFRDs. Finally, the compensated HFRDs and persistent HFRDs were comparable on measures of print exposure and lexical access speed.

One possibility for the lack of significant differences between the compensated HFRDs and the persistent HFRDs on many measures may be the differences in group sizes. The persistent HFRDs included 104 participants whereas the compensated HFRDs included only 26 participants. When examining the mean group scores, the compensated HFRDs generally demonstrated better skills than the persistent HFRDs, with a few exceptions and albeit nonsignificantly. Another possibility may be due to the participant selection criteria used to form these two groups. As previously mentioned, many previous studies identified compensated and uncompensated HFRDs based on performance on measures, whereas the current study selected the two groups based on self-report of current reading problems. Therefore, it is possible that the compensated HFRDs in the current study may not be fully compensated HFRDs, or that some of the persistent HFRDs may be performing better than they perceive. Interestingly, however, the compensated HFRDs and persistent HFRDs in the current study did reveal significant differences in measures of word reading and decoding efficiency. Therefore, regardless of whether the two groups would have demonstrated more differences with different methodology, it appears that the most marked discrepancy lies in the two groups' ability to perform under time pressure.

In summary, the compensated HFRDs in the current study outperformed the persistent HFRDs only on measures of word reading and decoding efficiency. The two groups performed similarly on all other reading skills, contradicting many previous results. Some possibilities for the lack of significant differences between the groups in the current study may lie in group sizes, participant selection criteria, and/or task demands.

Late-emerging HFRDs

Finally, the current study involved a group of participants who have not been previously studied in the HFRD literature. The LRD group consisted of individuals who did not report childhood reading difficulties, but instead did report reading difficulties in their post-secondary studies. Therefore, their reading difficulties can be considered as being late-emerging when compared to the CRD and PRD groups. The LRD group is particularly interesting to examine because previous studies selecting participants based on reported childhood reading difficulties (e.g., Lefly & Pennington, 1991; Parrila et al., 2007) would have excluded this group, or alternatively would have included them as controls.

When compared to the typical college readers, the late-emerging HFRDs were comparable to the controls in all word reading measures. When examining decoding skills, the late-emerging HFRDs were interestingly less accurate than the typical college readers, on both timed and untimed measures, but equal in speed. There were also no significant differences between the two groups on measures of phonological awareness or naming speed. When examining orthographic processing abilities, the late-emerging HFRDs were significantly less accurate at spelling dictated words (Dictated Spelling) than the controls, but were equally accurate and quick at recognizing correct spellings of words (Spelling Choice) and at identifying orthographic conventions (Wordlikeness). The two groups also showed no significant differences in morphological processing skills or lexical access speed. However, the late-emerging HFRDs displayed significantly less print exposure than the typical college readers. In previous studies that selected HFRDs based on reported childhood reading difficulties, it is possible that some late-emerging HFRDs would have been included as controls. Based on the current results showing relative deficits in the late-emerging HFRDs' decoding accuracy, spelling accuracy, and print exposure skills, the inclusion of late-emerging HFRDs as controls may have reduced the possibility of finding significant group differences between HFRDs and controls on some measures.

When compared to the persistent HFRDs, the late-emerging HFRDs were significantly more accurate at reading words on both timed and untimed measures, but were comparable in speed. The two groups were also similar in decoding accuracy, but the late-emerging HFRDs were significantly faster at choosing nonwords than the persistent HFRDs. The two groups showed no differences in phonological awareness or naming speed skills. On the other hand, the late-emerging HFRDs outperformed the persistent HFRDs on all measures of orthographic processing, except for accuracy in identifying sublexical orthographic conventions. Specifically, the late-emerging HFRDs were more accurate at spelling and recognizing correct spellings, and were significantly faster at recognizing correct spellings and identifying orthographic conventions. Moreover, the late-emerging HFRDs and persistent HFRDs displayed no significant differences in morphological processing skills, lexical access speed, or print exposure.

On the other hand, the late-emerging HFRDs and compensated HFRDs displayed almost no significant differences across the measures. They were comparable in all measures of word reading accuracy and speed. They also performed similarly in decoding accuracy, but the late-emerging HFRDs were significantly faster than the compensated HFRDs in decoding speed. There were no significant differences between the two groups in phonological awareness, naming speed, orthographic processing, morphological processing, lexical access speed, or print exposure. When examining the performance patterns of the two groups, the late-emerging HFRDs generally performed slightly better than the compensated HFRDs, with a few exceptions and albeit nonsignificantly. Therefore, it is possible that the lack of significant differences between the two groups could be partially due to small group sizes. The compensated HFRDs consisted of 26 participants and the late-emerging HFRDs consisted of 15 participants, with considerably smaller group sizes than the other two participants groups in the current study. However, if the two groups are relatively similar in reality, then previous studies selecting HFRDs solely based on childhood reading difficulties would have excluded the late-emerging HFRDs, therefore perhaps not taking advantage of all recruitment chances.

In summary, the late-emerging HFRDs performed most similarly to the compensated HFRDs, except for a relative strength in nonword reading speed. On the other hand, the late-emerging HFRDs showed relative strengths to the persistent HFRDs in word reading accuracy, spelling accuracy, decoding speed, word-level orthographic processing accuracy, and orthographic processing speed. Finally, the late-emerging HFRDs showed some relative weaknesses compared to the typical college readers in decoding accuracy, spelling accuracy, and print exposure. This latter finding cautions the exclusive use of reported childhood reading difficulties to recruit HFRDs, as the late-emerging HFRDs may be erroneously identified as controls despite some relative deficits, which would result in a weakened control group and fewer significant findings between the controls and HFRDs.

Regularity and Frequency Analyses

In addition to comparing group differences, I also investigated whether regularity and frequency effects existed in the four groups' performance. The few studies examining regularity effects in HFRDs have generally agreed that HFRDs exhibit regularity effects when measuring accuracy (e.g., Ben-Dror et al., 1991; Birch & Chase, 2004). When measuring speed, some results have shown regularity effects (e.g., Birch & Chase, 2004; Bruck, 1990) while others have not (e.g., Ben-Dror et al., 1991).

Results

To further examine regularity and frequency effects in the current sample, I used a mixed between-within subjects ANOVA to investigate whether the four groups performed similarly across the four regular and irregular word reading speed measures: Regular High Frequency Word Reading RT, Regular Low Frequency Word Reading RT, Irregular High Frequency Word Reading RT, and Irregular Low Frequency Word Reading RT. Specifically, I examined whether frequency (high frequency vs. low frequency words) and regularity (regular vs. irregular words) affected the four groups differently. For these analyses, I used the RT variables with within-individual outliers removed, rather than the transformed RT variables, in order to compare the measures on the same scale. The RT variables should be interpreted such that lower scores indicate faster responses. The RT variables were used instead of the accuracy variables due to ceiling effects (Regular High Frequency Word Reading mean proportion correct = .99; Regular Low Frequency Word Reading mean proportion correct = .98; Irregular High Frequency Word Reading mean proportion correct = .95; Irregular Low Frequency Word Reading mean proportion correct = .80).

The main effect of group was significant, $F(3, 211) = 13.33$, $p < 0.001$, $\eta_p^2 = .16$, with post hoc Games-Howell analyses showing that the Control and LRD groups were significantly faster than the PRD group, $p < .001$, similar to the results in the Group Comparison section (Table 2). The main effects of frequency, $F(1, 211) = 79.68$, $p < .001$, $\eta_p^2 = .27$, and regularity, $F(1, 211) = 71.85$, $p < .001$, $\eta_p^2 = .25$, were also significant. Therefore, participants were significantly faster at naming high frequency words than naming low frequency words, and were significantly faster at naming regular words than naming irregular words.

The results also revealed a significant interaction between frequency and group, $F(3, 211) = 7.79$, $p < .001$, $\eta_p^2 = .10$ (Figure 1). To further examine the interaction effect, I conducted an ANOVA to examine group differences on the difference scores between the high and low frequency word reading RTs. The difference scores were calculated by subtracting the high frequency word reading RTs (i.e., Regular High Frequency Word Reading RT + Irregular High Frequency Word Reading RT) from the low frequency word reading RTs (i.e., Regular Low Frequency Word Reading RT + Irregular Low Frequency Word Reading RT). The ANOVA results replicated the significant interaction effect, and the post hoc Games-Howell analyses revealed that only the Control and PRD groups differed significantly from each other. Therefore, the low frequency words impaired the PRD group (mean difference = 128 ms) significantly more than the Control group (mean difference = 48 ms).

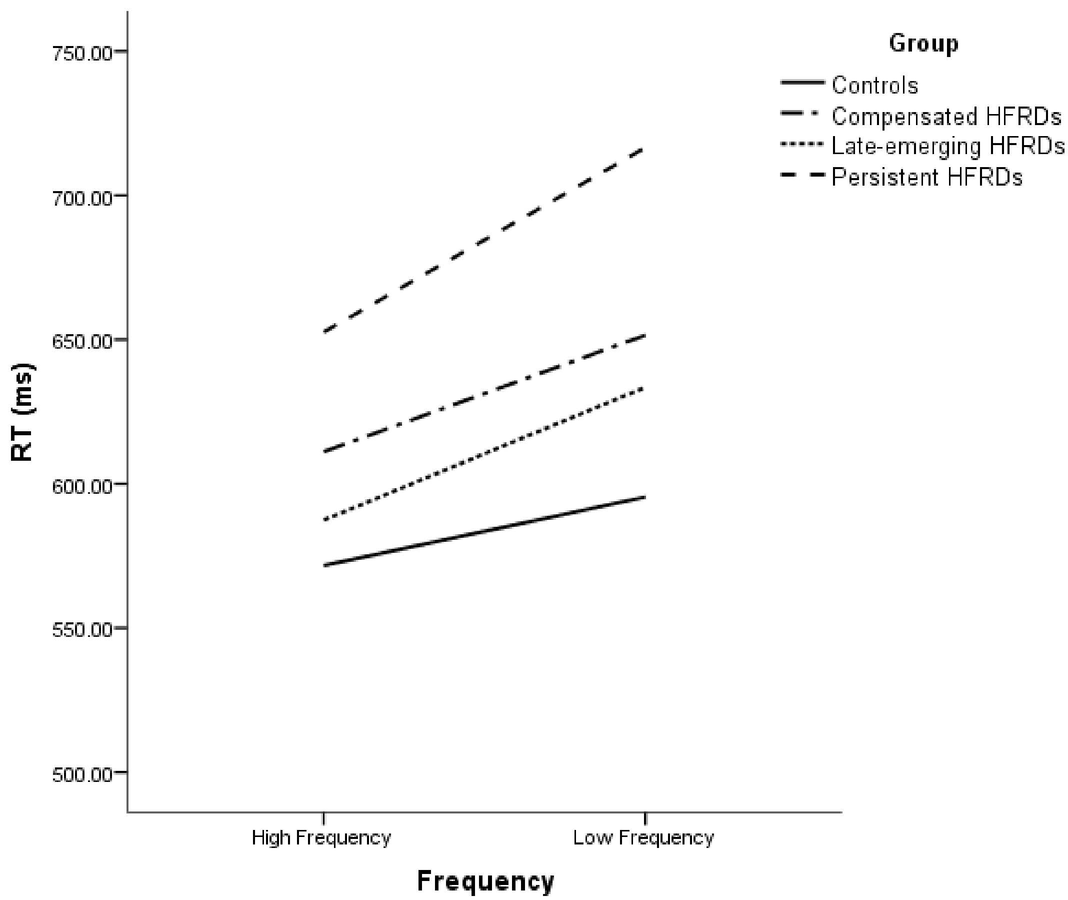

Figure 1. Interaction effect between group and frequency on word reading RT.

Similarly, the mixed between-within subjects ANOVA also revealed a significant interaction effect between group and regularity, $F(3, 211) = 2.85$, $p < .05$, $\eta_p^2 = .04$ (Figure 2). Again, I conducted an ANOVA to examine group differences on the difference scores between the regular and irregular word reading RTs. The difference scores were calculated by subtracting the regular word reading RTs (i.e., Regular High Frequency Word Reading RT + Regular Low Frequency Word Reading RT) from the irregular word reading RTs (i.e., Irregular High Frequency Word Reading RT + Irregular Low Frequency Word Reading RT). The ANOVA results replicated the significant interaction effect, and the post hoc Games-Howell analyses showed that only the Control and PRD groups differed significantly from each other. Therefore, the irregular words impaired the PRD group (mean difference = 96 ms) significantly more than the Control group (mean difference = 54 ms).

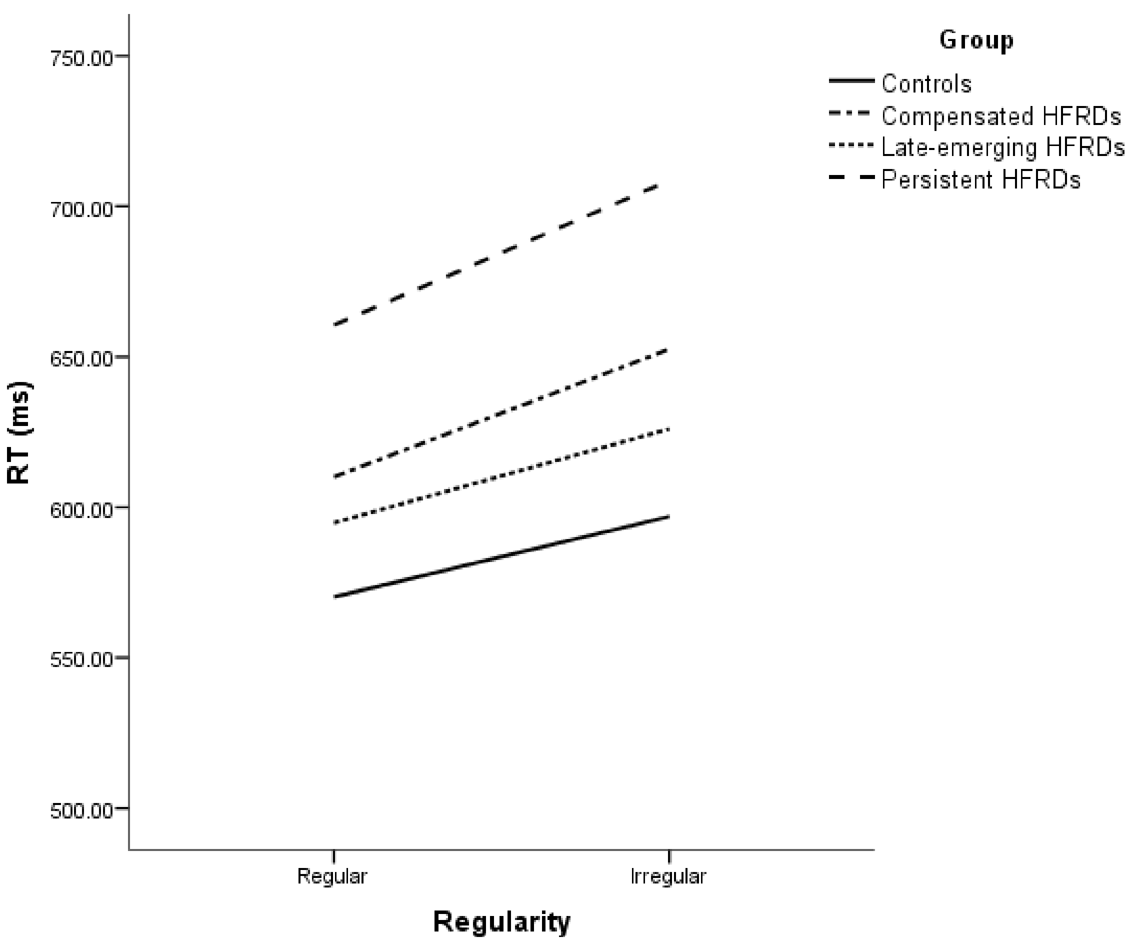

Figure 2. Interaction effect between group and regularity on word reading RT.

Finally, the mixed between-within subjects ANOVA also showed a significant interaction effect between frequency and regularity, F (1, 211) = 10.45, $p < .01$, $\eta_p^2 = .05$. Specifically, the irregularity of words impacted the participants more for low frequency words (mean difference = 51 ms) than for high frequency words (mean difference = 24 ms). The three-way interaction between group, frequency, and regularity was not significant, indicating that the interaction between frequency and regularity was similar across all four participant groups. In other words, all four participants groups were slowest at naming the irregular low frequency words.

Discussion

In the current study, all groups were slower at reading irregular words than regular words. These results replicate Birch and Chase's (2004) finding that typical college readers, compensated HFRDs, and uncompensated HFRDs all read irregular words more slowly than regular words. The regularity effect in the current study also echoes Bruck's (1990) finding that HFRDs were slower to read irregular words than regular words for both high frequency and low frequency words, but contradicts her finding that typical college readers read regular and irregular words equally quickly for both high frequency and low frequency words. One possible explanation for this discrepancy is that the current study and Birch and Chase's study both administered stimuli from Castles and Coltheart's (1993) study, which included monosyllabic and bisyllabic words, whereas Bruck's (1990) stimuli consisted of only monosyllabic words. The regularity effect also contradicts Ben-Dror et al.'s (1991) results when analyzing reading speed. However, the regular and irregular words in Ben-Dror et al.'s study were of higher frequency (mean Kucera-Francis Index = 70.76 for regular words and 67.76 for irregular words). On the other hand, Ben-Dror et al. found a significant regularity effect when analysing accuracy data, which was not examined in the current study.

In addition, all groups were slower at reading low frequency words than high frequency words. A significant interaction effect between regularity and frequency also indicated that all groups were more impaired by irregularity when reading low frequency words than when reading high frequency words; that is, all groups were the slowest at reading irregular low frequency words. These findings contribute to the HFRD literature, as previous studies have not examined frequency effects.

Furthermore, a significant interaction effect revealed that irregularity impaired the persistent HFRDs significantly more than the typical college readers. In fact, reading irregular words slowed the persistent HFRDs almost twice as much as the controls (96 ms vs. 54 ms difference between mean regular word reading time and mean irregular word reading time). This interaction between group and regularity contradicts Ben-Dror et al.'s (1991) findings when analyzing reading speed. Although Birch and Chase (2004) also examined group and word type interactions, they only found that uncompensated HFRDs were more impaired at reading nonwords than regular or irregular words, when compared to the controls and compensated HFRDs. Their data displayed a similar pattern, however, in that the mean difference between regular word reading time and irregular word reading time was smaller for the controls than for the uncompensated HFRDs (28 ms vs. 66 ms). Interestingly, Birch and Chase's compensated HFRDs showed the largest mean difference (75 ms), whereas the mean difference for the compensated HFRDs in the current study fell between those of the controls and persistent HFRDs (85 ms). Similarly, in the current study, low frequency words slowed the persistent HFRDs almost three times as much as the typical college readers (128 ms vs. 48 ms difference between mean high frequency word reading time and mean low frequency word reading time). However, previous studies have not examined frequency effects or interactions to allow for comparison.

In summary, the current study revealed that all groups read irregular words more slowly than regular words, similar to previous studies (Birch & Chase, 2004). To contribute to the HFRD literature, the results also showed that all groups read low frequency words more slowly than high frequency words, and that all groups were the slowest at reading irregular low frequency words. As well, word irregularity and low frequency affected the persistent HFRDs significantly more than the typical college readers, in contrast to some previous findings (e.g., Ben-Dror et al., 1991)

CHAPTER V: DISSOCIATION ANALYSES

In addition to examining residual weaknesses in the current sample of HFRDs, I also investigated the mechanisms by which these HFRDs have been able to compensate for their deficits. In particular, I examined a subset of HFRDs who have achieved word reading success despite phonological deficits. The profile of these HFRDs directly contrasts many reading theories that posit decoding as the key route to word reading (e.g., Snowling, 2001). Therefore, analyzing these HFRDs' skills can provide insight into possible mechanisms through which HFRDs can compensate for their phonological difficulties. For these analyses, I amalgamated the CRD, LRD, and PRD groups into a single RD group (n = 145). Then, I proceeded to identify participants in the RD group whose word reading skills surpassed their phonological skills in both untimed tasks (i.e., accuracy dissociation) and timed tasks (i.e., efficiency dissociation).

Accuracy Dissociations

To examine accuracy dissociations, I identified participants whose word reading accuracy scores were better than expected from their decoding accuracy scores. To calculate Accuracy Dissociation (AD) scores, I used the Word Identification measure to represent word reading accuracy skills, and the Word Attack measure to represent phonological decoding accuracy skills. First, I standardized both variables across all participants (including the Control group) so that participants' standardized scores represent their performance relative to the current sample. Then, I calculated Accuracy Dissociation scores for all the RD participants by subtracting their Word Attack z-scores from their Word Identification z-scores (i.e., Accuracy Dissociation = Word Identification – Word Attack).

Results

Table 5 shows the correlations between the AD scores and the other reading measures for all the RD participants. By definition, the AD scores were positively correlated with the Word Identification measure ($r = .33$, $p < .001$) and negatively correlated with the Word Attack

Table 5. Correlations between Accuracy Dissociation scores and other measures for RD group ($n = 145$).

Measure	***r***
Cognitive Ability	
Vocabulary	$.34^{***}$
Matrix Reasoning	-.05
Word Reading	
Word Identification	$.33^{***}$
Sight Word Efficiency	-.01
Regular High Frequency Word Reading RT	-.15
Regular Low Frequency Word Reading RT	-.10
Irregular High Frequency Word Reading RT	-.11
Irregular Low Frequency Word Reading RT	-.12
Decoding	
Word Attack	$-.51^{***}$
Phonemic Decoding Efficiency	$-.20^{*}$
Phonological Choice RT	.07
Phonological Awareness	
Elision Accuracy	.01
Elision RT	-.09
Naming Speed	
RAN Letters RT	.09
RAN Digits RT	.03
Orthographic Processing	
Wordlikeness RT	.06
Wordlikeness Accuracy	-.04
Dictated Spelling	$.22^{**}$
Spelling Choice RT	-.05
Spelling Choice Accuracy	.13
Morphological Processing	
Morphological Parsing Accuracy	-.01
Morphological Parsing Efficiency	.00
Print Exposure	
Author Recognition Test	$.22^{**}$
Lexical Access	
Picture Naming RT	$-.19^{*}$

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

measure ($r = -.51$, $p < .001$). The AD scores were also positively correlated with the Vocabulary ($r = .34$, $p < .001$), Dictated Spelling ($r = .22$, $p < .01$), and Author Recognition Test ($r = .22$, $p < .01$) measures. Therefore, the participants with higher dissociation scores also defined more words accurately, spelled more words accurately, and had more reading experience. On the other hand, the AD scores were negatively correlated with the Phonemic Decoding Efficiency ($r = -.20$, $p < .05$) measure, indicating that the participants with higher dissociation scores were less able to quickly decode nonwords. The AD scores were also negatively correlated with the Picture Naming RT ($r = -.19$, $p < .05$) measure, meaning that the participants with higher dissociation scores were quicker to retrieve object labels.

Next, I categorized the RD participants into three groups based on their AD scores. The AD(+) group consisted of 12 participants with AD scores ≥ 1, indicating that their standardized word reading accuracy scores were at least 1 standard deviation higher than their standardized decoding accuracy scores. The AD(+) group's mean word reading accuracy score (Word Identification $M = 47.50$, $SD = 3.80$) fell within one standard deviation of the control group mean ($M = 49.76$; $SD = 3.22$). In contrast, their mean decoding accuracy score (Word Attack $M = 33.75$, $SD = 5.35$) fell more than three standard deviations below the control group mean ($M = 42.11$, $SD = 2.56$).

Next, the AD(0) group consisted of 67 participants with AD scores ranging inclusively from -0.5 to 0.5, meaning that their standardized word reading accuracy scores and standardized decoding accuracy scores were relatively comparable. The AD(0) group's mean word reading accuracy score (Word Identification $M = 44.31$, $SD = 4.44$) and mean decoding accuracy score (Word Attack $M = 37.90$, $SD = 3.68$) both fell more than one standard deviation below the control group mean.

Finally, the AD(-) group consisted of 12 participants with AD scores ≤ -1, indicating that their standardized word reading accuracy skills were at least 1 standard deviation lower than their standardized decoding accuracy skills. The AD(-) group's mean phonological decoding accuracy score (Word Attack $M = 41.25$, $SD = 3.02$) fell within one standard deviation of the control group mean, whereas their mean word reading accuracy score (Word Identification $M = 40.92$, $SD = 5.07$) fell more than two standard deviations below the control group mean.

An ANOVA analysis revealed that, by design, the AD groups differed significantly on the Word Identification measure, $F(2, 88) = 7.04$, $p < .01$, $\eta_p^2 = .14$. The post-hoc Tukey's HSD analyses showed that the AD(+) group (M = 47.50, SD = 3.80) scored significantly higher than both the AD(0) group (M = 44.31, SD = 4.44) and the AD(-) group (M = 40.92, SD = 5.07). Similarly, the AD groups differed significantly on the Word Attack measure, $F(2, 88) = 11.32$, $p < .001$, $\eta_p^2 = .21$. The post-hoc Tukey's HSD analyses revealed significant pairwise differences between all three groups. Specifically, the AD(+) group (M = 33.75, SD = 5.35) scored significantly lower than the AD(0) group (M = 37.90, SD = 3.68), who in turn scored significantly lower than the AD(-) group (M = 41.15, SD = 3.02). It should be noted that the transformed Word Identification and Word Attack measures were used in the ANOVA analyses, whereas the reported group means are the raw scores.

After creating the AD groups, I examined whether the three groups differed significantly on the other measures, using the same methods as in the previous Group Comparison section. Table 6 shows the group comparison results and the three AD groups' scores on the various measures. Although the transformed variables were used in the analyses, the raw score descriptives are reported in the tables to facilitate comparison. For the RT variables, the reaction times are reported with within-individual outliers removed, and should be interpreted such that lower scores indicate faster responses.

First, I conducted a MANOVA investigating whether the AD groups differed on the measures of cognitive ability: Vocabulary and Matrix Reasoning. The overall effect was significant, Wilks' $\lambda = .88$, $F(4, 174) = 2.88$, $p < .05$. The ANOVAs revealed that the groups differed significantly on the Vocabulary measure but not the Matrix Reasoning measure. The post-hoc Tukey's HSD analyses indicated that the AD(+) group scored significantly higher than the AD(-) group on the Vocabulary measure.

Second, I conducted a MANOVA to examine whether the AD groups differed on the other word reading measures: Sight Word Efficiency, Regular High Frequency Word Reading RT, Regular Low Frequency Word Reading RT, Irregular High Frequency Word Reading RT, and Irregular Low Frequency Word Reading RT. The multivariate effect was not significant.

Third, I used a MANOVA to determine whether the AD groups differed on the other decoding measures: Phonemic Decoding Efficiency and Phonological Choice RT. The multivariate effect was also not significant.

Table 6. Raw score descriptives and pairwise differences between the three Accuracy Dissociation groups.

Measure	AD (-) (n = 12)		AD(0) (n = 67)		AD(+) (n = 12)		ANOVA (df = 2, 88)	
	M	SD	M	SD	M	SD	F	η_p^2
Cognitive Ability								
Vocabulary	14.17_1	3.10	16.43	5.64	19.92_1	5.37	3.66^*	.08
Matrix Reasoning	17.17	4.15	15.13	4.03	16.00	3.13	1.45	.03
Word Reading								
Sight Word Efficiency	87.33	11.92	88.36	11.89	88.25	14.05	0.06	.00
Regular High Frequency Word Reading RT	689	110	611	107	646	117	2.82	.07
Regular Low Frequency Word Reading RT	696	123	657	145	681	100	0.65	.02
Irregular High Frequency Word Reading RT	684	82	647	129	676	130	0.77	.02
Irregular Low Frequency Word Reading RT	770	145	710	147	733	137	0.93	.02
Phonological Decoding								
Phonemic Decoding Efficiency	51.42	7.51	50.64	7.86	47.17	9.75	0.74	.02
Phonological Choice RT	2362	588	2350	1127	2857	1193	1.53	.03
Phonological Awareness								
Elision Accuracy	13.58	2.54	13.90	2.46	13.83	2.66	.08	.00
Elision RT	1326	441	1061	305	1319	493	4.40^*	.09

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

Note: Subscripts denote pairwise differences significant at the $p < .05$ level.

Table 6 continued on next page.

Table 6 continued.

Measure	AD (-) (n = 12)		AD(0) (n = 67)		AD(+) (n = 12)		ANOVA (df = 2, 88)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	η_p^2
Naming Speed								
RAN Letters RT	20117	3905	19699	3596	21882	4916	1.53	.03
RAN Digits RT	20245	3859	19987	5319	21753	7245	0.53	.01
Orthographic Processing								
Wordlikeness RT	1237	434	1191	433	1438	582	1.09	.02
Wordlikeness Accuracy	18.92	2.84	18.54	2.74	18.00	2.52	0.35	.01
Dictated Spelling	19.58_1	4.78	21.93	4.52	24.42_1	4.25	3.43^*	.07
Spelling Choice RT	915	160	884	224	1007	508	0.55	.01
Spelling Choice Accuracy	16.00	2.26	16.93	2.50	18.08	2.64	2.12	.05
Morphological Processing								
Morphological Parsing Accuracy	31.33	5.03	29.72	4.29	30.75	4.48	0.85	.02
Morphological Parsing Efficiency	.65	.13	.62	.14	.66	.13	0.47	.01
Print Exposure								
Author Recognition Test	25.42_1	5.52	29.03	8.36	34.67_1	9.05	4.03^*	.08
Lexical Access								
Picture Naming RT	924	278	809	175	834	140	1.95	.04

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

Note: Subscripts denote pairwise differences significant at the $p < .05$ level.

Fourth, I used two separate ANOVAs to examine whether the AD groups differed on the phonological awareness measures: Elision Accuracy and Elision RT. The groups did not differ significantly on the Elision Accuracy measure. The overall effect for the Elision RT measure was significant, but the post-hoc Tukey's HSD analyses revealed no significant pairwise differences.

Fifth, I conducted a MANOVA determining whether the AD groups differed on the naming speed measures: RAN Letters RT and RAN Digits RT. The multivariate effect was not significant.

Sixth, I conducted a MANOVA to investigate whether the AD groups differed on the orthographic processing measures: Wordlikeness RT, Wordlikeness Accuracy, Dictated Spelling, Spelling Choice RT, and Spelling Choice Accuracy. The overall effect was not significant. Interestingly, the groups differed significantly on the Dictated Spelling measure, and the post-hoc Tukey's HSD analyses indicated that the AD(+) group scored significantly higher than the AD(-) group. However, the effect was rendered nonsignificant after controlling for Vocabulary, $F(2, 87) = 1.70$, $p > .05$. This significant univariate result should also be interpreted with caution in light of the nonsignificant multivariate effect.

Seventh, I used another MANOVA to examine whether the AD groups differed on the morphological processing measures: Morphological Parsing Accuracy and Morphological Parsing Efficiency. The overall effect was not significant.

Finally, I used two separate ANOVAs to determine whether the AD groups differed on the print exposure measure, Author Recognition Test, and the lexical access speed measure, Picture Naming RT. The ANOVA revealed a significant effect on the Author Recognition Test measure, and the post-hoc Tukey's HSD analyses revealed that the AD(+) group scored significantly higher than the AD(-) group. However, the effect disappeared when accounting for the Vocabulary measure, $F(2, 87) = 1.36$, $p > .05$. There were no significant effects on the Picture Naming RT measure.

As previous researchers have suggested that vocabulary can serve as a possible compensatory mechanism (e.g., Bruck, 1990; Gottardo et al., 1997; Hanley, 1997), I also conducted separate ANCOVAs to determine whether the AD groups differed on the Word Identification measure after controlling for the Vocabulary and Author Recognition Test measures. The AD groups remained significantly different on the Word Identification measure even when controlling for vocabulary, $F(2, 87) = 3.63$, $p < .05$, $\eta_p^2 = .08$, print exposure, $F(2, 87) = 4.81$, $p < .05$, $\eta_p^2 = .10$, or both, $F(2, 86) = 3.80$, $p < .05$, $\eta_p^2 = .08$.

In summary, the AD(+) group scored significantly better than the AD(-) group on Vocabulary, Dictated Spelling, and the Author Recognition Test measures. However, the latter two effects became nonsignificant when controlling for Vocabulary. Moreover, the AD groups continued to differ significantly on the Word Identification measure even after controlling for vocabulary and print exposure.

Discussion

In the current study, the AD(+) group consisted of individuals whose word reading accuracy skills were stronger than expected from their decoding accuracy skills. These individuals also defined more words (Vocabulary), had more reading experience (Author Recognition Test), and spelled words more accurately (Dictated Spelling) than the AD(-) group, which consisted of individuals whose word reading accuracy skills were weaker than expected from their decoding accuracy skills. In fact, the AD(+) group's mean vocabulary score fell within one standard deviation of the control group mean, whereas the AD(-) group's mean vocabulary score fell more than one standard deviation below (see Tables 2 and 6). Similarly, the AD(+) group's mean print exposure score was similar to the control group mean, whereas the AD(-) group's mean print exposure fell more than one standard deviation below (see Tables 4 and 6). Therefore, it is possible that increased language and reading experience can serve to buffer the phonological handicap, supporting previous suggestions that vocabulary serves as a prominent compensatory mechanism (e.g., Bruck, 1990; Gottardo et al., 1997; Hanley, 1997). However, even after controlling for vocabulary and print exposure in an additional analysis, the AD groups continued to differ significantly on the word reading accuracy measure, although to a lesser degree ($\eta_p^2 = .08$ compared to $\eta_p^2 = .15$). Therefore, although vocabulary and print exposure may be possible compensatory mechanisms, the two skills are insufficient to completely explain how some HFRDs are able to obtain better word reading accuracy abilities than others.

On the other hand, although the AD(+) group's spelling skills surpassed those of the AD(-) group, both group means fell more than one standard deviation below the control group mean (see Tables 4 and 6). Thus even HFRDs who achieve unexpectedly high levels of word reading accuracy continue to struggle with spelling accuracy. Moreover, the differences between the AD(+) and AD(-) groups in spelling accuracy could be accounted for by their differences in vocabulary skill. Therefore, it appears that HFRDs who have better vocabulary skills are better able to spell words accurately than HFRDs with weaker vocabulary skills, but the level of spelling accuracy attained remains below that of typical college readers.

Efficiency Dissociations

In addition to being accurate, successful reading also involves being efficient (i.e., accurate under time pressure). Therefore, I identified participants who were more efficient at word reading than their decoding efficiency skills would suggest. To calculate Efficiency Dissociation (ED) scores, I used the Sight Word Efficiency measure to represent word reading efficiency skills, and the Phonemic Decoding Efficiency measure to represent phonological decoding efficiency skills. First, I standardized both variables across all participants (including the Control group). Then, I calculated Efficiency Dissociation scores for all the RD participants by subtracting their Phonemic Decoding Efficiency z-scores from their standardized Sight Word Efficiency z-scores (i.e., Efficiency Dissociation = Sight Word Efficiency – Phonemic Decoding Efficiency).

Results

Table 7 shows the correlations between the ED scores and the other reading measures for all the RD participants. By definition, the ED scores correlated positively with the Sight Word Efficiency measure ($r = .47$, $p < .001$) and negatively with the Phonemic Decoding Efficiency measure ($r = -.47$, $p < .001$). The ED scores also correlated negatively with the RAN Letters RT measure ($r = -.20$, $p < .05$). Therefore, the participants with higher dissociation scores named letters more quickly. In contrast, the ED scores also correlated negatively with the Word Identification ($r = -.24$, $p < .01$) and Word Attack ($r = -.38$, $p < .001$) measures. Thus the participants with higher dissociation scores were less accurate at reading both words and nonwords in untimed tasks. Interestingly, the ED scores correlated positively with the Sight Word Efficiency scores, but negatively with the Word Identification scores. Therefore, the

Table 7. Correlations between Efficiency Dissociation scores and other measures for RD group (n = 145).

Measure	r
Cognitive Ability	
Vocabulary	.01
Matrix Reasoning	.12
Word Reading	
Word Identification	-.24**
Sight Word Efficiency	.47***
Regular High Frequency Word Reading RT	.05
Regular Low Frequency Word Reading RT	.04
Irregular High Frequency Word Reading RT	.01
Irregular Low Frequency Word Reading RT	.04
Decoding	
Word Attack	-.38***
Phonemic Decoding Efficiency	-.47***
Phonological Choice RT	.06
Phonological Awareness	
Elision Accuracy	-.12
Elision RT	-.03
Naming Speed	
RAN Letters RT	.20*
RAN Digits RT	.15
Orthographic Processing	
Wordlikeness RT	.01
Wordlikeness Accuracy	.00
Dictated Spelling	-.14
Spelling Choice RT	-.14
Spelling Choice Accuracy	-.08
Morphological Processing	
Morphological Parsing Accuracy	-.01
Morphological Parsing Efficiency	.09
Print Exposure	
Author Recognition Test	.01
Lexical Access	
Picture Naming RT	-.13

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

participants with higher dissociation scores were more able to quickly identify words in a timed task, but had more difficulty accurately identifying words in an untimed task. One possible explanation is that the Word Identification task included more difficult words than the Sight Word Efficiency task, suggesting that the ED participants could quickly identify familiar words but nevertheless struggled with unfamiliar words. It is also possible that ED participants tended to read words quickly without careful analysis, which may be an effective strategy for easier words but would hinder their accuracy on more difficult words.

Next, I categorized the RD participants into three groups based on their ED scores. The ED(+) group consisted of 24 participants with ED scores ≥ 1, meaning that their standardized word reading efficiency scores were at least 1 standard deviation higher than their standardized decoding efficiency scores. The ED(+) group's mean word reading efficiency score (Sight Word Efficiency $M = 96.25$, $SD = 8.80$) was comparable to the control group mean ($M = 96.64$, $SD = 8.27$). On the other hand, the ED(+) group's mean decoding efficiency score (Phonemic Decoding Efficiency $M = 44.38$, $SD = 9.39$) fell more than three standard deviations below the control group mean ($M = 58.51$, $SD = 4.38$).

Next, the ED(0) group consisted of 60 participants with ED scores ranging inclusively from -0.5 to 0.5, indicating that their standardized word reading efficiency scores and standardized decoding efficiency scores were relatively comparable. The ED(0) group's mean word reading efficiency score (Sight Word Efficiency $M = 88.05$, $SD = 10.67$) and mean decoding efficiency score (Phonemic Decoding Efficiency $M = 50.78$, $SD = 7.13$) both fell more than one standard deviation below the control group mean.

Finally, the ED(-) group consisted of 17 participants with ED scores ≤ -1, meaning that their standardized word reading efficiency scores were at least 1 standard deviation lower than their standardized decoding efficiency scores. The ED(-) group's mean decoding efficiency score (Phonemic Decoding Efficiency $M = 55.94$, $SD = 6.27$) fell within one standard deviation of the control group mean, whereas their mean word reading efficiency score (Sight Word Efficiency $M = 78.76$, $SD = 11.72$) fell more than two standard deviations below the control group mean.

An ANOVA analysis revealed that, by design, the ED groups differed significantly on the Sight Word Efficiency measure, $F(2, 98) = 14.58$, $p < .001$, $\eta_p^2 = .23$. The post-hoc Tukey's HSD analyses showed significant pairwise differences between all three groups. Specifically, the ED(+) group ($M = 96.25$, $SD = 8.80$) scored significantly higher than the ED(0) group ($M =$

88.05, *SD* = 10.67), who in turn scored significantly higher than the ED(-) group (*M* = 78.76, *SD* = 11.72). Similarly, the ED groups differed significantly on the Phonemic Decoding Efficiency measure, $F(2, 98) = 12.12$, $p < .001$, $\eta_p^2 = .20$. The post-hoc Tukey's HSD analyses also revealed significant pairwise differences between all three groups, but with the reverse pattern. Specifically, the ED(+) group (*M* = 44.38, *SD* = 9.39) scored significantly lower than the ED(0) group (*M* = 50.78, *SD* = 7.13), who in turn scored significantly lower than the ED(-) group (*M* = 55.94, *SD* = 6.27). It should be noted that the transformed Sight Word Efficiency and Phonemic Decoding Efficiency measures were used in the ANOVA analyses, whereas the reported group means are the raw scores.

After creating the ED groups, I examined whether the three groups differed significantly on the other measures, using the same methods as in the previous section. Table 8 shows the group comparison results and the three ED groups' scores on the various measures. Although the transformed variables were used in the analyses, the raw score descriptives are reported in the tables to facilitate comparison. For the RT variables, the reaction times are reported with within-individual outliers removed, and should be interpreted such that lower scores indicate faster responses.

First, I conducted a MANOVA investigating whether the ED groups differed on the measures of cognitive ability: Vocabulary and Matrix Reasoning. The overall effect was not significant.

Second, I conducted a MANOVA to examine whether the ED groups differed on the other word reading measures: Word Identification, Regular High Frequency Word Reading RT, Regular Low Frequency Word Reading RT, Irregular High Frequency Word Reading RT, and Irregular Low Frequency Word Reading RT. The overall effect was not significant. Interestingly, the ANOVAs revealed significant univariate effects for the Regular High Frequency Word Reading RT, Regular Low Frequency Word Reading RT, and Irregular High Frequency Word Reading RT measures. The post-hoc Tukey's HSD analyses indicated that the ED(0) group was significantly slower than the ED(-) group on the Regular Low Frequency RT and Irregular High Frequency Word Reading RT measures. There were no significant pairwise differences on the Regular High Frequency Word Reading RT measure. However, these univariate effects should be interpreted with caution in light of the nonsignificant multivariate effect.

Table 8. Raw score descriptives and pairwise differences between the three Efficiency Dissociation groups.

	ED (-) (*n* = 17)		**ED(0) (*n* = 60)**		**ED(+) (*n* = 24)**		**ANOVA (*df* = 2, 98)**	
Measure	***M***	***SD***	***M***	***SD***	***M***	***SD***	***F***	η_p^2
Cognitive Ability								
Vocabulary	16.59	5.75	15.40	5.03	17.54	5.32	1.53	.03
Matrix Reasoning	15.24	4.28	14.48	3.64	16.50	3.73	2.46	.05
Word Reading								
Word Identification	45.59	3.45	43.80	4.87	43.29	4.51	1.23	.03
Regular High Frequency Word Reading RT	575	96	639	101	600	115	3.34^{*}	.06
Regular Low Frequency Word Reading RT	603_{1}	107	697_{1}	137	629	109	5.24^{**}	.10
Irregular High Frequency Word Reading RT	603_{1}	95	678_{1}	112	619	114	4.68^{*}	.09
Irregular Low Frequency Word Reading RT	673	188	759	138	699	147	2.87	.06
Decoding								
Word Attack	39.71_{1}	3.35	37.97_{2}	3.68	34.75_{12}	5.06	8.58^{***}	.15
Phonological Choice RT	2297	1237	2427	958	2401	1002	.70	.01
Phonological Awareness								
Elision Accuracy	13.88	2.50	13.38	2.67	12.96	3.04	0.50	.01
Elision RT	1063	328	1189	360	1008	296	2.87	.06

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

Note: Subscripts denote pairwise differences significant at the $p < .05$ level.

Table 8 continued on next page.

Table 8 continued.

Measure	**ED (-) (n = 17)** *M*	*SD*	**ED(0) (n = 60)** *M*	*SD*	**ED(+) (n = 24)** *M*	*SD*	**ANOVA (df = 2, 98)** *F*	η_p^2
Naming Speed								
RAN Letters RT	20851	4227	20363	3619	19148	3450	1.29	.03
RAN Digits RT	20110	7402	18718	3441	20958	4612	2.73	.07
Orthographic Processing								
Wordlikeness RT	1063	309	1356	696	1222	569	2.62	.05
Wordlikeness Accuracy	18.53	2.50	18.47	2.77	18.71	2.29	0.07	.00
Dictated Spelling	20.76	5.25	21.47	4.62	20.96	3.65	0.22	.00
Spelling Choice RT	851	216	939_1	293	813_1	168	3.86^*	.07
Spelling Choice Accuracy	16.47	2.48	16.62	2.63	17.13	2.38	0.43	.01
Morphological Processing								
Morphological Parsing Accuracy	30.00	4.73	29.38	4.30	29.83	3.71	0.19	.00
Morphological Parsing Efficiency	$.57_1$	.13	.61	.10	$.66_1$	.13	3.83^*	.07
Phonological Awareness								
Author Recognition Test	27.06	9.24	26.97	6.56	30.96	11.08	1.79	.04
Lexical Access								
Picture Naming RT	826	187	864_1	176	752_1	195	3.27^*	.06

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

Note: Subscripts denote pairwise differences significant at the $p < .05$ level.

Third, I used a MANOVA to determine whether the ED groups differed on the other decoding measures: Word Attack and Phonological Choice RT. The multivariate effect was significant, Pillai's Trace = .16, $F(4, 196) = 4.31$, $p < .01$, $\eta_p^2 = .08$. The ANOVAs revealed a significant effect only for the Word Attack measure. The post-hoc Tukey's HSD analyses indicated that the ED(+) group was significantly less accurate than both the ED(0) and ED(-) groups.

Fourth, I used two separate ANOVAs to examine whether the ED groups differed on the phonological awareness measures: Elision Accuracy and Elision RT. The groups did not differ significantly on either measure.

Fifth, I conducted a MANOVA to determine whether the ED groups differed on the naming speed measures: RAN Letters RT and RAN Digits RT. The overall effect was significant, Wilks' $\lambda = .89$, $F(4, 194) = 3.01$, $p < .05$. However, the univariate effects were not significant for either measure.

Sixth, I conducted a MANOVA to investigate whether the ED groups differed on the orthographic processing measures: Wordlikeness RT, Wordlikeness Accuracy, Dictated Spelling, Spelling Choice RT, and Spelling Choice Accuracy. The overall effect was not significant. A significant univariate effect was revealed on the Spelling Choice RT measure and the post-hoc Tukey's HSD analyses indicated that the ED(+) group was significantly faster than the ED(0) group. However, this result should be interpreted with caution in light of the nonsignificant multivariate effect.

Seventh, I used another MANOVA to examine whether the ED groups differed on the morphological processing measures: Morphological Parsing Accuracy and Morphological Parsing Efficiency. The multivariate effect was significant, Wilks' $\lambda = .88$, $F(4, 194) = 3.10$, $p < .05$. The ANOVAs indicated a significant effect for only the Morphological Parsing Efficiency measure. The post-hoc Tukey's HSD analyses revealed that the ED(+) group was significantly more efficient than the ED(-) group.

Finally, I used two separate ANOVAs to determine whether the ED groups differed on the print exposure measure, Author Recognition Test, and the lexical access speed measure, Picture Naming RT. The ANOVAs revealed no significant effect for the Author Recognition Test measure, but a significant effect for the Picture Naming RT measure. The post-hoc Tukey's HSD analyses indicated that the ED(+) group was significantly faster than the ED(0) group.

To determine whether the ED(+) group's better word reading efficiency skills could be attributed to the found differences in other speed-related reading processes, I conducted separate ANCOVAs to examine whether the ED groups differed on the Sight Word Efficiency measure after controlling for the Regular High Frequency Word Reading RT, Regular Low Frequency Word Reading RT, Irregular High Frequency Word Reading RT, Picture Naming RT, Spelling Choice RT, and Morphological Parsing Efficiency measures. The ED groups remained significantly different on the Sight Word Efficiency measure even when controlling for regular high frequency word reading speed, $F(2, 97) = 15.43$, $p < .001$, $\eta_p^2 = .24$, regular low frequency word reading speed, $F(2, 97) = 15.91$, $p < .001$, $\eta_p^2 = .25$, irregular high frequency word reading speed, $F(2, 97) = 14.70$, $p < .001$, $\eta_p^2 = .23$, lexical access speed, $F(2, 97) = 13.29$, $p < .001$, $\eta_p^2 = .22$, spelling recognition speed, $F(2, 97) = 14.27$, $p < .001$, $\eta_p^2 = .23$, morphological parsing efficiency, $F(2, 97) = 13.00$, $p < .001$, $\eta_p^2 = .21$, or all six measures, $F(2, 92) = 13.75$, $p < .001$, $\eta_p^2 = .23$.

In summary, the ED(+) group performed significantly better than the ED(-) group on the Morphological Parsing Efficiency measure. The ED(+) also performed significantly better than the ED(0) group on the Spelling Choice RT and Picture Naming RT measures. In contrast, the ED(+) performed significantly worse than the ED(0) and ED(-) groups on the Word Attack measure. Moreover, the ED groups continued to differ on the Sight Word Efficiency measure even when controlling for regular word reading speed, irregular high frequency word reading speed, lexical access speed, spelling recognition speed, and morphological parsing efficiency skills.

Discussion

In the efficiency dissociation analyses, the ED(+) group consisted of 24 HFRDs whose word reading efficiency skills were much stronger than expected from their phonological decoding efficiency skills. The ED(+) group was significantly more efficient at morphological parsing than the ED(-) group, which consisted of individuals whose word reading efficiency skills were much weaker than expected from their phonological decoding efficiency skills. This result may be due to the ED(+) group's advantage in quickly recognizing sight words, as the morphological parsing task involved segmenting real words into its morphological constituents. Therefore, participants who are quicker to identify the words are also quicker to move onto the next step of parsing. However, both ED group means on this measure fell within one standard deviation of the control group mean (*M* = .68, *SD* = .12).

The ED(+) group was also significantly faster at labelling objects (Picture Naming RT) and recognizing correct spelling (Spelling Choice RT) than the ED(0) group, which consisted of individuals whose word reading efficiency skills were at the level expected from their decoding efficiency skills. Although the ED(+) group's lexical access speed was significantly faster than the ED(0) group, both group means fell within one standard deviation of the control group mean (see Tables 4 and 7). In contrast, the ED(+) group's mean spelling recognition speed fell within one standard deviation of the control group mean, whereas the ED(0) group's mean spelling recognition speed fell more than one standard deviation below (see Tables 4 and 7). Nevertheless, the ED groups' differences in these sublexical processes could not account for their differences in word reading efficiency. Thus the ED(+) group's superior ability to quickly identify words relies on more than their strengths in retrieving labels quickly, recognizing spellings quickly, or identifying morphological components quickly.

Furthermore, the ED(+) group was less accurate at decoding nonwords than both the ED(0) and ED(-) groups in an untimed task (Word Attack). This finding is consistent with the three groups' performance in decoding efficiency (Phoneme Decoding Efficiency), with the ED(+) group showing poorer performance than the other two groups. On the other hand, the three ED groups did not show any differences in word reading accuracy (Word Identification) despite significant differences in word reading efficiency (Sight Word Efficiency). In fact, the ED(+) group's mean word reading accuracy fell more than two standard deviations below the control group mean (see Tables 2 and 7), even though the two groups' word reading efficiency means were comparable. One possible explanation for these observations may stem from the stimuli included in these tasks. The stimuli comprising the timed tasks (Sight Word Efficiency and Phonemic Decoding Efficiency) are generally easier than the untimed tasks (Word Identification and Word Attack). Therefore, the ED(+) may excel in quick recognition of simple stimuli but continue to struggle with more difficult stimuli.

To further investigate the effect of word type on the different ED groups, I also conducted a mixed between-within subjects ANOVA to determine whether the three ED groups performed similarly on the regular and irregular word reading speed measures (similar to the analyses in the Regularity and Frequency Analyses section). The main effect of group was significant, $F(2, 98) = 4.38$, $p < .05$, $\eta_p^2 = .08$, and the post-hoc Tukey's HSD analyses revealed that the ED(0) group was significantly slower than the ED(-) group, similar to the previous ED group comparison results. The main effect of regularity was significant, $F(1, 98) = 52.01$, $p < .001$, $\eta_p^2 = .35$, but the interaction between group and regularity was not. Similarly, the main effect of frequency was significant, $F(1, 98) = 70.04$, $p < .001$, $\eta_p^2 = .42$, but the interaction between group and frequency was not. Therefore, all ED participants read regular words more quickly than irregular words, and read high frequency words more quickly than low frequency words. Moreover, the interaction between regularity and frequency was significant, $F(1, 98) = 10.09$, $p < .01$, $\eta_p^2 = .09$, but the three-way interaction between group, regularity, and frequency was not significant. Therefore, all ED groups were the quickest to read regular high frequency words and the slowest to read irregular low frequency words. The presence of regularity and frequency effects support the aforementioned possibility that the ED(+) participants' performance differs according to difficulty.

Overall, the ED(+) group appeared to display some relative strengths, perhaps in the quick recognition of familiar stimuli, but this strength was not evident in all reading processes. Their ability to quickly recognize sight words also could not be explained by their abilities to quickly retrieve labels, recognize spelling, or identify morphological components in words. Therefore, it remains inconclusive as to the possible mechanisms by which the ED(+) group reached their word reading efficiency success.

CHAPTER VI: INDIVIDUAL PERFORMANCE PROFILES

In addition to comparing groups of HFRDs whose word reading skills deviate from their decoding skills, it is also useful to examine performance profiles of individual participants. In particular, I examined the individuals in the AD(+) and ED(+) groups identified in the previous chapter. These participants are particularly informative to investigate in detail, as they are individuals whose word reading skills surpass their decoding skills. Therefore, their strengths and weaknesses in other reading processes may provide information as to how they have compensated for their decoding difficulties.

For each individual, I calculated their relative standing to the control group mean for each measure. Specifically, I used the control group mean and standard deviation for the listed measure, and determined whether each individual's score fell within one standard deviation of the control group mean (score of 0), between one to two standard deviations beyond the control group mean (score of 1), between two to three standard deviations beyond the control group mean (score of 2), or three or more standard deviations beyond the control group mean (score of 3). The scores that fell above the control group mean are marked with + and the scores that fell below the control group mean are marked with -.

AD(+) Individuals

First, I examined the 12 participants in the AD(+) group, whose word reading accuracy levels surpassed their decoding accuracy skills. In particular, I compared their individual scores to the control group mean across various reading component skills (Table 9). For reading skills that were measured by more than one task, the standardized or commonly used tasks were selected for comparison in order to simplify the procedure.

Prior to examining the individual profiles, I also compared the AD(+) group's mean scores to the control group mean scores (Table 9). As a group, the AD(+) participants showed word reading accuracy, cognitive ability, morphological processing, print exposure, and lexical access speed skills comparable to the control group. On the other hand, the AD(+) group showed

Table 9. Performance profiles of AD(+) participants (n = 12) whose word reading accuracies surpass their decoding accuracies, as compared to typical college readers.

	Word Reading		Phon. Decoding		Cog. Ability		Phon. Aw.	Naming Spd.		Orth. Proc.	Morph. Proc.		Print Exp.	Lex. Acs.[a]
ID	**WID**	**SWE**	**WA**	**PDE**	**V**	**MR**	**EL**	**L**	**D**	**DSP**	**MA**	**ME**	**ART**	**PN**
Grp.	0	-1	-3	-2	0	0	-1	-1	-1	-1	0	0	0	0
260	+1	0	0	0	0	-1	0	0	0	0	0	0	0	0
459	0	0	0	0	0	0	+1	0	-1	-1	0	0	-1	0
246	0	-2	0	-2	-1	0	0	0	0	-1	0	-1	-1	0
428	0	0	-1	0	+1	0	0	0	0	0	+1	+1	0	-2
402	0	0	-3	-1	0	0	-3	-1	-1	-2	0	0	0	-1
478	0	0	-3	-2	-1	0	0	-1	-2	-1	0	+1	+1	-2
518	0	-2	-3	-2	0	0	-2	-3	-3	0	0	0	0	0
239	-1	0	-3	-3	0	0	-2	0	0	-1	0	0	+1	+1
237	-1	0	-3	-2	0	0	0	-1	0	0	+1	0	-1	0
243	-1	-2	-3	-3	0	0	-1	-3	-3	-2	-1	-1	0	0
495	-2	0	-3	-3	-1	-2	-3	0	0	-2	0	0	0	0
220	-2	-3	-3	-3	-2	-2	-3	0	0	-1	-1	-1	-1	0

[a] A negative number indicates that the participant's score is higher (i.e., *slower*) than the control group mean.

Note: WID = Word Identification, SWE = Sight Word Efficiency, WA = Word Attack, PDE = Phonemic Decoding Efficiency, V = Vocabulary, MR = Matrix Reasoning, EL = Elision, L = RAN Letters RT, D = RAN Digits RT, DSP = Dictated Spelling, MA = Morphological Parsing Accuracy, ME = Morphological Parsing Efficiency, ART = Author Recognition Test, PN = Picture Naming RT.

relative weaknesses in word reading efficiency, decoding, phonological awareness, naming speed, and spelling skills. These group comparisons provide a reference for the following individual comparisons. However, when comparing the individual profiles to the group's overall performance, there are no participants that completely reflect the same pattern of strengths and weaknesses as the group's mean performance.

The first three participants (260, 459, and 246) listed in Table 9 are individuals whose word reading accuracy and decoding accuracy skills both fall within one standard deviation of the control group mean. All three participants also exhibited phonological awareness, letter naming speed, morphological parsing accuracy, and lexical access speed skills comparable to the control group mean. Interestingly, however, these three HFRDs reported different sets of reading difficulties on the ARHQ-R. Participant 260 belongs to the Compensated RD group, and only showed relative difficulty in nonverbal reasoning skills. Therefore, Participant 260 could be considered a truly compensated HFRD. On the other hand, Participant 459 belongs to the Late-emerging RD group, and displayed weaknesses in digit naming speed, spelling accuracy, and print exposure. Participant 246 belongs to the Persistent RD group, and showed difficulty with word reading efficiency, decoding efficiency, spelling accuracy, morphological parsing efficiency, and print exposure. Therefore, both the persistent HFRD and late-emerging HFRD, who reported current reading difficulties on the ARHQ-R, displayed more weaknesses than the compensated HFRD, but their current reading difficulties do not stem from word reading or decoding inaccuracy.

The next four participants (428, 402, 478, and 518) are perhaps the most remarkable, as they displayed word reading accuracy levels comparable to the control group mean but decoding accuracy levels that fell one or more standard deviations below the control group mean. All four individuals also demonstrated nonverbal reasoning, morphological processing, and print exposure skills comparable to the control group mean. Three of the four participants (428, 402, and 518) also displayed vocabulary skills comparable to the control group mean. Participants 428 showed few relative deficits in all other reading processes, suggesting that perhaps strengths in some or all sublexical reading processes can foster word reading accuracy despite severe decoding deficits. In contrast, Participants 402 and 518 showed relative weaknesses in phonological awareness and naming speed skills, exemplifying the typical double deficit profile identified by Wolf and Bowers (1999). However, whereas a double deficit profile carries the poorest reading prognosis, these two participants have achieved typical college word reading accuracy levels. They also showed comparable cognitive ability, morphological processing, and print exposure skills to the typical college readers. Another interesting observation is that two of the four participants (428 and 518) in this group belong to the Persistent RD group, whereas the third (402) belongs to the Compensated RD group, and the fourth (478) belongs to the Late-emerging RD group. Therefore, the residual reading difficulties reported by the persistent HFRDs may refer to reading processes not examined in the current study (e.g., reading comprehension), or may reflect perceived reading difficulties not manifested in reading tests.

The last five participants (239, 237, 243, 495, and 220) are individuals whose word reading and decoding accuracy skills fall behind their typically reading peers. Four of the five participants (239, 237, 243, and 220) belong to the Persistent RD or Late-emerging RD groups, therefore accurately reporting current reading difficulties. All five participants also showed severe decoding deficits, with decoding accuracy levels falling three or more standard deviations below the control group mean. They also all showed severe phonological awareness weaknesses, except for Participant 237. The first three participants (239, 237, and 243) displayed slightly better word reading accuracy skills than the last two participants (495 and 220), and also demonstrated vocabulary, nonverbal reasoning, and lexical access speed skills comparable to the control group mean. On the other hand, the last two participants (495 and 220) displayed naming speed and lexical access speed skills comparable to the control group mean, in contrast to the first three participants (239, 478, and 243). However, they showed weaknesses in vocabulary and nonverbal reasoning skills. Therefore, these last five participants consist of HFRDs who show many residual reading difficulties when compared to typical college readers.

ED(+) Individuals

Next, I examined the 24 participants in the ED(+) group, whose word reading efficiency skills surpassed their decoding efficiency skills. Similarly to the AD(+) group participants, I compared their individual scores to the control group mean across various reading component skills (Table 10). As well, prior to examining the individual profiles, I also compared the ED(+) group's mean scores to the control group mean scores (Table 10). As a group, the ED(+)

Table 10. Performance profiles of ED(+) participants (n = 24) whose word reading efficiencies surpass their decoding efficiencies, as compared to typical college readers.

	Word Reading		**Phon. Decoding**		**Cog. Ability**		**Phon. Aw.**	**Naming Spd.**		**Orth. Proc.**	**Morph. Proc.**		**Print Exp.**	**Lex. Acs.**[a]
ID	**WID**	**SWE**	**WA**	**PDE**	**V**	**MR**	**EL**	**L**	**D**	**DSP**	**MA**	**ME**	**ART**	**PN**
Grp.	-2	0	-2	-3	0	0	-2	0	0	-2	0	0	0	0
268	0	0	0	0	0	0	0	0	0	-2	0	0	0	+3
269	0	0	0	0	+1	-1	0	0	0	-2	0	+1	+2	+1
402	0	0	-3	-1	0	0	-3	-1	-1	-2	0	0	0	-1
463	-1	0	0	-1	0	0	0	-2	0	0	0	-1	-1	-1
419	-2	0	-1	-1	-1	0	+1	0	0	-1	-1	-2	-1	0
423	-2	0	0	-1	-2	0	0	0	0	-2	0	0	-1	0
425	-2	0	-2	-1	-2	-1	0	0	0	-2	0	-1	0	0
473	-1	0	-3	-1	0	-2	-1	0	0	-1	-1	-1	-2	-1
491	0	0	-1	-1	0	+1	+1	+1	+1	0	0	-1	0	+1
422	-3	0	-3	-2	0	-1	-3	0	-1	-2	0	0	0	0
466	0	0	-1	-2	0	0	0	0	-1	0	0	0	0	0
478	-1	0	-3	-2	-1	0	0	-1	-2	-1	0	+1	+1	-2
494	-1	0	-1	-2	-2	0	-2	0	0	-2	0	0	-1	0

[a] A negative number indicates that the participant's score is higher (i.e., *slower*) than the control group mean.

Note: WID = Word Identification, SWE = Sight Word Efficiency, WA = Word Attack, PDE = Phonemic Decoding Efficiency, V = Vocabulary, MR = Matrix Reasoning, EL = Elision, L = RAN Letters RT, D = RAN Digits RT, DSP = Dictated Spelling, MA = Morphological Parsing Accuracy, ME = Morphological Parsing Efficiency, ART = Author Recognition Test, PN = Picture Naming RT.

Table 10 continued on next page.

Table 10 continued.

	Word Reading		Phon. Decoding		Cog. Ability		Phon. Aw.	Naming Spd.		Orth. Proc.	Morph. Proc.		Print Exp.	Lex. Acc.[a]
ID	**WID**	**SWE**	**WA**	**PDE**	**V**	**MR**	**EL**	**L**	**D**	**DSP**	**MA**	**ME**	**ART**	**PN**
226	0	0	-1	-3	0	0	-3	0	0	0	0	0	-1	0
239	-1	0	-3	-3	0	0	-2	0	0	-1	0	0	+1	+1
249	-2	0	-3	-3	0	+2	0	0	0	-2	0	0	-1	+3
253	-1	0	0	-3	0	0	-3	0	-1	-3	0	-1	-2	0
427	-3	0	-3	-3	-2	0	0	-1	-1	-1	0	+1	0	0
457	-2	0	-3	-3	-1	-1	-2	+1	+1	-2	-1	0	0	0
469	-2	0	-3	-3	-1	0	-2	+1	0	-1	0	-1	0	+1
495	-2	0	-3	-3	-1	-2	-3	0	0	-2	0	0	0	0
224	-3	-1	-3	-3	-1	0	-3	-2	-2	-2	0	0	-1	0
248	-1	-1	-2	-3	0	+1	-2	-1	0	-2	0	0	-1	0
223	-3	-3	-3	-3	-2	-1	-3	-1	-1	-3	0	-1	-1	0

[a] A negative number indicates that the participant's score is higher (i.e., *slower*) than the control group mean.

Note: WID = Word Identification, SWE = Sight Word Efficiency, WA = Word Attack, PDE = Phonemic Decoding Efficiency, V = Vocabulary, MR = Matrix Reasoning, EL = Elision, L = RAN Letters RT, D = RAN Digits RT, DSP = Dictated Spelling, MA = Morphological Parsing Accuracy, ME = Morphological Parsing Efficiency, ART = Author Recognition Test, PN = Picture Naming RT.

participants were comparable to the control group in word reading efficiency, cognitive ability, naming speed, morphological processing, print exposure, and lexical access speed skills. They displayed relative weaknesses in their word reading accuracy, decoding, phonological awareness, and spelling skills. Of the individual profiles, only Participant 239 displayed the same pattern as the group's overall performance.

When surveying the individual profiles, the first interesting observation noted is that 21 out of the 24 ED(+) participants displayed word reading efficiency skills that are comparable to the control group mean, despite varying levels of decoding efficiency. This result differs from that of the AD(+) group, wherein only seven of the 12 participants displayed word reading accuracy comparable to the control group mean. Therefore, it appears that many HFRDs are able to automatically recognize sight words in the presence of impaired phonological processes, further exhibiting a disconnect between phonological and word reading skills.

On the other hand, 16 of the 21 ED(+) participants with control-level word reading efficiency skills displayed word reading accuracy skills that were one or more standard deviations below the control group mean. Therefore, although these participants were able to recognize sight words automatically, they exhibited persistent difficulties with reading more difficult words. Similarly, 17 of these 21 ED(+) participants also displayed spelling skills that were one or more standard deviations below the control group mean. Of the four participants who displayed spelling skills comparable to the control group, three participants also displayed word reading accuracy skills that were comparable to the control group. Therefore, most of the participants who were able to recognize sight words automatically nevertheless exhibited persistent spelling difficulties.

Another observation is that 13 of the 24 ED(+) participants belong to the Persistent RD group. In fact, the first group in Table 10 consists of two persistent HFRDs (Participants 268 and 269) who displayed word reading and decoding efficiencies comparable to the control group. These two individuals also showed relatively few weaknesses in other reading skills. For example, Participant 268 only exhibited a relative weakness in spelling, and Participant 269 only exhibited relative weaknesses in spelling and nonverbal reasoning. Oddly, these two participants nevertheless reported both childhood and current reading difficulties. Therefore, they may experience reading difficulties due to comprehension or other unidentified difficulties, experience academic difficulties that are not attributed to reading difficulties, or erroneously perceive themselves to have reading difficulties.

Moreover, the ED(+) participants' profiles demonstrate the importance of phonological awareness skills in decoding development more so than in word reading development. The second group in Table 10 consists of seven participants (402, 463, 419, 423, 425, 473, and 491) who showed word reading efficiency levels comparable to the control group mean, but decoding efficiency skills between one and two standard deviations below the control group mean. In this group, two of the seven individuals displayed phonological awareness weaknesses. The third group in Table 10 consists of four participants (422, 466, 478, and 494) who showed word reading efficiency levels comparable to the control group mean, but decoding efficiency skills between two and three standard deviations below the control group mean. In this group, two of the four individuals showed phonological awareness weaknesses. The fourth group in Table 10 consists of eight participants (226, 239, 249, 253, 427, 457, 469, and 495) who showed word reading efficiency levels comparable to the control group mean, but decoding efficiency skills that fell three or more standard deviations below the control group mean. In this group, six of the eight individuals demonstrated phonological awareness weaknesses. Therefore, the groups show a trend of decreasing decoding efficiency with decreasing phonological awareness skills, without affecting word reading efficiency.

In contrast to phonological awareness, the ED(+) participants displayed relatively few naming speed deficits. Of the 21 participants with word reading efficiency skills comparable to the control group mean, only three participants (402, 478, and 427) displayed both letter and digit naming weaknesses. One more participant (463) displayed only letter naming difficulties, and four more participants (422, 466, 253, and 478) showed only digit naming difficulties. Therefore, it appears that many ED(+) participants excelled in retrieving simple alphanumeric labels, and possibly applied a similar process to identify real words efficiently.

Finally, three of the ED(+) participants are particularly noteworthy to compare. Participants 402, 224, and 223 all exhibited both phonological awareness and dual (letter and digit) naming speed weaknesses, therefore demonstrating a double deficit profile (Wolf & Bowers, 1999). However, these three individuals differed greatly in their other reading skills. Participants 224 and 223 displayed word reading and decoding efficiencies that both fell significantly below the control group mean, thereby portraying the expected struggling reader profile of double deficit individuals. On the other hand, Participant 402 was able to achieve word reading efficiency levels comparable to the control group mean. One main difference between the two pairs is that the lower-performing pair (Participants 224 and 223) also exhibited vocabulary and print exposure weaknesses, whereas the higher-performing participants (402) showed vocabulary and print exposure skills comparable to the control group mean. Therefore, it is possible that increased reading experience and language skills can serve to alleviate difficulties with sublexical reading processes in some HFRDs.

Discussion

In the current section, I examined the performance patterns of individuals whose word reading skills surpassed their decoding skills, comparing their scores across various reading component skills to the control group mean scores. The most obvious, and perhaps the most important, observation was that the individuals varied greatly in skill across different reading processes. This finding suggests that reading interventions should not focus on a single skill, but rather provide struggling readers with multiple compensatory mechanisms so that they can select appropriate strategies based on their individual strengths. Thus current reading interventions that primarily focus on remediating phonological skills should become more comprehensive interventions that also encompass other strategies, such as using orthographic rimes, analyzing morphological units, and increasing vocabulary.

Second, eight of the 12 AD(+) participants and 13 of the 24 ED(+) participants showed print exposure levels that were comparable to the control group mean or better. Therefore, it is imperative that struggling readers continually be motivated to practice reading, particularly as a means to improve word reading accuracy. Combined with the previous observation, struggling readers may particularly benefit from reading practice that enables them to directly apply learned strategies. For example, students who are taught a specific letter-sound relationship, spelling pattern, or morphological unit in a particular lesson should then be provided with reading material that repeatedly includes the taught material in order to allow for focused practice.

Third, the AD(+) participants displayed varied patterns of naming speed performance, whereas the ED(+) participants generally displayed naming speed skills comparable to the control group mean. Thus, unsurprisingly, the automatization of simple stimuli seems to contribute more to the development of efficiency than to the development of accuracy. In the ED(+) group, the participants generally had naming speed skills comparable to the control group even when their decoding efficiencies fell two or three standard deviations below the control group mean. The participants who did display naming speed weaknesses also showed the most severe word reading and decoding efficiency weaknesses. In contrast, the participants in the AD(+) group with the most severe word reading and decoding accuracy difficulties exhibited naming speed skills comparable to the control group mean. Therefore, some HFRDs' ability to quickly name simple alphanumeric stimuli may also transfer to their ability to quickly recognize simple words, but not to their ability to read more complex words.

Finally, some participants in both the AD(+) and ED(+) groups portrayed the double deficit profile proposed in Wolf and Bowers (1999), with deficits in both phonological awareness and naming speed skills. In the AD(+) group, three participants displayed the double deficit profile, which purportedly predicts profound reading impairment. All three participants also displayed severe decoding weaknesses, both in accuracy and efficiency, but their word reading skills were varied. One participant showed word reading accuracy and efficiency skills comparable to the control group, one participant showed only word reading efficiency deficits, and the third participant showed both word reading accuracy and efficiency deficits. In the ED(+) group, two other participants also exhibited the double deficit profile (one participant belongs to both AD(+) and ED(+) groups). These two participants demonstrated the more typical struggles of the double deficit profile, with difficulties in both word reading accuracy and efficiency, and decoding accuracy and efficiency. Because these five double deficit participants exhibited varying word reading outcomes despite having the same phonological awareness and naming speed difficulties, it is possible that researchers and educators must look beyond these two reading processes when examining word reading. Furthermore, the double deficit participants with better word reading outcomes also demonstrated better vocabulary and print exposure skills, suggesting that language development and reading exposure can help HFRDs ease handicaps in their sublexical reading skills.

CHAPTER VII: GENERAL DISCUSSION

In the current study, I examined a group of 145 individuals who have coped with their reading difficulties successfully in order to enter into postsecondary studies. Similar to previous research, I compared these high-functioning adults with reading difficulties (HFRDs) to typical college readers to determine whether HFRDs show persistent weaknesses in various reading skills. However, unlike previous studies, I identified three groups of HFRDs: the compensated HFRDs who reported childhood reading difficulties but no current reading difficulties, the persistent HFRDs who reported both childhood and current reading difficulties, and the late-emerging HFRDs who reported current reading difficulties but no childhood reading difficulties. In particular, the late-emerging HFRDs have not been previously identified in the HFRD literature.

Although the following sections discuss the reading profiles of the HFRDs in the current study, the overall success of these individuals must not be undermined. As briefly discussed earlier in the Group Formation section, many of the HFRDs achieve Grade 12 levels of word reading skills, In fact, even the persistent HFRDs obtained a mean grade equivalent of 12.5 in word reading accuracy, and the lowest word reading accuracy score was equivalent to the Grade 7.8 level. Therefore, all participants in the study achieved at least a junior high reading level, and have sufficient reading skills to complete secondary school and gain admission into postsecondary education. Therefore, as their persisting reading difficulties are discussed, it must be remembered that their strengths and weaknesses are discussed in relation to academically successful adults who do not have reading difficulties.

Reading Profiles of High-Functioning Adults with Reading Difficulties

Compared to their typically reading peers, the persistent HFRDs in the current study displayed weaknesses across many reading skills. In accord with previous findings, they fell behind the controls in word reading accuracy and speed (e.g., Bruck, 1990; Deacon et al., 2912; Law et al., 2015; Parrila et al., 2007; Wilson & Lesaux, 2001), decoding accuracy and speed, (e.g., Bruck, 1990; Felton et al., 1990; Gallagher et al., 1996; Law et al., 2015; Leong, 1999;

Snowling et al., 1997; Wilson & Lesaux, 2001), alphanumeric naming speed (e.g., Parrila et al., 2007), spelling accuracy (e.g., Everatt, 1997; Hanley, 1997; Kemp et al., 2008; Law et al., 2015; Wilson & Lesaux, 2001), sublexical orthographic processing (e.g., Kitz & Tarver, 1989), and morphological processing skills (e.g., Deacon et al., 2006; Leong, 1999). The persistent HFRDs also fell behind the controls in word reading efficiency and print exposure, but were equal to the controls in their lexical access speed.

On the other hand, the comparisons between the compensated HFRDs and the typical college readers yielded results that only partially echoed previous literature. As in previous studies, the compensated HFRDs were comparable to the controls in letter naming speed (e.g., Birch & Chase, 2004) and sublexical orthographic processing skills (e.g., Lefly & Pennington, 1991), and had more difficulty in decoding accuracy and speed (e.g., Birch & Chase, 2004) and spelling accuracy (e.g., Lefly & Pennington, 1991). In contrast to previous findings, however, the compensated HFRDs in the current study were comparable in word reading speed and morphological processing skills, and performed significantly worse than the controls in word reading accuracy, phonological awareness, and digit naming speed.

Furthermore, the comparisons between the persistent and compensated HFRDs in the current study yielded many contradictory findings to those in previous studies. In the current findings, the two groups did not show significant differences in word reading accuracy and speed, decoding accuracy and speed, phonological awareness, alphanumeric naming speed, orthographic processing, morphological processing, print exposure, and lexical access speed skills. In fact, the compensated HFRDs in the current study significantly outperformed the persistent HFRDs only in word reading and decoding efficiency, in contrast to the many significant differences found in previous literature (e.g., Birch & Chase, 2004; Law et al., 2015; Lefly & Pennington, 1991).

Finally, the current study included a group of late-emerging HFRDs who were previously unidentified in the literature. Compared to their typically reading peers, the late-emerging HFRDs were less accurate at reading nonwords and spelling words, and less efficient at reading nonwords. They also had less reading experience. Therefore, the late-emerging HFRDs were perceptive in their reporting of current reading difficulties. On the other hand, the late-emerging HFRDs significantly outperformed the persistent HFRDs in word reading accuracy and efficiency, irregular word reading speed, decoding speed, word-level orthographic accuracy, and orthographic processing speed. Therefore, although both groups reported and demonstrated current reading difficulties, they nevertheless display different reading profiles. In the current study, the late-emerging HFRDs performed most similarly to the compensated HFRDs, with the only significant difference between the two groups being that the late-emerging HFRDs decoded nonwords faster than the compensated HFRDs. The similarity between the two groups is surprising, as they reported opposite periods of reading difficulties: the late-emerging HFRDs reported current reading difficulties without childhood reading difficulties whereas the compensated HFRDs reported childhood reading difficulties without current reading difficulties. However, it is possible that the late-emerging HFRDs' reading difficulties refer to struggles in reading processes not examined in the current study, such as reading comprehension.

In summary, all types of HFRDs in the current study continue to display various reading weaknesses when compared to their typically reading peers. The persistent HFRDs exhibited relative deficits across all reading skills, except for sublexical orthographic processing skills and lexical access speed skills. The compensated HFRDs displayed relative difficulties in cognitive ability, word reading accuracy, decoding accuracy and speed, phonological awareness, digit naming speed, word-level orthographic processing accuracy, and print exposure. The late-emerging HFRDs showed relative weaknesses in decoding accuracy and efficiency, spelling accuracy, and print exposure. Therefore, it appears that individuals with reading difficulties continue to struggle with some mechanics of reading into adulthood, regardless of whether they are considered compensated or uncompensated dyslexics.

Compensating for Phonological Deficits

In addition to examining group differences between controls and HFRDs, as did previous studies, I also investigated subsets of HFRDs with dissociations between their phonological and word reading skills. One particular noteworthy subset consisted of individuals whose word reading accuracy skills surpassed their phonological accuracy skills (i.e., the AD(+) group). This group also displayed relative strengths in vocabulary, spelling accuracy, and print exposure, when compared to their peers whose word reading accuracy skills were weaker than expected based on their phonological accuracy skills. In fact, the surprisingly accurate group was comparable to their typically reading peers in word reading accuracy, cognitive ability, morphological processing, print exposure, and lexical access speed skills. Therefore, it is possible that increased language and reading experience allowed these HFRDs to improve their word reading skills despite phonological deficits. Moreover, upon examining the individual profiles of the unexpectedly accurate word readers, I identified four participants who showed word reading levels comparable to the typical college readers, despite having decoding accuracy skills that fell one or more standard deviations below the controls. All four participants also showed nonverbal reasoning and morphological processing skills comparable to the control group, and three of the four participants also showed vocabulary skills comparable to the control group. More surprisingly, two of the four participants exhibited the double deficit profile of both phonological awareness and naming speed difficulties, yet their word reading levels did not reflect the typical struggling reader prognosis of the double deficit profile. Therefore, it is likely that some HFRDs are able to use their strengths in other reading processes to compensate for weaknesses even in core reading processes such as phonological awareness and naming speed.

Similarly, another remarkable subset of HFRDs in the current study consisted of individuals whose word reading efficiency skills surpassed their decoding efficiency skills (i.e., the ED(+) group). This group also showed strengths in morphological parsing efficiency, compared to their peers whose word reading efficiency skills were weaker than expected from their decoding efficiency skills. They also demonstrated strengths in the speed of recognizing correct spellings of words and of labelling objects, compared to their peers whose word reading efficiency and decoding efficiency skills were evenly developed. Moreover, the surprisingly efficient group was comparable to their typically reading peers in word reading efficiency, cognitive ability, alphanumeric naming speed, morphological processing, print exposure, and lexical access speed skills. When examining the individual profiles of these unpredictably efficient word readers, I identified 21 participants who displayed word reading efficiency levels comparable to the control group, despite varying levels of decoding efficiency skills. Thus it appears that some HFRDs may be able to quickly identify sight words despite impaired phonological processes. However, most of these efficient word readers fared worse on the word accuracy measure, suggesting that the ability to quickly read familiar words does not transfer easily to the ability to read more complex words. Interestingly, many of the surprisingly efficient word readers also showed naming speed skills on par with the control group. Therefore, it is possible that their strengths in both word reading efficiency and naming speed stem from an ability to quickly label simple stimuli. Furthermore, one of the efficient word readers also displayed word reading efficiency levels comparable to the controls, despite having the double deficit profile of phonological awareness and naming speed difficulties. This reader also showed strengths in vocabulary, morphological processing, and print exposure. Hence this HFRD may have coped with his or her decoding difficulties through strengthening overall language skills and increasing reading experience.

In summary, some extraordinary HFRDs with phonological deficits manage to achieve normal levels of word reading skills, representing anomalies to the traditional model of phonological skills being the primary route to word reading development (e.g., Snowling, 2001). Even more fascinating is the discovery that some HFRDs with double deficits in phonological awareness and naming speed are also able to achieve normal levels of word reading skills, defying the expected prognosis of the double deficit profile (e.g., Wolf & Bowers, 1999). The exploration of the group and individual profiles of these exceptional HFRDs suggests that strong language skills and increased reading experience may be possible methods of compensation for weaknesses in core reading skills.

Practical Implications

One main finding in the current study is that all three HFRD groups (i.e., compensated, persistent, and late-emerging HFRDs) continue to display reading skills that fall behind those of typical college readers. Therefore, it is imperative to continue providing academic accommodations and assistance to HFRDs in postsecondary institutions. Although some HFRDs may appear to be "compensated" and do not report or show difficulties in some reading measures, they likely continue to struggle with some reading processes. These reading difficulties, however isolated, may be further compounded by the increased academic demands of postsecondary studies, resulting in academic frustration and failure. Similarly, it is also essential to provide pre-emptive awareness of available resources and the importance of using such resources to students with reading difficulties prior to postsecondary entry, in order to increase their chances of maintaining academic success.

Second, the existence of HFRDs who achieve word reading success despite phonological deficits highlights the need for research on varied reading interventions. The traditional reading remediation method for students with reading difficulties involves repeated instruction in phonological strategies. However, students with core phonological deficits may become easily frustrated when required to practice in their area of weakness. Therefore, they may be more accepting of reading interventions that supplement phonemic strategies with alternative reading strategies, such as larger-unit phonological strategies (e.g., onset-rime methods such as word families), orthographic strategies, or reading comprehension strategies. These alternate methods may be particularly appealing for students who have displayed minimal progress during repeated phonological interventions, as the academic goal may then convert from remediating reading difficulties to coping with reading difficulties.

Methodological Considerations and Future Directions

One notable discrepancy between the methodology in the current study and that of previous studies lies in the participant selection criteria. Few studies in the HFRD literature use only self-report measures to identify control and dyslexic participants, instead opting to use scores on reading measures to determine participant groups. Moreover, the studies that have used self-report measures to identify HFRD participants have only used childhood reading difficulties as inclusion criteria (e.g., Parrila et al., 2007). Thus these studies would have combined the persistent HFRDs and compensated HFRDs into the same participant group, as both groups reported childhood reading difficulties. However, the current study has shown that the compensated HFRDs outperformed the persistent HFRDs in word reading efficiency and decoding efficiency. The typical college readers in the current study also surpassed the persistent HFRDs in more reading skills than the compensated HFRDs. Therefore, the combination of the persistent HFRDs and compensated HFRDs into one group may lead to fewer significant differences between the control and dyslexic groups due to a stronger HFRD sample. Similarly, the previous studies may have selected some late-emerging HFRDs as controls, as both groups did not report childhood reading difficulties. However, the current study revealed that the late-emerging HFRDs performed significantly worse than the controls in decoding accuracy and efficiency, spelling accuracy, and print exposure. Therefore, including the late-emerging HFRDs as controls may also result in fewer significant differences between the control and dyslexic groups, due to a weaker control group.

Second, the current study is the first to identify a group of late-emerging HFRDs who reported experiencing postsecondary reading difficulties despite no childhood reading difficulties. Because the identification of this group was not planned in the participant recruitment process, the current sample is relatively small (n = 15). Therefore, it is possible that some of the group differences between the late-emerging HFRDs and the other three groups may not have reached statistical significance due to the smaller sample size. Hence future studies should actively recruit HFRDs who fall into each of the three HFRD groups in order to determine whether actual group differences exist. These findings would also serve to inform researchers attempting to recruit HFRDs using self-report measures, as they may need to consider the implications of using childhood reading difficulties, current reading difficulties, or both, in their HFRD inclusion criteria. Moreover, the late-emerging HFRDs in the current study exhibited a reading profile very similar to the compensated HFRDs, despite the two groups reporting opposite reading experiences. Therefore, it is also possible that the late-emerging HFRDs' reading difficulties stem from weaknesses in reading skills that were not examined in the current study. Thus future research should attempt to explore the late-emerging HFRDs' performance in other reading areas, such as reading comprehension.

Third, the current results support previous research suggesting the compensatory role of vocabulary in HFRDs (e.g., Bruck, 1990; Hanley, 1997). Specifically, the HFRDs who displayed better word reading accuracy skills than expected based on their decoding skills (i.e., the AD(+) participants) also showed strengths in vocabulary and print exposure. In fact, four of these HFRDs achieved word reading accuracy levels comparable to the controls despite decoding skills that fell one to three standard deviations below. Therefore, the results suggest that vocabulary and increased reading experience may enable some HFRDs to compensate for their phonological weaknesses. Hence, in addition to vocabulary, future studies should examine language processes in HFRDs and determine whether overall language skills contribute to their word reading skills.

Conclusion

The current study expanded on the HFRD literature by comparing three groups of HFRDs with each other and to a group of typical college readers. Consistent with previous research, the findings increased awareness that persistent HFRDs continue to display weaknesses in many reading skills and that even compensated HFRDs exhibit some residual difficulties. In addition, the identification of the late-emerging HFRDs brings to attention a third group of HFRDs whose reading difficulties emerge during postsecondary education, and whose support needs may differ from the former two groups. The reading profile of this new HFRD group requires further exploration in future studies that actively recruit a larger sample of late-emerging HFRDs and that measure more reading areas. The existence of this group also serves as a reminder to consider implications of different participant inclusion criteria.

Moreover, the current study investigated subsets of HFRDs whose word reading skills surpass their phonological skills. These HFRDs challenge the position that phonological skills serve as the exclusive route to word reading development, and simultaneously increase optimism that even individuals with severe phonological deficits can achieve normal levels of word reading, possibly through compensatory mechanisms such as increased language and reading exposure. The diverse reading profiles of such HFRDs also indicate that diversified reading interventions should be developed and researched so that students with reading difficulties can have the opportunity not only to remediate phonological difficulties but also to develop alternative strategies for coping with their reading difficulties.

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APPENDIX

Appendix A. Adult Reading History Questionnaire - Revised

1. Male _____ Female _____

2. Age ________

3. First language learned ______________________________________

4. Spoken language of preference ______________________________________

   Written language of preference ______________________________________

5. You prefer to use your: Right hand _____ Left hand _____ Ambidextrous ______

6. You have normal or corrected-to-normal vision Yes ____ No _____

7. Number of years of schooling (from elementary school to present) ____________________

8. To the best of your knowledge, did your parents ever report that either of them had a problem with reading or spelling?

________ Yes If yes, please give details: ___________________________
________ No ____
________ Not Sure ____

9. To the best of your knowledge did your brother(s) and/or sister(s) ever have a problem with reading or spelling?

________ Yes If yes, please give details: ___________________________
________ No ____
________ Not Sure ____

10. To the best of your knowledge, have any other members of your family (e.g., aunt, uncle, grandparents) ever had difficulties with reading?

________ Yes If yes, please give details: ___________________________
________ No ____
________ Not Sure ____

ELEMENTARY SCHOOL

Please circle the number of the response that most nearly describes your attitude or experience for each of the following questions or statements. If you think your response would be between numbers, place an "X" where you think it should be.

11. How much difficulty did you have learning to read in elementary school?

None				A great deal
0	1	2	3	4

12. How much extra help did you need when learning to read in elementary school?

No help	Help from: Friends	Teachers/ parents	Tutors or special class 1 year	Tutors or special class 2 or more years
0	1	2	3	4

13. How would you compare your reading skill to that of others in your elementary classes?

Above average		Average		Below average
0	1	2	3	4

14. Which of the following most nearly describes your attitude toward reading as a child?

Very positive				Very negative
0	1	2	3	4

15. When you were in elementary school, how much reading did you do for pleasure?

A great deal		Some		None
0	1	2	3	4

16. How would you compare your reading speed in elementary school with that of your classmates?

Above average		Average		Below average
0	1	2	3	4

17. How much difficulty did you have learning to spell in elementary school?

None		Some		A great deal
0	1	2	3	4

18. When you were in elementary school, how many books did you read for pleasure each year?

More than 10	6-10	2-5	1-2	None
0	1	2	3	4

CURRENT STATUS

19. How much difficulty do you currently have with reading?

None				A great deal
0	1	2	3	4

20. How would you compare your reading skill to that of others in your postsecondary classes?

Above average		Average		Below average
0	1	2	3	4

21. Have you experienced difficulty in any of your postsecondary English classes?

Not at all		Some		A great deal
0	1	2	3	4

22. What is your current attitude toward reading?

Very positive				Very negative
0	1	2	3	4

23. How much reading do you do for pleasure?

A great deal		Some		None
0	1	2	3	4

24. How would you compare your current spelling to that of others of the same age and education?

Above average | | **Average** | | **Below average**
0 ______ **1** ______ **2** ______ **3** ______ **4**

---

25. How much reading do you do in conjunction with your studies?

Over 40 hours a week	30-40 hours a week	20-30 hours a week	10-20 hours a week	Less than 10 a week
0	**1**	**2**	**3**	**4**

---

26. How would you compare your current reading speed with that of others with the same age and education?

Above average | | **Average** | | **Below average**
0 ______ **1** ______ **2** ______ **3** ______ **4**

---

27. To date, have you found the readings for your post-secondary English class(es) challenging?

Not at all | | **Some** | | **A great deal**
0 ______ **1** ______ **2** ______ **3** ______ **4**

---

28. In comparison to your classmates, how much difficulty do you have with the readings for your classes?

Below average | | **Average** | | **Above average**
0 ______ **1** ______ **2** ______ **3** ______ **4**

---

29. When writing with a computer, how much do you use the spell check if available?

Not at all | | **Some** | | **A great deal**
0 ______ **1** ______ **2** ______ **3** ______ **4**

---

30. Compared to other students in your classes, how much time do you spend reading an average textbook chapter?

Above average | | **Average** | | **Below average**
0 ______ **1** ______ **2** ______ **3** ______ **4**

Appendix B. Wordlikeness Stimuli

Part A		Part B	
dake	*daik*	***tays***	*tayz*
tave	*taiv*	***waff***	*waph*
zame	*zaym*	***nide***	*nyde*
pank	*panc*	***vime***	*vyme*
kade	*kayd*	***hine***	*hyne*
deef	*defe*	***siff***	*siph*
neep	*nepe*	***moin***	*moyn*
hife	*hyfe*	***hool***	*hewl*
fise	fyse	***poaf***	*pofe*
jick	*jikk*	***murn***	*mirn*
syve	***sive***	**dault**	dallt
gilc	***gilk***	**chee**	chii
boep	***bope***	kefe	**keaf**
gewm	***goom***	booce	**buice**
rorc	***rork***	jorze	**jores**
vawc	***vock***	girse	**gurse**
tuop	**toop**	voest	**voast**
tewj	***tuge***	nyfts	**nifts**
ploo	***plew***	merst	**mirst**
lunc	***lunk***	kyft	**kift**
		zayl	**zail**
		zaij	**zage**
		tayze	**taise**

Correct responses are in bold.

Items replicated from Conrad et al. (2013) are italicized.

Appendix C. Spelling Choice Stimuli

Part A		Part B	
take	taik	**guarantee**	gaurantee
grown	grone	**guerrilla**	guerrila
please	pleese	**consensus**	concensus
rain	raine	**daiquiri**	dacquiri
answer	anser	**believe**	beleave
grammar	grammer	**misspell**	mispell
deep	deap	**neighbour**	nieghbour
heavy	hevvy	**occurrence**	occurrance
ninth	nineth	**rhythm**	rhythmn
skate	skait	**savvy**	savy
smoke	smoak	**seize**	sieze
tape	taip	**vicious**	visious
keep	keap	**icicle**	isicle
evry	**every**	ligthning	**lightning**
hert	**hurt**	marshmellow	**marshmallow**
gote	**goat**	potatoe	**potato**
stoar	**store**	publically	**publicly**
streat	**street**	exhilirate	**exhilarate**
nead	**need**	fulfil	**fulfill**
roare	**roar**	villan	**villain**
scair	**scare**	athiest	**atheist**
eazy	**easy**	burgler	**burglar**
thum	**thumb**	reciept	**receipt**
wate	**wait**	resevoir	**reservoir**
chooze	**choose**	nostrels	**nostrils**

Correct responses are in bold.

Appendix D. Morphological Parsing Stimuli

Morphological Parsing Accuracy

Word	**Correct Parsing**	**Word**	**Correct Parsing**
pillbox	pill/box	administer	ad/minister
addictive	addict/ive		ad/minis/ter*
irrational	ir/ration/al	counterattack	counter/attack
rocket	rocket	antifreeze	anti/freeze
hypersensitive	hyper/sens/itive	correlate	co/rrelate
	hyper/sensi/tive		cor/relate
affiliate	a/ffili/ate	irrigate	ir/rigate
	af/fili/ate		ir/riga/te*
rattlesnake	rattle/snake	earnest	earnest
decay	de/cay	coral	coral
sandwich	sandwich	antidote	anti/dote
cookbook	cook/book	preside	pre/side
hyperbola	hyper/bol/a	accustom	ac/custom
seminal	semin/al	trifle	trifle
flapjack	flap/jack	devalue	de/value
metal	metal	planet	planet
interlock	inter/lock	extradite	ex/tradite
needle	needle	illustrator	il/lustr/at/or
bilingual	bi/lingu/al	semicircles	semi/circle/s
affirm	a/ffirm	premature	pre/mature
	af/firm	interrogate	inter/rogate
woodshed	wood/shed		inter/roga/te*
triangular	tri/angul/ar	bible	bible
extrasensory	extra/sens/ory	illogically	il/logic/al/y
chessboard	chess/board	counterfeit	counter/feit
Word	Correct Parsing	activate	act/iv/ate

* The final slash is an archaic slash. Participants who correctly place this slash are awarded an extra point. Participants who place a slash one letter position from the archaic slash position are not penalized for an incorrect slash.

Morphological Parsing Efficiency

Word	Correct Parsing	Word	Correct Parsing
nailbrush	nail/brush	convey	convey
archbishops	arch/bishop/s	colourful	colour/ful
conform	con/form	superstar	super/star
freeze	freeze	uncle	uncle
harmony	harmony	immobile	im/mobile
compassion	com/passion	archer	arch/er
gingerbread	ginger/bread	polygon	poly/gon
metaphor	meta/phor	abduction	ab/duct/ion
unable	un/able	dietary	diet/ary
headache	head/ache	prolonging	pro/long/ing
beloved	be/love/d	forehand	fore/hand
	be/lov/ed	market	market
abnormal	ab/norm/al	foreclose	fore/close
pocketknife	pocket/knife	discrete	discrete
disproved	dis/prove/d		discre/te*
	dis/prov/ed	furnace	furnace
imitate	imitate	polymer	poly/mer
robin	robin	malfunctioning	mal/funct/ion/ing
profane	pro/fane	comma	comma
mallet	mallet	metaphysical	meta/physic/al
moonlight	moon/light	pickle	pickle
dioxide	di/oxide	collaboration	co/llaborat/ion
behold	be/hold		col/laborat/ion
dishwasher	dish/wash/er	superstitious	super/stiti/ous
			super/stitio/us

* The final slash is an archaic slash. Participants who correctly place this slash are awarded an extra point. Participants who place a slash one letter position from the archaic slash position are not penalized for an incorrect slash.

Appendix E. Author Recognition Test Stimuli

Authors

Maya Angelou
Isaac Asimov
Jean M. Auel
James Clavell
Jackie Collins
Dick Francis
Stephen King
Judith Krantz
Robert Ludlum
James Michener
Toni Morrison
Sidney Sheldon
Danielle Steel
J. R. R. Tolkien
Alice Walker
Isabel Allende
Margaret Atwood
Ann Beattie
Samuel Beckett
Saul Bellow
T. C. Boyle
Ray Bradbury
Willa Cather
Raymond Chandler
Tom Clancy
Clive Cussler
Nelson Demille
Umberto Eco
T. S. Elliot
Ralph Ellison
Nora Ephron
William Faulkner
F. Scott Fitzgerald
Sue Grafton
John Grisham
Ernest Hemingway
Brian Herbert
Tony Hillerman
John Irving
Kazuo Ishiguro
James Joyce
Jonathan Kellerman
Wally Lamb
Harper Lee
Jack London
Bernard Malamud
Gabriel Garcia Marquez
Anne McCaffrey
Margaret Mitchell
Vladimir Nabokov
Joyce Carol Oates
Michael Ondaatje
George Orwell
James Patterson
Thomas Pynchon
Ayn Rand
Salman Rushdie
J. D. Salinger
Jane Smiley
Paul Theroux
Kurt Vonnegut
E. B. White
Thomas Wolfe
Virginia Woolf
Herman Wouk

Foils

Neil Berthier
Susan D. Calkins
Adele Diamond
Sydney Hans
Eva Lefkowitz
Mark Sabbagh
Glorisa Canino
Ruth Chao
Rebekah Levine Coley
Susan Crockenberg
Rachel Dunifon
Sumru Erkut
Alexandra Freund
Per F. Gjerde
Megan Gunnar
Harlene Hayne
Charles Kalish
Tama Leventhal
Mary Levitt
Christine Ohannessian
Linda Pagani
Ty Partridge
Laura Scaramella
Ronald Seifer
Christina Theokas
Brenda Volling
Elizabeth Votruba-Drzal
Arnetha Ball
Patricia Baquedano-Lopez
Rosalinda Barrera
Andrew Biemiller
Pietro Boscolo
Judith Bowey
Adriana Bus
Maria Lucia Castanheira
Tempii Champion
Richard Duran
Aydin Durgunoglu
John Elkins
Carl Frederiksen
Robert Jimenez
Connie Juel
John Kirby
Kevin M. Leander
Jeff MacSwan
Yolanda Majors
Stuart McNaughton
Sarah Michaels
Jerome Morris
Kate Nation
Marjorie Faulstich Orellana
Annemarie Palincsar
Scott Paris
Mastin Prinsloo
Keith Rayner
D. Ray Reutzel
Elaine Richardson
Elsie Rockwell
Deborah Wells Rowe
David Share
Hua Shu
Gale Sinatra
Christa van Kraayenoord
Jerri Willett
David Yaden