# Morphological Awareness and its Role in Compensation in Adults with Dyslexia

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**Abstract**

This study examines the role of morphological awareness (MA) in literacy achievement and compensation in word reading of adults with dyslexia through an exploration of three questions: 1) Do adult dyslexics demonstrate a deficit in MA and how is this potential deficit related to phonological awareness (PA)? 2) Does MA contribute independently to literacy skills equally in dyslexics and control readers? 3) Do MA and PA skills differ in compensated and non-compensated dyslexics?

A group of dyslexic and normal reading university students matched for age, education and IQ participated in this study. Group analysis demonstrated an MA deficit in dyslexics; as well, MA was found to significantly predict a greater proportion of word reading and spelling within the dyslexic group compared to the controls. Compensated dyslexics were also found to perform significantly better on the morphological task than non-compensated dyslexics. Additionally, no statistical difference was observed in MA between the normal reading controls and the compensated group (independent of phonological awareness and vocabulary).

Results suggest that intact and strong morphological awareness skills contribute to the achieved compensation of this group of adults with dyslexia. Implications for MA based intervention strategies for people with dyslexia are discussed.

*Keywords:* adults, dyslexia, morphology, morphological awareness, reading compensation, word reading.

# Morphological Awareness and its Role in Compensation in Adults with Dyslexia

Dyslexia is often characterized as a difficulty with the development of effective word-decoding strategies, low levels of word reading and poor spelling performance (Vellutino, Fletcher, Snowling, & Scanlon, 2004). Research has demonstrated that individuals with dyslexia often have poor phonological representations and deviant phonological processing skills (Snowling, 2000). Although this is the accepted view, recent studies have suggested that phonological representations of dyslexic individuals may be intact indicating a deficit in the access to these representations or in phonological skills (Ramus et al., 2013). Evidence of a phonological deficit has been provided by several studies demonstrating dyslexics' poorer performances on measures assessing phonological short term memory, phonemic and phonological awareness, and rapid lexical access when compared to their reading age matched peers (for a review see Snowling, 2000).

The importance of these skills is represented in the Dual Route Model of reading (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001), characterizing the two paths to achieve lexical access while reading: the lexical route and the sub-lexical route. Unlike the lexical route, the sub-lexical route is reliant on an individual's phonological processing ability. The sub-lexical route requires the decomposition of a word into its base components before seamlessly blending associated grapheme–phoneme correspondences allowing an individual to decode new or unfamiliar texts. Such ability is crucial in the independent learning of new words and the reading of unfamiliar texts, which affects word reading, comprehension and vocabulary acquisition. According to the phonological representation hypothesis, acquisition of these grapheme-phoneme correspondence rules are difficult for dyslexic readers due to the poor representation of phonemes and lexical memory (Elbro, 1996; Swan & Goswami, 1997). Such phonological deficits have been observed to characterize adults with dyslexia (Vellutino et al., 2004). Findings have indicated that phonological awareness does not develop in accordance with chronological age or reading level (Bruck, 1993; Miller-Shaul, 2005), therefore, deficits in this area persist into adulthood. This being said, some adults with dyslexia are able to compensate for their deficit and minimize its impact on reading. It is believed that these compensated dyslexics achieve word reading success through the application of various top down and/or bottom up strategies allowing them to bypass their poorly developed phonological skills. Research has shown that strengths in cognitive abilities, such as the use of contextual cues (Nation & Snowling, 1998), semantic knowledge (Snowling, 2001), visual memory (Campbell & Butterworth, 1985), and morphological knowledge (Elbro & Arnbak, 1996) help individuals with dyslexia to minimize the expression of their reading difficulties.

Due to the nature of the English language, words are formed by morphological and phonological elements (Chomsky & Halle 1968). It can be assumed that an explicit knowledge of both language elements would aid in the decoding process and in visual word recognition (Rastle, Davis, Marslen-Wilson, & Tyler, 2000). Morphemes, the smallest linguistic units of meaning, are used in combination to form more complex words. Within the English language, two types of morphological processes can be identified: inflectional and derivational. Inflections are morphological changes often altering the grammatical function of the word where the base word's meaning is preserved. Such inflectional changes result in person agreement, number and tense changes in the base word (e.g., jump, jumped, jumping). On the other hand, a derivation is a morphological change of a base morpheme through the addition of a prefix (e.g., dis-) or suffix (e.g., –er) usually resulting in the generation of new words which differ from the base word in meaning and possibly word class (Kirby et al., 2011); such can be seen in the change of the verb 'jump' to the noun 'jumper'.

Knowledge of the morphological principles of the English language aids in the reading and understanding of many of the language's linguistic inconsistencies. For example, the word *health* is not spelled as *helth,* which would be consistent with phoneme-grapheme rules, yet it is written in a way to preserve the spelling of the root morpheme *heal*. Research has shown that the conscious ability to reflect on and manipulate the morphemic structure of words – also known as morphological awareness (Carlisle, 1995) – has been found to contribute to reading outcomes and development independently of phonological awareness (for a review see Bowers, Kirby, & Deacon, 2010; Mahony, Singson, & Mann, 2000; Nagy, Berninger, & Abbott, 2006). Research has provided evidence that morphological awareness can be observed as early as kindergarten and first grade (Berko, 1958; Carlisle, 1995). Unlike phonemic awareness, regression analysis has demonstrated morphological awareness' contribution in predicting word reading ability increases through time (Carlisle, 1995; Singson, Mahony, & Mann, 2000). These results, however, could not be replicated by Roman, Kirby, Parrila, Wade-Woolley, and Deacon (2009). Instead Roman et al. found a constant influence of both variables in children in grades 4, 6 and 8.

Morphological awareness' importance in reading has contributed to its role in decoding skills, word recognition, comprehension and motivation (Carlisle, 1995; Carlisle, Colé, & Sopo, 2004; Deacon & Kirby, 2004; Roman et al., 2009). Priming studies have shown that processing morphologically complex words involves the sub-lexical segmentation of the word along its morphological boundaries (Diependaele, Grainger, & Sandra, 2011; Leikin & Zur Hagit, 2006). The importance of such segmentation at the morpheme level can be seen by its influence on word reading by aiding in the pronunciation of letter sequences, so that 'ea' is segmented and processed as one phoneme in the word 'reach' (which constitutes a single morpheme), while 'ea' is pronounced separately in 'react' due to its placement in two adjacent morphemes (Bowers, Kirby, & Deacon, 2010). Such segmentation at the morpheme boundary allows for the deconstruction of the word into its base form for an easier activation of the orthographic representations, thus influencing visual word recognition and bypassing the phonological route (Rastle & Davis, 2008).

Unlike phonemes or syllables, morphemes possess syntactic and semantic information. Such value-added information has been shown to aid in vocabulary acquisition (Carlisle, 2000; Nagy et al., 2006; Singson et al., 2000; Sparks & Deacon, 2013) and in the reading comprehension of children (Carlisle, 1995; Carlisle, 2000; Deacon & Kirby, 2004; Nagy et al., 2006) and adults (Nagy et al., 2006; Wilson-Fowler, 2011). Knowledge of frequent morphological units and the ability to segment along morpheme boundaries allows for the extraction of information from new or infrequently used words whose meanings may have been unknown. For example, when the suffix '-ian' is adjoined to a word such as 'music', creating 'musician', little past knowledge of the word 'musician' is needed for the reader to surmise that the target word is referring to a person who produces music.

The frequency of morpheme exposure has been shown to be vital in the development and utilization of morphological awareness. Nagy, Anderson, Schommer, Scott and Stallman (1989) found that in the reading of a morphologically complex word, the family size of the base word and its frequency within the reader's lexicon affects the speed of recognition of the target morphemes, which ultimately facilitates word recognition of familiar and unfamiliar words. Lazaro, Camacho and Burani (2013) showed a similar positive effect of base frequency in child readers, yet their results showed this benefit only for skilled readers. Such findings demonstrate how print exposure and vocabulary knowledge are explicitly linked to the development of the person's morphological knowledge. Correlations between the variables of morphological awareness and vocabulary have been repeatedly demonstrated across various languages and age groups (Fowler, Feldman, Andjelkovic, & Oney, 2003; Fowler & Liberman, 1995; Nagy et al., 2006; Singson et al., 2000). Such relationships have been shown to exist independent of phonological processing and word reading ability (McBride-Chang, Wagner, Muse, Chow, & Shu, 2005). Like many relationships related to language and reading development, the relationship between vocabulary and morphological awareness can be considered as bi-directional. Vocabulary knowledge has the potential to aid in the growth and development of a dyslexic's morphological awareness, for an increased vocabulary affords the individual the opportunity to gain familiarity with the morphological regularities in language. Such familiarity provides a greater resource base from which the reader can then extract morphological regularities and generalizable units. Accounting for such influences of vocabulary is paramount when examining individuals with dyslexia, for whom a resulting lack of print exposure has the potential to limit vocabulary growth.

In addition to supporting comprehension and vocabulary development, studies have asserted morphological awareness' contribution to word reading and to spelling abilities, independent of phonological awareness. Morphological awareness has been shown to independently explain 4-15% of the variance of word reading and nearly 7% of the variance in the spelling ability of elementary school children (e.g., Carlisle & Normanbhoy, 1993; Mahony et al., 2000; McCutchen, Green, & Abbott, 2008; Singson et al., 2000; Wolter, Wood, & D'Zatko, 2009) and in adults (Nagy et al., 2006; Wilson-Fowler, 2011).

To be considered as a means of compensation for individuals with dyslexia, morphological awareness needs to be independent of phonological awareness. Furthermore, morphological awareness must be shown to remain intact and a strength for individuals with dyslexia. Although research on morphological awareness of individuals with dyslexia has demonstrated a weakness in morphological awareness and processing compared to chronologically age match controls (Martin, Frauenfelder, & Cole, 2013; Tsesmeli & Seymour, 2006; Schiff & Raveh, 2007), several studies have demonstrated intact (or at least relatively intact) morphological skills in dyslexic readers. Studies comparing reading level matched controls with persons with dyslexia have shown similarities in several tasks of morphological awareness, implying that poor morphological processing is unlikely to be the cause of the observed reading deficits (Deacon, Parrila, & Kirby, 2008; Casalis et al., 2004; Egan & Pring, 2004). A training study by Arnbak and Elbro (2000) demonstrated that there was no significant correlation between the gains made in a dyslexic reader's morphological awareness and the extent of their phonological deficit. Arnbak and Elbro proposed that the often observed co-occurrence of poor phonological awareness and morphological awareness in individuals with dyslexia may be an indirect consequence of their reading disability resulting from their deficits in phonological awareness. Children with dyslexia who struggle early on with reading often end up with reduced print exposure resulting in less opportunity to develop adequate tools in noting morphological cues and knowledge (Joanisse, Manis, Keating, & Seidenberg, 2000; Fowler & Liberman, 1995).

Elbro and Arnbak (1996) presented two studies that provided evidence of the role morphological awareness is playing in compensation. In their first study, they found that dyslexic adolescents' reading speed benefited more from semantically transparent morphological structures than from control-matched words. This benefit and improvement of response times was found to correlate with improvements in reading comprehension. These results differed from the reading scores of matched controls who showed no benefit. The second study showed that dyslexics were significantly better at reading texts that were deconstructed and presented as morphemes compared to texts presented as syllables, whereas reading level controls showed a trend in the opposite direction. Leikin and Zur Hagit (2006) also found that adults with dyslexia benefited more from morphological priming than control readers did. They concluded that in the process of lexical access, compensated dyslexics may rely more on the slower morphological decomposition route than relying on orthographic or phonological codes for a faster whole word recognition.

This current study will firstly attempt to answer questions of how morphological awareness is represented and interacts with the phonological and literacy variables of adults with dyslexia. In this regard, we will explore morphological awareness' relationship to literacy skills and phonological processing. Secondly, we will evaluate morphological awareness' association to word reading, spelling and reading comprehension, independent of phonological awareness and vocabulary. Alongside this analysis, we will examine if the variance explained by morphological awareness is the same in both samples of adults with dyslexia and normal reading age matched controls. Finally, we will divide the dyslexic population into a group of compensated and a group of non-compensated dyslexics, and compare morphological awareness in both groups.

# Method

## Participants

The sample of participants was the same as presented in Law et al. (2014): 54 non-dyslexic and 36 adults with dyslexia. Participation required an official diagnosis of dyslexia produced during secondary school or earlier and completed by a registered and qualified clinical psychologist. The fact that the participants were selected from a university population, and given the selectivity of universities, a higher level of reading achievement was expected than those in a general sample of individuals with dyslexia of the same age. This is reflected in the normal reading and spelling scores of some individuals with dyslexia as seen in Table 1. Participants who have achieved higher than expected literacy scores might be considered as 'compensated' dyslexics.

The normal reading control population contained students with no documentation or history of reading difficulty. The dyslexic population was recruited in two English speaking universities in Ontario (Canada) through the University's Student Services, while the control sample was obtained through class announcements and posters placed on campus at the same universities.

All participants were at least 18 years old and were native English speakers without a history of brain damage, language problems, psychiatric symptoms, hearing impairments or visual problems which could not be corrected for by a corrective lens. Additionally, all participants had an adequate nonverbal IQ as defined by a standard score greater than 85 on the Raven's advanced progressive matrices. Groups did not differ in age, gender and nonverbal IQ. Participants' characteristics can be found in Table 1.

**Materials and Procedure**

**Literacy.** Word reading and spelling was assessed by the WRAT-III reading and spelling sub-tests (Wilkinson, 1993).

***Word reading***. The reading sub-test required the participant to read aloud a list of 42 words. The participant received a single point for each correctly pronounced word to a maximum score of 42. The reliability coefficient for this WIAT–III subtest was obtained utilizing the split-half method and found to be .98. (Wilkinson, 1993).

***Spelling.*** The spelling sub-test required the participant to accurately spell a series of dictated words. The words were presented orally by the test administrator and were followed by a sentence containing the word. One point was awarded for each correctly spelled word to a maximum score of 40 points. Reliability coefficient of this subtest was reported to be .97 (Wilkinson, 1993).

***Reading comprehension.*** This was accessed by the use of the passage comprehension sub-test of the Woodcock-Johnson III (WJ-III) (Woodcock, McGrew, & Mather, 2001). Items required participants to read a short passage silently and identify the missing key word that would make sense based on the context of the passage. Items progressively increased in difficulty by increasing passage length, level of vocabulary, and the syntactic and semantic cue complexity. The WJ-III reports a median reliability of .88 for an adult population. Testing was discontinued when six consecutive incorrect responses were made or until the last test item was administered. Participants could obtain a maximum score of 47.

**Phonological skills.** Each aspect of phonological skills, as represented in Wagner & Torgesen (1987), was individually tested. Assessment methods followed the same procedures as those expressed in Law et al. (2014) and are described as follows:

***Phonological awareness***. Research has demonstrated spoonerism tasks' ability to significantly differentiate between an adult dyslexic population and control groups (Ramus et al., 2003). The assessment of phonological awareness (PA) utilized the spoonerism sub-test from the Phonological Assessment Battery (PhAB) (Frederickson, Firth, & Reason, 1997). In two parts, this task targeted onset-rhyme awareness and required phoneme manipulation and deletion. Target words were presented orally. The first task required the participant to replace the first sound of the word with a new sound (e.g. cot with a /g/ gives 'got'). In part two, participants were requested to transpose the onset of the sounds of the two words. For example, "plane crash" will become "crane plash" or "king John" becomes "jing kon". The PhAB reports a Cronbach's coefficient alpha of .89 for an adult population. Rate scores were calculated as the total correct responses divided by the total time required to complete the task creating a measure of correct items per second. Accuracy was not separately evaluated due to ceiling level achievement within the control group.

***Rapid automatic naming.*** Two tasks were used in the assessment of Rapid Automatic Naming (RAN). First presented was a colour-naming test adapted from Boets Wouters, van Wieringen, and Ghesquiere (2006), which presented five colours (black, yellow, red, green and blue) in 5 rows containing 10 colour stimuli each. In addition, the object-naming sub-test from the Phonological Assessment Battery (PhAB) (Frederickson et al., 1997) was presented. This task used five line drawings of common objects (desk, ball, door, hat, box) in 5 rows each containing 10 items. Participants were asked to name aloud each of the objects or colours as quickly and as accurately as possible. A score of the number of symbols named per second was calculated.

***Verbal short-term memory.*** Verbal short-term memory was assessed through the application of two tasks. Firstly, the number repetition (digit span forward) sub-test from the Clinical Evaluation of Language Fundamentals 4th ed. (CELF-4) (Semel, Wiig, & Secord, 2003) was administered. This task required the immediate serial recall of orally presented lists of digits between 2 and 9, spoken at a rate of one digit per second. List length increased incrementally from one to nine digits. The CELF-4 reports a Cronbach's coefficient alpha of .78 for a young adult population. The final score was the total number of correctly recalled lists with a maximum score of 16.

Secondly, the non-word recall (NWR) sub-test from the Working Memory Test Battery (WMTB) (Pickering & Gathercole, 2001) was administered. Each participant was instructed to repeat lists of orally presented single syllable nonsense words in the correct order. The reported test-retest reliability of the test is .68. List length was incrementally increased from one to six words. Final scores were calculated as the total number of correctly recalled lists with a maximum score of 36.

**Vocabulary.** To assess vocabulary the CELF4 word definitions sub-test was used. The participants were asked to define or describe the meaning of a word after it was presented orally alone and in a sentence. The CELF4 word definition subset offers 2- or 1-point criteria, which were used as the basis for scoring the participants' responses. If the response did not meet the 2- or 1-point criteria, a score of 0 was given. The CELF-4 reports a Cronbach's coefficient alpha of .86 for a adult population. A raw score for the sub-test was computed by adding the scores obtained for each item. The maximum score was 48.

**Morphological awareness.** Morphological awareness was measured through the use of a validated measure created by Willson-Fowler (2011). This morphological awareness task was designed for use with university students. The questions used in the test were selected after conducting an IRT on the university students' responses on three morphological awareness tasks. Willson-Fowler maintained 24 of the original 99 items in the creation of this task. These items were demonstrated to provide good discrimination and difficulty estimates in a university population. The selected morphological measure included items from two different types of tasks: a derivational suffix task and a non-word sentence completion task.

***The derivational suffix task (DST).*** Items in the derivational suffix task were created by Willson–Fowller (2011) and were based on tasks created by Carlisle (2000) and Mahony's (1994) real word, multiple choice and sentence completion task. The task required participants to complete a sentence by applying a derivational suffix to a target root word (e.g., act: The secret police arrested the ________ before he could give his speech). Several studies have provided evidence relating the ability to read morphologically complex words to the frequency of the base word appearing in morphologically complex words (i.e., average family frequency; AFF). As a result all root words selected fell within an AFF range of 31.65 to 40.1 based on the standard frequency index (SFI). The frequency range of the selected derived words was 22.1 to 53.6 SFI. Stimuli included items which involved both phonological and orthographical changes. Some items contained only one change while others involved both. Instructions along with four examples were presented verbally and in writting. The items on this task measure syntactic and productive morphological awareness.

***The non-word sentence completion task (NWSC).*** Items selected for the non-word sentence completion task were based on Mahony's (1994) study. Participants were instructed to read and complete incomplete sentences (e.g., They presented the highly ____ evidence first) from a selection list of four possible non-word choices that varied according to their real English suffixes (e.g., credenthive, credenthification, credenthicism, credenthify). The target words were equally divided between nonsense nouns, adjectives and verb derivatives. Instructions and one example were presented both verbally and in writting. Responses were scored as correct or incorrect.

# Results

## Performance of Adults with Dyslexia Versus Normal Reading Adults

**Literacy.** Results of the literacy tasks are found in Table 1. As expected, the normal reading adult group (NR) was found to perform significantly better than the dyslexic group (DYS) in both word reading and spelling.

Both literacy tests, the WRAT reading and spelling sub-test, were found to be normally distributed for both DYS and NR groups, as assessed by Shapiro-Wilk's test ($p > .05$). Homogeneity of variance was not found for either the reading or spelling, as assessed by Levene's Test for Equality of Variances ($p = .034$ and $p = .001$, respectively).

Group comparisons revealed, however, a statistically significant difference in the mean scores of reading and spelling between both groups, $t(50.283) = 8.575$; $p < .005$ for reading, and $t(60.675) = 10.305$; $p < .005$ for spelling.

**Phonological skills.** The scores for the different aspects of phonological skills are presented in Table 2. Independent sample *t*-tests were run to determine whether the differences between groups in measures of phonological skills were significant. Scores of the NWR and Spoonerism tasks were not found to be normally distributed. In order to approach a normal distribution they were transformed by a square root transformation. Dyslexics were found to perform significantly poorer than the controls on all measures.

**Morphological awareness.** An ANCOVA was run to determine the effect of group differences in terms of normal and dyslexic readers on morphological awareness. After adjustment for vocabulary knowledge and phonology there was a statistically significant difference in the morphological awareness between the two groups: $F(1, 83) = 22.711$, $p < .001$, partial $\eta^{2} = .215$.

## Morphological Awareness' and Phonology's Contribution to Literacy of Dyslexic and Normal Readers

Table 3 displays Pearson correlations between all predictor and literacy outcome variables within each group. Morphological awareness differed in its relationships between the groups. Within the dyslexic group morphological awareness was found to have a positive relationship with reading and phonological awareness (measured with the spoonerism task) while these relationships were not found within the normal reading sample. As expected, vocabulary knowledge was shown to be closely related to morphological awareness in both groups.

To assess the contribution of morphological awareness to the literacy variables of word reading, spelling and reading comprehension, above vocabulary and phonological awareness, a series of hierarchal regressions was conducted. Separate regressions were performed within each group to understand whether or not morphological awareness can explain equal proportions of variance of word reading in adults with dyslexia compared to normal reading controls.

Three separate regressions were performed with word reading, spelling and reading comprehension as the outcome measure. In these analyses, vocabulary and phonological awareness were included as controls in steps one and two. In the control group these variables accounted for a total of 14.6% of the variance for word reading, 25.9% for spelling and 13.6% for reading comprehension. In step 3, the morphological awareness measure was entered into the regression equation. The results of these analyses are shown in Table 4 (a) for the normal reading control population and (b) for the dyslexic group. For the normal reading sample, morphological awareness contributed unique variance to spelling (19.4%) and reading comprehension (17.3%), yet not for word reading after controlling for the above-mentioned variables. In the dyslexic group, morphological awareness accounted for similar proportions of variance of spelling (17.4%) and reading comprehension (15.6%). However, the dyslexic group contrasted sharply with the control group in that morphological awareness was found to explain a significant proportion of the variance of word reading (16.5%) after controlling for the above-mentioned variables.

**Morphological Awareness and Compensation**

To explore the contribution of morphological awareness to the achievement of normal word reading performance of some dyslexics, the dyslexic population was sub-divided into two groups. The two groups were labeled as non-compensated Dyslexics (NCDYS) (those who were found to still possess deviant performance on word reading achievement) and Compensated Dyslexics (CDYS) (those who have received a diagnosis of dyslexia in the past, but yet were able to achieve a non-deviant score on word reading). An individual was determined to be deviant on word reading if his/her measured performance fell below -1.65 *SD* from the established mean of the well-matched control sample. Group characteristics and differences of these two new sub-groups can be seen in Table 5. No alteration was made to the normal reading control population, whose characteristics are displayed in Tables 1 and 2.

An ANCOVA was used to examine any group differences between the normal readers and the non-compensated dyslexic and compensated dyslexic groups on measures of morphological awareness. Vocabulary was used as a covariate variable due to group differences found between the CDYS and NCDYS sub-groups. After adjustment for vocabulary there was a statistically significant difference in morphological awareness between the three groups, $F(2, 85) = 50.864$, $p < .0005$, partial $\eta^2 = .545$. Post-hoc analysis was performed with Bonferroni correction for multiple testing. Morphological awareness was found to be significantly greater in the normal reader group vs. NCDYS group ($p < .0005$) and the CDYS group ($p = .006$). The NCDYS group had the poorest performance on the morphological awareness task, which was significantly lower than the compensated group ($p < .0005$).

To isolate morphological awareness from phonology, group comparisons were made with the composite score phonology as a covariate alongside with vocabulary. With both vocabulary and phonology as covariates, a statistically significant difference between groups was still found, $F(2, 83) = 22.944$, $p < .0005$, partial $\eta^2 = .356$. The post hoc analysis (Bonferroni adjustment) differed from the original ANCOVA without phonology in that the compensated and normal reading groups were not found to have any statistically significant differences on their performance on the morphological awareness measure ($p = .179$) while the NCDYS sub-group remained significantly lower than both the CDYS group ($p < .0005$) and the normal group ($p < .0005$).

Regression analysis was not performed within the sub-groups of compensated and non-compensated dyslexics due to the small sample size.

## Discussion

The present study examined the nature of the relationships between morphological awareness, phonological skills, word reading, spelling and reading comprehension in adults with dyslexia and age-matched adult controls.

Consistent with much of the literature on dyslexia, the dyslexic sample was found to have a significantly poorer performance on measures of phonological processing, spelling, word reading and reading comprehension when compared to a normal reading population (Vellutino, Fletcher, Snowling, & Scanlon, 2004). In addition, adults with dyslexia were found to perform poorer on tasks assessing morphological awareness than age-matched controls; such findings support earlier research in children (Carlisle, 1995;

Carlisle, 2000; Deacon & Kirby, 2004; Nagy et al., 2006) and adults (Nagy et al., 2006; Leikin and Zur Hagit, 2006). Within the dyslexic sample, relationships across the variables that were found to be deviant were examined and revealed morphological awareness' significant relationship with all literacy measures and vocabulary. Of these relationships, the one found existing between morphological awareness and word reading was the strongest. In terms of morphological awareness' relationship with phonological skills, only phonological awareness and non-word recall were found to be related to morphological awareness in this sample. These findings support previous developmental studies of children that have suggested the interrelationship of these two variables (Carlisle, 1995; Casalis et al., 2004; Nagy et al., 2006; Roman et al., 2009). Studies have found that these variables, although correlated, are distinct literacy skills, with morphological awareness having a longer developmental trajectory than phonological awareness (Berninger, Abbott, Nagy, & Carlisle 2010; Deacon & Kirby, 2004; Jarmulowicz et al., 2008; Kirby et al., 2012). It is thought that morphological awareness is a late-emerging skill that is built upon an individual's phonological awareness (Seymour, 1999; Casalis et al., 2004; Ehri, 2005). Based on the supposed influence of phonological awareness on the development of morphological knowledge, phonological awareness was used as a control variable throughout all analyses of this study.

To understand morphological awareness' independent contribution to the assessed literacy variables, a regression analysis was conducted controlling for both phonological awareness and vocabulary knowledge. Morphological awareness was found to contribute to spelling and reading comprehension in both the normal reading and dyslexic sample. The results were different for word reading. The regression analysis demonstrated a larger interaction between morphological awareness and word reading ability in adults with dyslexia when compared to the normal reading population. For the dyslexic readers, 16.7% of the variance in word reading was accounted for by morphology, while phonological skills were not found to provide any statistically significant contribution. This relationship was in stark contrast to the normal readers, where morphological awareness was not found to significantly explain any variance of word reading above that of phonology's 12.4%. Two differing and competing conclusions could be drawn from these results.

The first, and least likely of the two conclusions, is that difficulties in morphology are in part responsible for the observed reading difficulties in dyslexics. Leikin and Zur Hagit (2006) suggested that a deficit in the morphological awareness of dyslexics together with a significant contribution of morphological awareness (independently of phonological awareness) to word reading, could be taken as evidence of deviant morphological awareness skills thus contributing to the observed literacy difficulties of dyslexics. Although a reasonable argument, few researchers would support the idea that morphological awareness is a causal factor in dyslexia. In addition, counter evidence of intact morphological skills of individuals with dyslexia has been provided by reading age matched studies demonstrating equal and/or better performance of dyslexics in spelling (Bourassa, Treiman, & Kessler 2006; Bruck, 1993) and reading (Carlisle & Stone, 2003; Elbro & Arnbak, 1996; Joanisse et al., 2000; Martin et al., 2013). Such results suggest that the observed deficit in morphological awareness is more likely to be secondary to the more primary deficits of phonological processing and reading ability.

The second possible conclusion is that adults with dyslexia have made a shift in the underlying cognitive mechanisms of word reading. When results of the regression analysis between both sample groups are compared, the dyslexic group exhibited a shift away from an association between phonological skills and word reading – as represented in the control group – to a greater involvement of morphological awareness. A phonological deficit, as observed in the dyslexic population, is believed to impede sub-lexical processing and the reading of new or unfamiliar words. As discussed by Taft (2003), the nature of written morphemes allows for segmentation of morphologically complex words into their constituent parts (base, prefix, suffix) allowing for an alternate path of sub-lexical processing ultimately facilitating word reading by minimizing dependence on phonological processing.

If a stronger reliance on morphological knowledge were to be utilized by adults with dyslexia as a compensatory mechanism, then it would be expected that adults with dyslexia, who are able to compensate and achieve normal levels of word reading, would also possess stronger morphological awareness skills than non-compensated dyslexic adults. Although dyslexia by definition is a reading impairment, not all dyslexics included in our study demonstrated deviant performance on the word reading measure.

While all dyslexic participants had received an early diagnosis of dyslexia, compensatory factors and strategies could explain their word reading success. To evaluate our proposed theory of morphological awareness' role in the compensation process, the dyslexic population was subdivided into two groups: compensated dyslexics (those whose reading scores were no longer found to be deviant) and non-compensated dyslexics (those whose reading scores were still deviant). The two groups did not differ significantly in IQ, age, or phonological skills, yet group differences were found in vocabulary and morphological awareness.

Surprisingly, after differences in vocabulary and phonological skills were controlled for, no statistical difference could be observed in morphological awareness between the normal reading and the compensated dyslexic groups, while the non-compensated group differed from both other groups. Linked with the earlier discussed finding of morphological awareness' significant contribution to reading outcomes in the dyslexic sample, one can conclude that intact and strong morphological awareness skills are directly associated to the achieved compensation of these dyslexics. Such a notion of morphology playing an active role in the compensation of dyslexics is not new and is consistent with past research. Elbro and Arnbak (1996) demonstrated that compared to reading age matched controls, dyslexics benefited significantly more from reading a text segmented into morphemes than from a text segmented into syllables. The same paper also presented findings showing that dyslexic adolescents were reading words containing semantically transparent morphological structures faster than matched words.

**Educational Implications**

In support of previous adult studies, our results have expressed morphological awareness' importance in explaining the variance of word reading in adults with dyslexia along with explaining a significant portion of spelling and reading comprehension across both groups of adults (Nagy et al., 2006; Tighe & Binder, 2013; Wilson-Fowler, 2011). Linked with the evidence of strong and intact morphological awareness skills of compensated adult dyslexics, these results demonstrate the potential of intervention and remediation programs for adult dyslexics. It has been estimated that nearly 60% of all unfamiliar words an individual encounters beyond middle school are morphologically complex. Explicit instruction on how to utilize the tools of the morphological properties of these words would allow the dyslexic reader to read and extract meaning from a word (Nagy et al., 1989). As demonstrated by intervention studies in children, the explicit teaching of morphological knowledge can improve morphological awareness and vocabulary, ultimately having a positive effect on word reading, spelling and reading comprehension. Children with special literacy needs have been shown to benefit as much or more from morphological training than their normal reading peers (Bowers et al., 2010; Nagy, Carlisle, & Goodwin, 2014). The instruction and creation of strong morphological skills could provide a possible tool for adults or children with dyslexia to bypass their poor phonological skills and utilize the morphological structure and larger lexical units of morphemes which can then be generalized across a word and which contain added value of semantic and syntactic information compared to syllables and phonemes. Recent calls for the development of such intervention programs have been made and supported by Nunes and Bryant (2006) and Tighe and Binder (2013). Yet, longitudinal intervention studies of an adult dyslexic population are needed to understand the best means of instruction and to explore which aspects of morphology are most beneficial to an adult population.

**Limitations of the Present Study**

A limitation of the current research is that only production tasks involving sentence completion were utilized in the assessment of morphological awareness, and therefore, our results can only be generalized to implicit morphological awareness with the aid of sentence context. The lack of diversity in the testing battery of this study may have limited the ability to fully capture the potential and different underlying dimensions of morphological awareness. Differences in task design and in the measuring of morphological awareness have produced some conflicting results regarding the role and strength of morphological awareness in the reading process of dyslexic individuals. For example, explicit tasks such as those involving the segmentation and manipulation of morphemes are not able to replicate strengths of dyslexic participants in morphological production tasks (Elbro, 1990; Casalis, 1987; Casalis et al., 2004).

It is noted that the prediction of word reading by the used RAN measure may have been stronger with the use of the alphanumeric sub-test which had been replaced by the colour naming task in order to be in line with other ongoing research.

Another limitation of this study is the limited focus of the word reading measure. Alternate conclusions could have been drawn with the inclusion of pseudo-word reading, reading speed, and/or specially tailored morphologically complex word reading tasks. The inclusion of a more diverse testing battery in future research will allow for a finer grained analysis and understanding of how specific aspects of morphological awareness aid in compensation.

## Conclusions

The results of this study indicate that morphological awareness is an important predictor of dyslexic adult word reading, spelling and reading comprehension over and above the influence of phonological awareness and vocabulary knowledge. The findings that compensated adults with dyslexia possess similar levels of morphological awareness as normal readers (when differences in phonological skills are controlled for), indicates not only intact morphological processing, but also its relative strength and possible aid in this subgroup's achievement of normal levels of word reading. In line with previous studies implicating morphology as a possible compensatory variable, our study further supports the need for the development and study of interventions explicitly targeting the morphological awareness skills of adults with dyslexia. The explicit teaching of morphological rules and methods for the morphological decomposition of words could potentially improve adult dyslexics' morphological awareness; subsequently, improving their word reading skills. Although its potential to help individuals in overcoming their reading difficulties is promising, further research is still needed to fully understand morphological awareness' role in compensation and how to effectively direct such target interventions.

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Table 1

Participant characteristics

| | NR | | DYS | | | |
|---|---|---|---|---|---|---|
| Measure | *M* | *SD* | *M* | *SD* | *t* | *p* |
| Age (years) | 22.0 | 3.0 | 21.8 | 4.8 | 0.227 | 1 |
| Non-Verbal IQ (APM) | 112.7 | 9.9 | 107.0 | 20.7 | 1.777 | .158 |
| *Literacy* | | | | | | |
| Word-reading[a] (SS) (WRAT-III) | 106.1 | 5.8 | 91.7 | 10.1 | 8.575 | < .002 |
| Spelling[a] (SS) (WRAT-III) | 107.6 | 6.6 | 90.8 | 8.8 | 10.305 | < .002 |
| Reading Comprehension (WCJ) | 40.0 | 2.6 | 36.9 | 3.0 | -5.203 | < .003 |
| Morphological Awareness | 19.7 | 2.3 | 14.5 | 3.8 | 8.024 | < .002 |

*Notes*. All *p* values are Bonferroni adjusted for multiple comparisons. APM = Raven advanced progressive matrices; WRAT-III = Wide Range Achievement Test III. WCJ = Woodcock-Johnson III: passage comprehension sub-test.
[a] Scores are standardized ($M$ = 100, $SD$ = 15). [b] Pearson Chi-Square value.

Table 2

Phonological abilities: descriptive statistics and *t* and *p*-values from independent *t*-tests

| | NR | | DYS | | | |
|---|---|---|---|---|---|---|
| Measure | *M* | *SD* | *M* | *SD* | *t* | *p* |
| Spoonerism (correct/sec) | 0.23 | 0.08 | 0.10 | 0.04 | 9.042 | < .005 |
| Digit Span | 12.32 | 1.87 | 10.78 | 2.00 | 3.712 | < .005 |
| Non-word recall | 20.09 | 2.25 | 17.61 | 2.62 | 4.795 | < .005 |
| RAN (colour) | 2.01 | 0.33 | 1.72 | 0.31 | 4.262 | < .005 |
| RAN (object) | 1.77 | 0.24 | 1.50 | 0.25 | 5.059 | < .005 |

*Note*. All *p* values are Bonferroni adjusted for multiple comparisons.

Table 3

Correlations between measures for phonology, morphological awareness, vocabulary and literacy skills (bottom left adults with dyslexia group, top right control group)

| Measure | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Read | -- | .310* | .474*** | .234 | .352** | .130 | .061 | .227 | .219 | .345** |
| 2. Spell | .389* | -- | .228 | .400** | .506*** | .279* | .305* | .502*** | .150 | .432*** |
| 3. DS | .041 | -.055 | -- | .454*** | .436** | .200 | .273* | .240 | .183 | .320* |
| 4. NWR | .255 | .217 | .582** | -- | .597*** | .323* | .326* | .382** | .283* | .282* |
| 5. PA | .401* | .243 | .014 | .074 | -- | .491*** | .499*** | .197 | .203 | .231 |
| 6. RANob | -.003 | -.020 | .056 | -.019 | -.144 | -- | .699*** | .202 | .137 | .158 |
| 7. RANcol | -.052 | .086 | .219 | .016 | .112 | .761*** | -- | .286* | .096 | .161 |
| 8. Morph | .619*** | .450** | .219 | .370* | .489** | .068 | .090 | -- | .488*** | .534*** |
| 9. Vocab | .448** | -.020 | .221 | .183 | .275 | -.092 | -.068 | .367* | -- | .318* |
| 10. RComp | .665*** | .140 | .258 | .402* | .306 | .040 | .011 | .568*** | .439** | -- |

*Note*. Read = WRAT reading; Spell = WRAT spelling; DS = Digit Span; NWR = non-word recall; PA = Spoonerism; RANob = RAN object naming; RANcol = RAN colour naming; Morph = morphological awareness; Vocab = CELF4 sub-test: word definitions; RComp = WCJ reading comprehension measure.

**p* < .05. ***p* < .01. ****p* < .001. (*)Approaching significance of .05.

Table 4

Hierarchical regressions showing the unique variance in the word reading, spelling and reading comprehension accounted for by PA, vocabulary and MA ($R^2$change and standardized Beta)

(a) Normal reading age matched controls

| Step | Read | | Spelling | | ReadComp | |
|---|---|---|---|---|---|---|
| | $R^2$ change | Beta | $R^2$ change | Beta | $R^2$ change | Beta |
| 1. PA | .124** | .309 | .256*** | .443 | .053 | .123 |
| 2. Vocab | .022 | .093 | .003 | -.180 | .082* | .068 |
| 3. MA | .012 | .125 | .194*** | .508 | .173** | .481 |

(b) Dyslexic sample

| Step | Read | | Spelling | | ReadComp | |
|---|---|---|---|---|---|---|
| | $R^2$ change | Beta | $R^2$ change | Beta | $R^2$ change | Beta |
| 1. PA | .173* | .121 | .059 | .057 | .098(*) | .983 |
| 2. Vocab | .099* | .208 | .006 | -.204 | .119* | -.030 |
| 3. MA | .165** | .484 | .174* | .497 | .158** | -.030 |

*Note*. Read = WRAT reading; Spell = WRAT spelling; PA = Spoonerism; Morph = morphological awareness; Vocab = CELF4 sub-test: word definitions; ReadComp = WJ-III passage comprehension measure.

*$p < .05$, **$p < .01$, ***$p < .001$, (*) Approaching significance of .05

Table 5

Participant characteristics for dyslexic (DYS) and compensated dyslexic (CDYS) sub-groups

| | CDYS | | DYS | | | |
|---|---|---|---|---|---|---|
| Measure | *M* | *SD* | *M* | *SD* | *t* | *p* |
| Gender (f/m) | 11/4 | | 15/6 | | .016[b] | .602 |
| Age (years) | 22 | 1.9 | 22 | 6.1 | .523[c] | 1 |
| Non-Verbal IQ (APM) | 112.7 | 11.9 | 102.8 | 24.6 | -1.467[c] | .760 |
| Vocabulary (Raw) | 40.9 | 2.3 | 37.2 | 3.5 | -3.537[c] | **.005** |
| PA (z-score) | -1.49 | 1.1 | -1.82 | .60 | -1.100[c] | 1 |
| Morphological Awareness | 17.6 | 1.3 | 12.4 | 3.6 | -5.161[c] | **<.005** |
| Word-reading[a] | 101.6 | 5.8 | 84.7 | 5.8 | -8.870[c] | **<.002** |
| Spelling[a] | 92.8 | 8.7 | 89.3 | 8.8 | -1.168[c] | .251 |
| Reading Comprehension | 39 | 2.1 | 35.1 | 2.3 | -5.513[c] | **<.002** |

*Note*. All *p*-values are Bonferroni adjusted for multiple comparisons. APM = Raven Advanced Progressive Matrices.

[a] Scores are standardized (*M* = 100, *SD* = 15), [b] Pearson Chi-Square value, [c] *t*-value.