■ Morphological Awareness and Its Role in Compensation in Adults with Dyslexia

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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? and (3) Do MA and PA skills differ in compensated and noncompensated 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 with the controls. Compensated dyslexics were also found to perform significantly better on the morphological task than noncompensated dyslexics. Additionally, no statistical difference was observed in MA between the normal reading controls and the compensated group (independent of PA and vocabulary).

Results suggest that intact and strong MA 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. Copyright © 2015 John Wiley & Sons, Ltd.

Keywords: adults; dyslexia; morphology; morphological awareness; reading compensation; word reading

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, Marshall, Rosen, & van der Lely, 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 with 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 *et al.,* 2001), characterizing the two paths to achieve lexical access

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while reading: the lexical route and the sublexical route. Unlike the lexical route, the sublexical route is reliant on an individual's phonological processing ability. The sublexical 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 is difficult for dyslexic readers because of 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 (PA) 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 CDYS 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, and 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 that differ from the base word in meaning and possibly word class (Kirby *et al.*, 2012); 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 grapheme–phoneme 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 (MA) (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 MA 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 that increases through time (Carlisle, 1995; Singson, Mahony, & Mann, 2000). These results, however, could not be replicated by Roman et al., (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 sublexical 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' because of its placement in two adjacent morphemes (Bowers et al., 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 convey 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 et al., (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 affect the speed of recognition of the target morphemes, which ultimately facilitates word recognition of familiar and unfamiliar words. Lázaro, 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 MA 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 et al., 2005). Like many relationships related to language and reading development, the relationship between vocabulary and MA can be considered as bidirectional. Vocabulary knowledge has the potential to aid in the growth and development

of a dyslexic's MA, 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 MA's contribution to word reading and to spelling abilities, independent of PA. MA 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 & Nomanbhoy, 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, MA needs to be independent of PA. Furthermore, MA must be shown to remain intact and a strength for individuals with dyslexia. Although research on MA of individuals with dyslexia has demonstrated a weakness in MA and processing compared with chronologically age match controls (Martin, Frauenfelder, & Cole, 2014; Schiff & Raveh, 2007; Tsesmeli & Seymour, 2006), 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 (Carlisle, Colé, & Sopo, 2004; Deacon, Parrila, & Kirby, 2008; 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 MA and the extent of their phonological deficit. Arnbak and Elbro (2000) proposed that the often observed co-occurrence of poor PA and MA in individuals with dyslexia may be an indirect consequence of their reading disability resulting from their deficits in PA. 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 (Fowler & Liberman, 1995; Joanisse, Manis, Keating, & Seidenberg, 2000).

Elbro and Arnbak (1996) presented two studies that provided evidence of the role MA 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 with 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, CDYS 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 first attempt to answer questions of how MA is represented and interacted with the phonological and literacy variables of adults with dyslexia. In this regard, we will explore MA's relationship to literacy skills and phonological processing. Second, we will evaluate MA's association to word reading, spelling and reading comprehension, independent of PA and vocabulary. Alongside this analysis, we will examine if the variance explained by MA 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 noncompensated dyslexics (NCDYS) and compare MA in both groups.

METHOD

Participants

The sample of participants was the same as presented in Law, Vandermosten, Ghesquière, and Wouters (2014): 54 nondyslexic 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,

Table 1. Participant characteristics

Measure	NR		DYS		t	p
	M	SD	M	SD		
Age (years)	22.0	3.0	21.8	4.8	0.227	1
Nonverbal 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

NR, normal reading; DYS, dyslexic; SD, standard deviation; APM, Raven's advanced progressive matrices; WRAT-III, Wide Range Achievement Test III; WCJ, Woodcock-Johnson III; SS, standard score.
All *p* values are Bonferroni adjusted for multiple comparisons.
passage comprehension subtest.
[a]Scores are standardized (*M* = 100, *SD* = 15).
[b]Pearson Chi-Square value.

hearing impairments or visual problems that 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 Wechsler Individual Achievement Test (WRAT)-III reading and spelling subtests (Wilkinson, 1993).

Word reading
The reading subtest 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 WRAT-III subtest was obtained by utilizing the split-half method and found to be .98. (Wilkinson, 1993).

Spelling
The spelling subtest 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 subtest 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 PA utilized the spoonerism subtest from the Phonological Assessment Battery (PhAB) (Frederickson, Frith, & 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. ot 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 because of ceiling level achievement within the control group.

Rapid automatic naming
Two tasks were used in the assessment of Rapid Automatized 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 five rows containing 10 colour stimuli each. In addition, the object-naming subtest from the PhAB (Frederickson *et al.*, 1997) was presented. This task used five line drawings of common objects (desk, ball, door, hat and box) in five 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) subtest from the Clinical Evaluation of Language Fundamentals Fourth Edition (CELF-4) (Semel, Wiig, & Secord, 2003) was administered. This task required the immediate serial recall of orally presented lists of digits between two and nine, 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.

   Second, the nonword recall subtest from the Working Memory Test Battery (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 CELF-4 word definitions subtest 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 CELF-4 word definition subset offers 2-point or 1-point criteria, which were used as the basis for scoring the participants' responses. If the response did not meet the 2-point or 1-point criteria, a score of 0 was given. The CELF-4 reports a Cronbach's coefficient alpha of .86 for an adult population. A raw score for the subtest was computed by adding the scores obtained for each item. The maximum score was 48.

Morphological awareness
MA was measured through the use of a validated measure created by Wilson-Fowler (2011). This MA task was designed for use with university students. The questions used in the test were selected after conducting an item response theory

on the university students' responses on three MA tasks. Wilson-Fowler (2011) 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 nonword sentence completion task.

The derivational suffix task
Items in the derivational suffix task were created by Wilson-Fowler (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 that 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 writing. The items on this task measure syntactic and productive MA.

The nonword sentence completion task Items selected for the nonword 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 nonword choices that varied according to their real English suffixes (e.g. credenthive, credenthification, credenthicism and credenthify). The target words were equally divided between nonsense nouns, adjectives and verb derivatives. Instructions and one example were presented both verbally and in writing. 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 was found to perform significantly better than the dyslexic group in both word reading and spelling.

Both literacy tests, the WRAT-III reading and spelling subtest, were found to be normally distributed for both dyslexic group and normal reading adult group, 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

Table 2. Phonological abilities: descriptive statistics and *t* and *p*-values from independent *t*-tests

Measure	NR		DYS			
	M	*SD*	*M*	*SD*	*t*	*p*
Spoonerism (correct/s)	0.23	0.08	0.10	0.04	9.042	< .005
Digit span	12.32	1.87	10.78	2.00	3.712	< .005
Nonword 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

NR, normal reading; DYS, dyslexic; SD, standard deviation; RAN, Rapid Automatized Naming.
All *p*-values are Bonferroni adjusted for multiple comparisons.

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 nonword recall 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 analysis of covariance (ANCOVA) was run to determine the effect of group differences in terms of normal and dyslexic readers on MA. After an adjustment for vocabulary knowledge and phonology, there was a statistically significant difference in the MA between the three groups: $F(1, 83) = 22.711$, $p < .001$ and partial $\eta^2 = .215$.

Morphological Awareness's 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. MA differed in its relationships between the groups. Within the dyslexic group, MA was found to have a positive relationship with reading and PA (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 MA in both groups.

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

Three separate regressions were performed with word reading, spelling and reading comprehension as the outcome measure. In these analyses, vocabulary and PA were included as controls in steps 1 and 2. In the control group, these

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. MA	.619***	.450***	.219	.370*	.489**	.068	.090	—	.488***	.534***
9. Vocabulary	.448**	-.020	.221	.183	.275	-.092	-.068	.367*	—	.318*
10. RComp	.665***	.140	.258	.402*	.306	.040	.011	.568***	.439**	—

DS, Digit Span; NWR, nonword recall; PA, pathological awareness; RANob, Rapid Automatized Naming object naming; RANcol, Rapid Automatized Colour Naming; MA, morphological awareness.
Read = WRAT reading;
Spell = WRAT spelling;
PA = Spoonerism;
Vocabulary = CELF4 subtest: 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 pathological awareness, vocabulary and morphological awareness (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. Vocabulary	.022	.093	.003	−.180	.082*	.068
3. MA	.012	.125	.194***	.508	.173**	.481
(b) Dyslexic sample						
1. PA	.173*	.121	.059	.057	.098[(*)]	.983
2. Vocabulary	.099*	.208	.006	−.204	.119*	−.030
3. MA	.165**	.484	.174*	.497	.158**	-.030

PA, pathological awareness; MA, morphological awareness.
Read = WRAT reading;
Spell = WRAT spelling;
PA = Spoonerism;
Vocabulary = CELF4 subtest: word definitions;
ReadComp = WJ-III passage comprehension measure.
*Approaching significance of .05.
*$p < .05$;
**$p < .01$;
***$p < .001$

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 MA 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, MA 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, MA 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 MA 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 MA to the achievement of normal word reading performance of some dyslexics, the dyslexic population was subdivided into two groups. The two groups were labelled as noncompensated dyslexics (those who were found to still possess deviant performance on word reading achievement) and compensated dyslexics (those who have received a diagnosis of dyslexia in the past but were able to achieve a nondeviant 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 subgroups 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.

Table 5. Participant characteristics for dyslexic and compensated dyslexic subgroups

| Measure | CDYS | | DYS | | | |
	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
Nonverbal 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
MA	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**

DYS, dyslexic; CDYS, compensated dyslexic; APM, Raven's Advanced Progressive Matrices; PA, pathological awareness; MA, morphological awareness.
All p-values are Bonferroni adjusted for multiple comparisons.
[a]Scores are standardized ($M = 100$, $SD = 15$),
[b]Pearson Chi-Square value.
[c]t-value.

The ANCOVA was used to examine any group differences between the normal readers and the NCDYS and CDYS groups on measures of MA. Vocabulary was used as a covariate variable because of group differences found between the CDYS and NCDYS subgroups. After adjustment for vocabulary, there was a statistically significant difference in MA between the three groups, $F(2, 85) = 0.864$, $p < .0005$ and partial $\eta^2 = .545$. *Post hoc* analysis was performed with Bonferroni correction for multiple testing. MA was found to be significantly greater in the normal reader group than the NCDYS ($p < .0005$) and CDYS ($p = .006$) group. The NCDYS group had the poorest performance on the MA task, which was significantly lower than the CDYS group ($p < .0005$).

To isolate MA 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, $F(2, 83) = 22.944$, $p < .0005$ and partial $\eta^2 = .356$. The *post hoc* analysis (Bonferroni adjustment) differed from the original ANCOVA without phonology, in which the compensated and normal reading groups were not found to have any statistically significant differences on their performance on the MA measure ($p = .179$), while the NCDYS subgroup remained significantly lower than both the CDYS group ($p < .0005$) and the normal group ($p < .0005$).

Regression analysis was not performed within the subgroups of CDYS and NCDYS because of the small sample size.

DISCUSSION

The present study examined the nature of the relationships between MA, 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

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

To understand MA's independent contribution to the assessed literacy variables, a regression analysis was conducted in controlling for both PA and vocabulary knowledge. MA 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 MA and word reading ability in adults with dyslexia when compared with 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 MA 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 MA of dyslexics together with a significant contribution of MA (independently of phonological awareness) to word reading could be taken as evidence of deviant MA skills, thus contributing to the observed literacy difficulties of dyslexics. Although it is a reasonable argument, few researchers would support the idea that MA 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., 2014). Such results suggest that the observed deficit in MA 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 MA. A phonological deficit, as observed in the dyslexic population, is believed to impede sublexical 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 and suffix), allowing for an alternate path of sublexical 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 MA skills than NCDYS 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 MA role in the compensation process, the dyslexic population was subdivided into two groups: CDYS (those whose reading scores were no longer found to be deviant) and NCDYS (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 MA.

Surprisingly, after differences in vocabulary and phonological skills were controlled for, no statistical difference could be observed in MA between the normal reading and the CDYS groups, while the NCDYS group differed from both other groups. Linked with the earlier discussed finding of MA's significant contribution to reading outcomes in the dyslexic sample, one can conclude that intact and strong MA skills are directly associated with 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 with 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 MA's 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 MA skills of compensated adult dyslexics, these results demonstrate the potential of intervention and remediation programmes 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 MA 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 with syllables and phonemes. Recent calls for the development of such intervention programmes 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 MA 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 MA. Differences in task design and in the measuring of MA have produced some conflicting results regarding the role and strength of MA 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; Carlisle, 1987; Carlisle, Colé, & Sopo, 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 subtest, 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 pseudoword 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 MA aid in compensation.

Conclusions

The results of this study indicate that MA is an important predictor of dyslexic adult word reading, spelling and reading comprehension over and above the influence of PA and vocabulary knowledge. The findings that compensated adults with dyslexia possess similar levels of MA as normal readers (when differences in phonological skills are controlled for) indicate 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 MA 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's role in compensation and how to effectively direct such target interventions.

ACKNOWLEDGEMENTS

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