The Role of Morpheme Recognition and Morphological Awareness in Dyslexia

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This paper begins by presenting theoretical arguments and empirical evidence to support the idea that morpheme analysis strategies play a part in word recognition in reading, and in dyslexia in particular. The results of two studies are presented which indicate that dyslexic adolescents use recognition of root morphemes as a compensatory strategy in reading of both single words and coherent text. Furthermore, the evidence is reviewed that the use of morpheme recognition as a strategy in reading to some extent depends on the linguistic awareness of morphemes in spoken language. Finally, results from a pilot study of the effects of morphological awareness training of dyslexic students are presented which suggest that it may be possible to improve the awareness of morphology independently of phoneme awareness, and that such a training may have positive effects on reading of coherent text and on the accurate spelling of morphologically complex words.

WHY MORPHOLOGY MIGHT BE RELEVANT TO READING AND SPELLING

Alphabetic orthographies use letters to represent sound units at the level of the phoneme. In fact, the existence of alphabetic orthographies is perhaps the strongest evidence supporting the ex-

Annals of Dyslexia, Vol. 46, 1996
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ISSN 0736-9387

istence of phonemes. However, some orthographies are not entirely predictable on the basis of the phonemes. This is true for notoriously "irregular" orthographies like English and to some extent Danish and French. These so-called "deep" orthographies are not entirely transparent at the grapheme-phoneme level because they are governed not only by phonology, but also by morphology. *Morphology* refers to the patterns of word formation based upon morphemes, which can be defined as the smallest units of meaning and expression. A typical example of morphologically governed spelling in English is the regular spelling of the past tense verb ending *-ed*. The spelling is the same although the pronunciation differs in words like *rained* [-d], *knocked* [-t], and *tested* [-id]. That this really is a morphologically determined pattern is further seen by the fact that the constancy holds only for regularly inflected verbs. The spelling of the past tense ending is phonemic in irregularly inflected verbs: *dealt, sold, spent, wound,* etc. In general, many "irregularities" from a phonemic point of view are regularities from a morphemic point of view, such as the "silent" letters in *condemn* (*condemnation*) and *bomb* (*bombardment*) and the spelling of phonemically ambiguous letters (such as *-city/-sity*) in *electricity* (the second *c* in morphological analogy with *electric*), and in *university* (like *universe*).

There are several reasons morphology might be relevant to reading and spelling:

1. Morphology plays a role in the English (and Danish) orthography. Reading and spelling acquisition is, in a way, simply a question of mastering the orthography of the language.
2. Morphemes are good indicators of the meaning of words. If the reader can identify the morphemes of unfamiliar words like *unputdownable, fold-up spoon,* or *telescope straw,* he or she has a chance to guess the meaning of the word. On the blurb of Fay Weldon's novel *The Hearts and Lives of Men,* the last and presumably strongest argument to buy the book is that "it's unputdownable, of course." The core of the argument is the single word *unputdownable.* To our knowledge, this word is not in any English dictionary. Still the publisher uses this word as the strongest printed means of persuasion to buy the book. The only way this persuasion will work is when the prospective buyer and reader can figure out the meaning of the word. To do so the reader has to analyse the word into its morphological components:

The verb phrase *put down* is the (unusual) compound root, the class derivation suffix *-able* turns the root into an adjective with the meaning "which can be put down", and the prefix *un-* is a simple negation, which gives the general meaning of the word "which cannot be put down" or, taking the context into account, "which you cannot stop reading once you have begun." And that *is* a strong argument. This is really just a single example of the type of task that children (and adults) are faced with many times a day, when they encounter new words. Given that most of the new words that children encounter in print are poly-morphemic and morphologically transparent (Nagy and Anderson 1984), it is not surprising that vocabulary growth has been found to depend to some extent on ability to analyse complex words into morphemes (White, Power, and White 1989; Wysocki and Jenkins 1987).

3. It is more economical to store words in the orthographic lexicon by their morphemes than as wholes. Although computational models have achieved quite high rates of spelling-to-sound accuracy without access to specific word (or morpheme) knowledge, there are still about 10% of the sounds of the letters that are not predicted correctly even by the best models (Seidenberg and McClelland 1989; Borgen and Lorenzen 1995). To get an idea of the precision in practice, a prediction rate at 90% would yield the correct pronunciation of an average of 50% of words of five letters. Examples might be overgeneralizations like *chord* pronounced with an initial [tʃ-]instead of [k-], or erroneous irregular pronunciations like *shave* pronounced [ʃæv] to rhyme with *have*. In all these cases, the particular letter sounds can only be predicted correctly by access to the unique morpheme of which they are part. Because there is an average of about four to five word forms per root morpheme (in Danish), it would considerably reduce demands on long-term memory to store the spelling of morphemes rather than of whole word forms.
4. A reading strategy that involves morpheme analysis and recognition may to some extent provide a direct mapping onto the lexicon of spoken words. There is evidence from some languages, e.g., Dutch (Jarvella and Meijers 1983), English (Henderson 1985, and many others), and Italian (Caramazza, Laudanna, and Romani

1988), that the mental lexicon may be organized in terms of stems (roots plus derivations) and endings, rather than in terms of whole word forms: in fact, very much like most dictionaries. If this is the case, then a reading strategy that identifies words by means of an analysis in stems and endings will map directly onto the lexicon and thereby ease the identification and access to meaning.

5. Some errors in reading, spelling, and naming are morphologically based. Over-use of morphological analogies is a common source of spelling errors such as *proceedure* (*proceed*), *pronounciation* (*pronounce*), and *rememberance* (*remember*). When writers of Danish erroneously divide long compounds, the division always coincides with a boundary between roots, *intercity toget* ("the intercity train"), *butiks center* ("shopping centre"). Some errors in reading may be explained as a consequence of a faulty morpheme analysis, e.g., scar/city (*scarcity*) and car/pet (*carpet*) (see study 1 below for documentation). Finally, there is ample evidence from children's language acquisition that they make morphologically based generalizations. The regularization of irregular verbs is a standard example.
6. Non-alphabetic writing systems are often based upon morphology. This is true for the Chinese writing system as well as for the Japanese Kanji which is borrowed from Chinese. The use of a morpheme-based writing system is motivated when, for example, the number of homophones (and thus homographs) is relatively high, as is the case for Chinese (Sampson 1985).

EMPIRICAL EVIDENCE FROM NORMAL READING

Data from a number of languages support the view that morphological analysis does in fact contribute to word decoding and reading comprehension. This is so for Danish (Elbro and Arnbak in preparation), Dutch (e.g., Libben 1994), English (e.g., Taft and Forster 1975; Bradley 1980; Taft 1981; 1984; Marslen-Wilson et al. 1994), Greenlandic (Jacobsen 1995), Italian (e.g., Caramazza, Laudanna, and Romani 1988), and Serbo-Croatian (e.g., Feldman and Andjelkovic 1992). In order to interpret these data it is necessary to explain two concepts: transparency and productivity.

Transparency refers to the degree to which the sound and meaning of a complex word is predictable from its constituent morphemes. A list of compounds with *black* as first root may exemplify a scale of decreasing transparency: *blackbird* ("a black bird"), *blackboard* (could be green), *blacksmith* (handles black metal, but is not necessarily black himself), *blackguard* (a scoundrel is only black metaphorically speaking, and the final k in *black* is assimilated by the initial g of the second root), and *blackjack* (the card game is hardly "black" at all). Using lexical decision tasks (and other techniques), many recent studies have found indications that normal, fluent readers decompose semantically and phonologically transparent words into their constituent morphemes (Libben 1994; Zwitserlood 1994; reviews are given by Marslen-Wilson et al. 1994, and by Stolz and Feldman 1995).

Productivity refers to how often a morpheme is used to create new words. For instance, some suffixes such as *-ish* and *-ness* are highly productive; *-ish* can even be used in derivations of numbers, *three'ish* is "around three." Many other suffixes are far less productive. Studies by Bradley (1980 and later) have indicated that the cumulative frequency of a morpheme across all the words of which it is part may be more important to reading than the frequency of the particular word in which it is presented. This makes highly productive morphemes much better candidates as units in word decoding than less productive morphemes.

DOES MORPHEME RECOGNITION CONTRIBUTE TO READING IN DYSLEXIA? IS THE CONTRIBUTION DIFFERENT IN DYSLEXIA AND IN NORMAL READING?

There is some evidence that poor readers make less use of morphological analysis in reading and writing than good readers do. Leong and Parkinson (1995) reported that differences in the use of morphological analogies in reading correlated highly with general reading abilities in poor readers in grades 4 to 6. And, poor spellers among young adults have been found to make little use of morphological analogies in spelling (Carlisle 1987; Fischer, Shankweiler, and Liberman 1985).

However, this may not be the whole picture. Two Danish studies of dyslexic adolescents and reading-level-matched normal controls found evidence that morpheme recognition may be a compensatory strategy in word decoding and reading comprehension in dyslexia. Some results from these two studies are reported below.

STUDY 1. MORPHOLOGICAL ANALYSIS AS A STRATEGY IN WORD DECODING

The first study was of word decoding strategies in dyslexia and normal reading. This study was first published by Elbro (1990, pp 142 f). The study employed several techniques to investigate morpheme analysis strategies in word decoding. Results with one technique only are presented here, with the full analyses of variance presented for the first time. The technique was to assess the impact of morphological transparency on decoding. The measure was the degree to which transparent words like *sunburn*, *reading*, and *lovebird* were decoded more easily than words without such a transparent structure (e.g., *window*, *trumpet*, and *limerick*). The rationale was that if morphological transparency is important in decoding, then words with a transparent structure should be easier to decode than matched words without a transparent structure.

METHOD

Participants. The study employed a reading-level-match design including 26 dyslexic and 26 younger, normally achieving readers. The dyslexic participants were recruited from a special school for teen-aged dyslexics (typically among the 1% poorest readers of normal intelligence in the Copenhagen area). The normal controls were selected from second and third grade classes in two public schools to match the dyslexics on reading comprehension as measured by a standard silent reading test with 60 short passages (Nielsen et al. 1986), and on IQ as measured by the Raven's Progressive Matrices (Raven 1960). In the reading comprehension test, participants were asked to read short passages (often only one sentence long) and to select the matching picture out of four choices. The number of correct items within five minutes was 33.5 (*SD* 8.5) and 33.2 (*SD* 8.2) in the groups of dyslexics and normal controls respectively. The Raven raw scores were 44.3 (*SD* 6.3, range 26-54) and 31.2 (*SD* 6.4, range 15-46) in the dyslexic group and in the younger controls, corresponding to average percentiles of 56.1 (range 8-91) and 62.8 (range 10-93). The small difference between the age-related mean scores was not statistically significant. The mean age of the dyslexics was 15:3 years (*SD* 0:11, range 13:-17:3), and the mean age of the normal controls was 9:4 years (*SD* 0:8, range 8:4-10:11). Since the normal controls were average readers in their classes, it is obvious that the dyslexic teenagers were indeed severely reading disabled. They were at a reading age level about six years below their chronological age. All participants had normal or corrected-to-normal sight, normal hearing, and displayed no signs of gross neurological or emotional disorders. The first language of all participants was Danish.

Measures. As a part of an extensive list of reading and language tasks, the participants were asked to read aloud single words. Among the words were 19 with a semantically transparent morphological structure (e.g., *sunburn*), and 19 matched words with a non-transparent structure (e.g., window). The words were matched for word length (they were 4-8 letters long), consonant-vowel structure, word class, frequency, and concreteness.

Procedure. The words were presented in the same random order to each participant one word at a time on a separate filing card. No time limits were imposed. Responses were tape-recorded, and response times were measured from the recordings by means of a manually operated electronic stop watch. Only response latencies from correctly read words were used in the data analysis.

RESULTS

Accuracy and latency data (presented in table I) were analysed in separate 2 (reader groups) x 2 (word types) MANOVAs with repeated measures on readers. The main effects of reader groups were significant for accuracy, ($F(1,50) = 14.6$, $p < 0.001$ and for latency, $F(1,43) = 24.9$, $p < 0.001$ (seven participants read too few words correctly to obtain reliable latency scores), as were the main effects of morphological structure, $F(1,50) = 33.3$, $p < 0.001$ for accuracy, $F(1,43) = 11.3$, $p < 0.005$ for latency. The interactions between reader groups and morphological transparency were also significant, $F(1,50) = 10.2$, $p < 0.005$ for accuracy, $F(1,43) = 10.2$, $p < 0.005$ for latency. Simple comparisons indicated that the dyslexic teenagers were significantly supported by morphological transparency in that they read morphologically transparent words both more accurately, $t(25) = 6.00$, $p < 0.001$, and faster, $t(20) = 3.45$, $p < 0.005$, than opaque words. The comparable differences were not significant in the normal controls, $t(25) = 1.97$, $p < 0.1$, and $t(23) = 0.20$, $p > 0.2$, respectively for accuracy and latency.

The dyslexic teenagers as a group showed a dependency on morphological word structure. Of further interest is whether this dependency had anything to do with their overall reading ability. In order to assess the impact of morphological transparency at the individual level, simple quotients were calculated between the reading latency with opaque and transparent

Table I. Reading accuracy and latency in groups of dyslexics and normal reading-age-matched controls as a function of the morphological transparency of the words.

Word type	Reader groups Dyslexic	Normal
	Accuracy (% correct)	
Transparent	59.3	74.6
Opaque	42.5	69.7
	Latency (sec.)	
Transparent	2.7	1.5
Opaque	3.3	1.5

words. A reader with a high dependency upon morphological structure would thus get a high quotient (opaque words take much longer to read than transparent words), whereas a reader with a low dependency on morphological structure would have a low quotient. Hence, for each of the dyslexic teenagers, their dependency on the morphological structure of the words could be expressed in one measure. The question was then whether this measure correlated with reading comprehension as measured by the standard test of written passage comprehension (Nielsen et al. 1986). In fact, the correlation between morphological dependency and reading comprehension was positive and significant ($r(26) = 0.53$, $p < 0.01$). The positive correlation indicates that the dyslexics who were making use of morphological analysis in word reading were also among the best readers in terms of passage comprehension. No such correlation was found in the normal controls.

DISCUSSION

The interactions indicate that the dyslexic teenagers were significantly more affected by morphological word structure than the normal reading-level-matched controls. Reading words like *sunburn,* which invite a semantic analysis, was a significant help for the dyslexics, whereas the normal controls did not use and maybe did not even need, such a semantically transparent structure to decode the words. Moreover, the degree to which dyslexics were supported by a transparent morphological structure correlated positively with their reading comprehension. The absence of such a correlation in the normal controls may suggest that the morphological analysis strategy observed in the dyslexic teenagers is a compensatory strategy developed in the context of their poor phonological recoding skills.

Although the two groups in the study were matched on passage comprehension, the dyslexics performed significantly lower than the younger normal controls on single word reading (the experimental measures). Hence, some of the differences in reading strategies observed may stem from differences in *levels* of reading skills rather than from differences in reading *strategies* between dyslexic and normal readers. The results from the study would have been easier to interpret if the two groups had been matched on a reading measure (word decoding) more closely related to the experimental measures.

For this reason, and to enable us to study morphological analysis as a strategy in reading of coherent text, we did a new study which was first reported in Danish by Elbro and Petersen (1993) and which is reported in English for the first time here.

STUDY 2: AN ON-LINE STUDY OF MORPHOLOGICAL ANALYSIS AS A STRATEGY IN TEXT READING

This time we wished to study the influence of morphological structure on text reading. In order to do so, we devised a computer-driven system that can display texts in small units in a text window that the reader advances by pressing a button (Elbro 1991) (figure 1).

Figure 1 illustrates how the first four units of the sentence *the pointed church spire is almost hidden by the wood* are displayed in a word-by-word condition. The experiment also included syllable-by-syllable, morpheme-by-morpheme, and letter-by-letter conditions, in addition to a control condition in which the text was fully visible. The system displays the text as underscores instead of letters except for a single unit of text which is fully visible. By pressing a key, the reader can make the next unit visible while the previous one is turned back into underscores. Another key can make the text window move backwards. The reader may thus move forward and backward through the text with only one unit visible at a time. The size of the window varies according to the particular unit being displayed, a long word (or syllable or morpheme) occupies a long window while a short word results in a small window. At the end of the text five pictures are presented, from which the reader is asked to select the one that fits best with the content of the text (figure 1, panel 5).

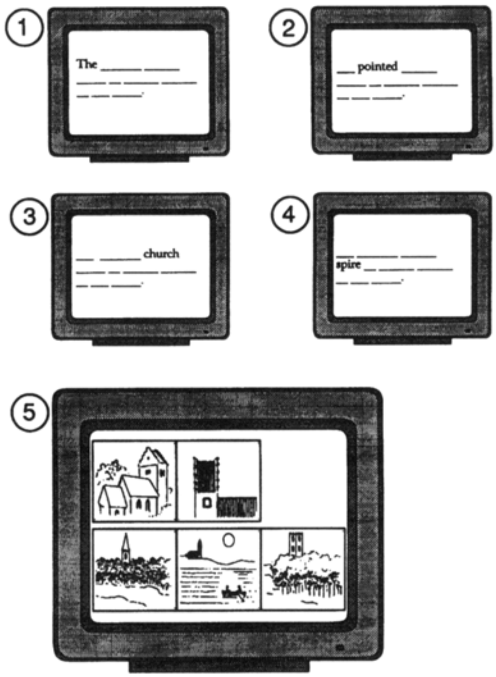

Figure 1. A manually advanced text window. The first four units (words) are shown of the sentence the pointed church spire is almost hidden by the wood. *Panel 5 is the picture selection following the reading of the sentence.*

The motivation for the manual text window was that we expected some linguistic units to be more supportive than others to the reading of individual readers. In particular, we expected that dyslexic adolescents would read better if they saw one morpheme at a time than if they saw one syllable at a time. On the other hand, we expected normal readers of similar reading ability to show no difference between a morpheme and a syllable condition.

Reading with the manually advanced text window is certainly not ordinary reading; but other moving window experiments have indicated that reading with moving windows displays many of the characteristics of normal unconstrained reading (e.g., Jarvella and Lundberg 1987; Elbro and Christoffersen 1988; Chen, Chan, and Tsoi 1988).

METHOD

Participants. We compared the reading of a group of 16 dyslexic adolescents (mean age 13:7 years, *SD* 1:8, range 11:5-17:9

years) with reading in a group of 16 normally achieving, younger controls (mean age 8:7 years, *SD* 0:5, range 7:9-9:2 years). Five of the dyslexic participants were recruited from the special school for dyslexics mentioned above, another 11 were recruited from remedial reading classes in three public schools. The average reading age of the dyslexics was about 5 years below their chronological age, and according to school records they conformed to the same traditional definition of dyslexia as did the subjects in the previous study. Separate IQ measures were not obtained for this study. We selected the two groups to match on the whole-word condition when reading with the manual text window described above. This control measure was chosen as being more closely related than the reading measure employed in Study 1 to the experimental measures of interest (reading morpheme-by-morpheme and syllable-by-syllable). As it turned out, performance of the two groups was also comparable in a second control condition in which the entire passage was fully visible in the manual text window. As can be seen in table II the two groups did, however, differ in terms of oral reading accuracy of 20 single words using a measure adapted from Elbro (1990) (dyslexic group: 13.1 correct, *SD* 3.4; control group: 17.4 correct, *SD* 1.8, $F(1,30) = 211.0$, $p < .001$). On this same measure, the two groups did not differ in terms of latency to read correct words (dyslexic group: 1533 ms, *SD* 667 ms; control group: 1259 ms, *SD* 598 ms, $F(1,30) = 1.3$, *ns*).

Measures. Ninety short passages, mostly only one sentence long, were adapted from two standard tests of reading comprehension (Nielsen et al. 1986). Each passage was displayed under one of five conditions: one letter at a time, one syllable at a time, one morpheme at a time, one word at a time, or with the whole passage visible at one time. The letter-by-letter condition turned out to be exceedingly difficult and to yield unreliable results. Therefore, we only report results from the four other conditions here: the syllable, morpheme, word and the fully visible passage conditions. There were 18 passages to be read under each condition. The texts were modified to contain an equal number of syllables and morphemes so that any differences in eye-hand coordination would be irrelevant to the interpretation of the data from these two conditions. (A pilot study had shown that older dyslexics were faster on average than younger controls when they were asked to press a key as soon as they saw an X appearing on the screen). The reading performance in each condition was measured in terms of accuracy (number of correctly read passages as indicated by a correct picture choice) and latency (average time in milliseconds to

Table II. Reading accuracy, latency, and power with a manually advanced text window as a function of the linguistic unit visible at a time. Average scores (with standard deviations in parentheses) are presented for groups of dyslexic and normal reading-age-matched readers.

Condition	Reader groups: Dyslexic	Normal
	Accuracy (% passages correct)	
Syllables	74.7 (14.6)	79.5 (10.9)
Morphemes	78.5 (16.7)	76.5 (16.7)
Words	77.4 (21.8)	80.0 (18.3)
Passages	82.6 (12.6)	85.0 (10.6)
	Latency (ms per word)	
Syllables	2202 (568)	2025 (252)
Morphemes	1943 (625)	2085 (318)
Words	1689 (402)	1723 (371)
Passages	1568 (555)	1418 (306)
	Power (correct words per minute)	
Syllables	21.8 (7.9)	24.0 (4.8)
Morphemes	27.1 (11.7)	22.7 (5.7)
Words	29.2 (12.0)	29.4 (8.8)
Passages	35.6 (14.1)	37.6 (8.7)

read a word in correctly read passages). A combined measure of reading power was calculated as the number of correctly read words per minute, a standard combination of accuracy and latency, where the number of correctly read words was the sum of words in correct passages.

Procedure. Participants were tested individually in a quiet room in their own school. They were introduced to the manual text window and given 10 practice passages (two in each of the five conditions) before they were given the test passages. The test passages were presented in blocks of 30 and in the same order of increasing difficulty to all participants.

RESULTS

The data analyses focused on the two experimental conditions: the syllable and the morpheme conditions. The expected pattern of results was found for both speed and power of reading (figure 2).

A two (reader groups) x two (conditions: syllables and morphemes) MANOVA of the latency data indicated no significant

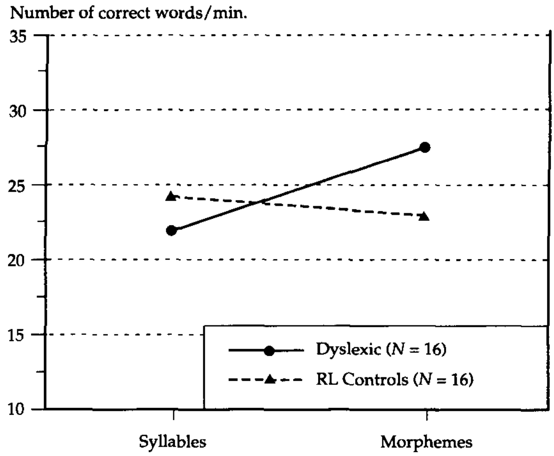

Figure 2. *Reading efficiency in dyslexic and normal reading-age-matched controls under two conditions with the manual text-window: reading syllable-by-syllable and morpheme-by-morpheme. Groups were matched on the word-by-word condition, but also performed equally well in a control condition with fully visible text.*

effect of group, $F(1,30) < 1$, *ns*, but a significant effect of condition, $F(1,30) = 5.0$, $p < 0.05$, and a significant interaction between groups and conditions, $F(1,30) = 12.8$, $p = 0.001$. Similar results were found for the reading power data: no significant main effect of group, $F(1,30) < 1$, *ns*, but a marginally significant effect of condition, $F(1,30) = 3.3$, $p < 0.1$, and a significant interaction between groups and conditions, $F(1,30) = 8.9$, $p < 0.01$. A similar, although non-significant pattern was found for the accuracy data (table II).

Pairwise *t*-tests indicated that the dyslexics read significantly faster in the morpheme condition than in the syllable condition, $t(15) = 3.5$, $p < 0.005$, and with more overall reading power in the morpheme condition than in the syllable condition, $t(15) = 3.1$, $p < 0.01$. No such differences were found in the normal controls (all *t*-values were below 1.3). The dyslexic adolescents read practically as well in the morpheme condition as in the whole word condition; the difference in reading power in the two conditions was not statistically significant, $t(15) = 0.9$, *ns*. This was true despite the fact that it was necessary to press the key to advance the window many more times in the morpheme condition than in the whole word condition. Clearly the dyslexics were relatively more supported by the morpheme condition than were the younger normal controls, who read better in the word condition than in the morpheme condition, $t(15) = 4.1, p = 0.001$.

DISCUSSION

The results indicate that when dyslexic adolescents are forced to read texts morpheme-by-morpheme they do better than one would expect given their reading syllable-by-syllable. The method of the study does not allow us to claim that reading by morpheme recognition was the preferred strategy of the dyslexic adolescents; but we can see that they did relatively well when such a strategy was required.

The two groups performed similarly on reading comprehension as measured by the control condition with fully visible text, in addition to the word-by-word condition. The groups differed on a word decoding measure; the younger normal controls outperformed the older dyslexics on accuracy, but not on speed. In short, the older dyslexics appeared to compensate for their word decoding difficulties when reading coherent texts, achieving a higher level of reading comprehension than would be expected from their word decoding skills. This result is in accordance with earlier work by, for example, Bruck (1990); Elbro (1990); Elbro, Nielsen, and Petersen (1994); Gough and Tunmer (1986).

The results suggest that written morpheme recognition may be one way that older dyslexics manage to compensate for their basic phonological difficulties while reading coherent text. If this conclusion holds any truth, it might be worthwhile to try to support the development of fluent reading in cases of dyslexia by teaching morpheme recognition as a reading strategy. However, one could also be more cautious and pursue the conditions for morpheme recognition in reading a little further. The development of morphological analysis strategies in reading might depend to some extent on the sensitivity to and awareness of morphemes in *spoken* language. Some dyslexics might be able to develop morpheme analysis and recognition in reading because they already have an idea that spoken words consist of smaller significant parts, whereas other dyslexics may not develop such a strategy in reading because they are unaware of the morphological structure of words. If this were the case then it would probably make sense to teach morphological analysis before, or concomitant with, the teaching of morpheme recognition in reading. This suggestion will be pursued in the following section.

DOES MORPHEME RECOGNITION AS A STRATEGY IN READING DEPEND ON THE LEVEL OF AWARENESS OF MORPHEMES IN SPOKEN LANGUAGE?

We use the term *morphological awareness* in a broad sense to cover a whole range of morphological skills and knowledge. The term covers the kind of implicit knowledge used, for example, to inflect or derive new words following standard morphological patterns as in the Wug test: *Here is a wug. Now there are two ____? (Wugs)* (Berko 1958). It also covers more explicit knowledge required to judge morphological relations, e.g., *do you think that the words* male *and* malicious *have the same linguistic ancestor?*

There is a fairly small, but consistent body of research which indicates that differences in implicit, productive knowledge of morphology explain differences in reading and spelling. This has been found in correlational studies with first and second graders (e.g., Brittain, 1970). And it has been reported for spelling in second grade children, learning disabled children, and adults with literacy problems (Rubin, Patterson, and Kantor 1991). There are also now some longitudinal studies which indicate that differences in morphological abilities in spoken language in kindergarten and first grade are predictive of reading achievement in second grade (e.g., Tornéus 1987; Carlisle 1995). The results from a recent study by Carlisle (1995) further indicate that morphological abilities in first grade may be more strongly related to reading comprehension than to word decoding in second grade.

Furthermore, Mahony and Mann (1992) found evidence that second grade children's appreciation of phonologically and morphologically based puns correlated with reading ability independently of receptive vocabulary. The children were asked which solution they would prefer to questions like "If a dog lost its tail, where would he get a new one? (a) At a re-tail store. (b) At a pet store?" Children's preference for the pun-answers (as in a) correlated with their reading abilities, whereas their choices in a control task with puns based on homonyms did not (e.g., a pun based on the double meaning of *blue* 'color' and 'depressed').

In a way, it is more complicated to study morphological awareness than phonological awareness. There are obviously very different types of morphemes that may play different roles in the reading process. Therefore, a study of morpheme awareness should include separate measures of various types of morphemes: roots, derivations, and inflections. Then it would be possible to look for correlations between awareness of specific types of morphemes and the ability to read these types of morphemes. It might be the case that awareness of, for example, inflections in spoken language predicts the reading and spelling accuracy of inflections. Yet, even such relations between awareness and reading of specific types of morphemes would probably show up in more general measures of morpheme awareness and reading ability.

In addition to the reading measures administered in study 1 above, the dyslexics and normal controls in this study were given oral language tasks involving morphological awareness, allowing us to assess both the general and more specific relations between morphological awareness and reading. The results have been presented in detail elsewhere (Elbro 1989, 1990) and will just be mentioned and discussed briefly here. There were five measures of morphological awareness: (1) a sentence analysis task in which the participants were asked to count the number of words in sentences that were spoken to them; this task was particularly demanding for those dyslexics who had only a vague idea of function words as separate words, (2) a task requiring inflection and compounding of new words, adapted from Berko's (1958) Wug test, (3) a morphological reversal task that required subjects to reverse the roots of compound words (e.g., *postman* > *manpost*), (4) a morpheme synthesis task in which the subjects heard pairs of separate morphemes pronounced and were asked to judge whether they would make up a real word or not when put together, and (5) a morphological completion task in which subjects heard a bound morpheme like *whelm* and were asked to say a whole word that contained the spoken segment (e.g., *overwhelm*).

Dyslexic teenagers were not particularly good at solving these tasks. In fact they were significantly outperformed even by reading-level matched controls (who were six years younger) in three out of the five tasks (sentence analysis, reversal of root morphemes, and completion). In other studies, dyslexics and reading-age-matched controls have been found to perform at the same level, but below the level of chronological-age-matched normal readers (e.g., van Bon, Dierx, and Klerkx 1990).

The important point for our present purposes is that variance in morphological awareness explained some of the variance in word decoding. The correlations between word decoding and an unweighted average of scores in all five morphological tasks were significant in both groups, $r(26) = .40$, $p < 0.05$, and $r(26) = 0.38$, $p < 0.05$ in dyslexics and controls, respectively. The correlation was particularly high among participants (from both groups) with above average IQ scores, $r(26) = .64$, $p < 0.001$; but only marginally significant among participants with below average IQ scores, $r(26) = .34$, $0.05 < p < 0.1$. This influence of IQ on the strength of correlations has also been reported in other studies (Brittain 1970; Tornéus 1987).

Even more interestingly, it was found that ability to apply inflections to new words, as measured by a subset of the items from the Wug test, correlated with reading accuracy of inflections, $r(26) = .40$, $p < 0.05$ in the dyslexics; this and the following correlations were insignificant in the controls. The proportion of reading errors that *only* involved an inflection served as a measure of reading of inflections. Reading accuracy of inflections also correlated significantly with scores in the morphological synthesis test, $r(26) = .46$, $p < 0.01$, and surprisingly, with scores in sentence analysis, $r(26) = .35$, $p < 0.05$; but *neither* with scores in the morpheme reversal test nor in the completion test. Both the Wug test and the synthesis test involved manipulations of inflections, whereas the reversal and the completion test did not. Hence the pattern of results (with the exception of those of the sentence analysis test) suggests that there might be a specific link between awareness of inflections in spoken language and accuracy of recognition of written inflections.

The influence of IQ on the relation between morphological awareness and reading can be interpreted in several ways. Assuming that oral language awareness of morphological inflections is facilitating identification of written inflections, one might speculate that only the most reflective readers (with above average IQ) use their linguistic knowledge during reading. Less reflective readers may possess relevant linguistic knowledge, but not make use of it. On the other hand, assuming that reading ability boosts morphological awareness, the pattern of results may be explained in terms of more reflective readers being more adept at extracting morphological knowledge during reading than less reflective readers. In other words, the interpretation depends on the causal direction between morphological awareness and reading abilities. This issue of causal direction can only be reliably addressed by means of intervention studies.

Another question that is raised by Fowler and Liberman (1995) and by Carlisle (1995), which can also be answered most reliably by intervention studies, concerns the possible contribution of phonological awareness to the connection between morphological awareness and reading ability. In Fowler and Liberman's words: "Is the association between morphological awareness and reading mediated by joint demands on phonological awareness. . . ?"

Fowler and Liberman asked good and poor readers (in second to fourth grades) to produce derived forms of spoken words (and base forms from derivations), for example, *four. The big racehorse came in _____(fourth).* Half of the items were "phonologically simple" in the sense that the pronunciation of the roots did not change (e.g., *four* > *fourth*), the other half were "phonologically complex" like *five* > *fifth*. The results indicated that the performance with the phonologically complex items was more closely related to reading ability than was the performance with the phonologically simple items. Furthermore, the phonologically simple items did not distinguish poor readers from reading ability (RA) matched good readers. In conclusion, Fowler and Liberman suggest that differences in morphological awareness may to a large extent be a consequence of phonological awareness and exposure to written language rather than an independent factor underlying differences in reading.

In contrast, Carlisle (1995; see also Carlisle and Nomanbhoy 1993) reported that morphological awareness (implicit knowledge in particular) in grade 1 predicted significant variance in both word analysis and reading comprehension in grade 2—even after controlling for differences in phoneme awareness.

Theoretically, it is possible that the relative difficulty of the phonologically complex condition in Fowler and Liberman's (1995) study could be explained in terms of morphology rather than in phonological terms. The morphological bonds between representations of simple and derived word forms in the lexicons of the poor readers just might not be strong enough to resist the phonological alterations. Again, a training study would be needed with a built-in control for differences in phonological awareness.

A third reason to do a training study with morphological awareness lies in the relative difficulty that dyslexics have with phonology. We know that it is difficult to help dyslexics advance their phoneme awareness and their use of the alphabetical principle of writing. Therefore, as a supplement to the continued teaching of phonological awareness we might teach them to develop alternative strategies that can carry them through reading development anyway. One possibility is to help them increase morphological awareness and morphological analysis as a strategy in reading and spelling.

DOES MORPHEME AWARENESS TRAINING AFFECT READING AND SPELLING SKILLS AND STRATEGIES?

The training studies of morphological awareness reported in the international literature can probably be counted on one hand.

The most well known is the work of Marcia Henry (Henry 1988, 1989, 1990). Her training materials incorporate morpheme patterns to a large extent, especially those of Latin and Greek origin. She reported positive effects of a comprehensive approach including both letter-sound correspondences, syllable patterns, and morpheme patterns with respect to the origin of the words (Anglo-Saxon, Latin, or Greek) (Henry 1989). However, the instruction was not focused on morphology alone for good reasons and the population included both normally achieving and reading disabled third, fourth, and fifth graders.

In Norway, Lyster (1995, submitted) has reported promising results of a morphological training study with kindergarten children. Children benefitted just as much from morphological awareness training as from phonological awareness training as judged from their reading development in grade 1. Both groups outperformed a control group on a composite reading measure.

STUDY 3: A TRAINING STUDY OF MORPHOLOGICAL AWARENESS

Recently we have completed the first quasi-experimental training study of morphological awareness with dyslexic students. This study was concerned with the possibility of teaching morphology to 10- to 12-year-old dyslexics and with the effects of such training on morpheme awareness, phoneme awareness, reading, and spelling. Much of the work, including preparation of teaching materials, training of teachers, some of the testing, and scoring of the data, was done by the second author. The study is reported for the first time here.

METHOD

Participants. Dyslexic students were recruited from remedial reading classes in 17 schools randomly selected within the Copenhagen area. All participants had severe reading and spelling problems and conformed to the standard definition of dyslexia used in the studies reported previously. A few of the students performed quite poorly on the IQ test, but low IQ was not considered by the schools to be the primary cause of their reading difficulties. Each student had at least a two-year discrepancy between chronological age and reading age. The experimental group consisted of 33 dyslexics (23 boys and 10 girls) from nine schools. A control group consisted of 27 dyslexics (17 boys and 10 girls) from similar classes in eight different schools. The two groups were matched with respect to age, sex ratio, and IQ (Raven's progressive matrices) (table III).

Table III. Characteristics of the experimental group (*n* = 33) and matching control group (*n* = 27) in the training study of morphological awareness.

	Experimental group			Control group		
	m	*SD*	Range	*m*	*SD*	Range
Age (yrs., mos.)	11,0	0,11	9,9–12,11	11,2	0,11	10,0–12,9
Raven raw score	33.8	7.4	12–48	31. 3	7.5	20–47
Raven percentile	47	20	4–92	40	24.7	9–96

Teaching procedures. The teaching of the students was carried out by the group's own teachers using Arnbak's materials (Arnbak 1993). The teachers in the experimental group were given a 12-hour course on morphology at the university. The course also introduced the teaching materials. The training itself was distributed over 36 sessions lasting 15 minutes each, with three sessions per week. This time was taken from remedial teaching, so that of each lesson in the experimental groups 15 minutes was spent on morphology, and approximately 25 minutes on traditional reading and writing activities. The total training period was three to four months long. The teaching of morphology was predominantly oral. Printed words were only presented in cases where they were needed for the students to understand morphology. Furthermore, the teachers of the experimental group agreed not to teach any phonological analysis skills, such as syllable and phoneme segmentation, during the whole treatment period. The training program was in three parts.

The first phase of the training dealt with compounds. Students were asked to segment transparent compounds, to change the order about, figure out possible meanings of the reversed order words (what is the difference between a *song evening* and *evening song*), they played games where they made the second root of a compound the first, and then added a new root, e.g., *flute music > music box > box office > office . . .*, they invented new names (compounds) for new things (such as a "fold-up spoon" and a "telescope straw"), and they continued to study more opaque, metaphorical compounds such as *dragonfly, butterfly,* and other flies.

The second phase of the training focused on derivational affixes, both derivations of meaning (common prefixes, corresponding to English *un-, mis-, be-, for-,* and suffixes such as *-ly,* and *-ish*) and derivations of form (such as *-ing, -er,* and *-ness*). One of the more advanced tasks was to explain the differences between negations, as in *untrustful, mistrustful,* and *distrustful.*

The final phase dealt with inflections of nouns, verbs, and adjectives. As far as possible, the training focused on the significance of the morphemes. For example, the significance (semantic content) of the inflections was studied and discussed extensively, not only in the relatively simple cases of, for example, plural forms, but also in complicated cases such as the many meanings of the present tense (e.g., "always" *Jane lives in England,* "timeless" *two plus two is four,* "future" *John comes tomorrow,* and dramatic present).

The materials included discussion of pseudo-morphemes such as *car/pet,* and ambiguous structures such as in *babysitter* ("a person who is sitting on babies"?), and alternative derivations such as *mouse* > *mussels.* (Note that *mouse, muscle,* and *mussel* have the same root in Greek). This was mainly because of the author's fondness of humor in linguistics and education. There was no attempt to teach other aspects of grammar, such as syntax.

The *control* groups received traditional remedial instruction during the whole experiment. This instruction included a variety of activities, among which reading and writing under teacher supervision took most of the time. The control groups were also instructed in decoding and spelling prerequisites such as syllable and phoneme segmentation. Because of the predominantly oral contents of the *experimental* instruction, the experimental groups spent less time overall on reading and writing activities than the control groups did.

Oral language measures. The same extensive set of language and reading tests was administered before and after the training period. The measures included tests of morpheme awareness, phonological awareness, receptive vocabulary, reading, and writing. In addition to measures of implicit and explicit morphological knowledge, measures of phoneme awareness and receptive vocabulary were included as control measures. We expected the morphological training to have a specific effect, that is, to show up in the morphological measures, not in the phonological awareness measure or in receptive vocabulary.

Inflections. This morphological task was modeled after Berko's (1958) Wug test . Each participant is shown line drawings of invented animals and asked questions about them requiring the production of an inflected form, e.g., *Here is one sput. Here is another one. Now there are two* _____? (expected: *sputs*). This task and the following one were modified from earlier versions in Danish (Elbro 1989, 1990).

Compounds. This task was modeled in the same way as the inflection tasks, but invited the participants to form compounds of the new animal names, for example, *Here is a sput that knows how to tane. It is a* _____? (expected answer in Danish: *tanesput*).

Morphological analogies. This task was developed as a more flexible and versatile measure of awareness of morphological relationships between real words, including both common and rare morphological relationships. Each item had the following format: *Reading relates to read in the same way as writing relates to* _____? (Expected: *write*). This test included inflections and derivations of nouns, verbs, and adjectives, both regular and irregular ones. For 18 of the 20 items participants were asked for a simple form given a complex, for two items they were asked to generate a complex form given another complex one. Half of the items involved a phonological change of the root; the other half were phonologically "simple." Infinitives of verbs were scored as correct alternatives to roots.

Morpheme subtraction and identification. This fourth morphological task required the participants to say the first part of compound words, for example, *What is left in* hand-grenade *if you take away* grenade? If the participants replied with the bound allomorph [hæn], they were asked to name the word as it sounds as a separate word [hænd] (the identification part of the task). The scores reported below are number of correctly identified first roots.

Phoneme identification (Nielsen and Petersen 1992). For each item of this task participants were shown four pictured words and asked to indicate the one that contained a target sound presented in a model word, for example, *[m] is the first sound in map, point to the picture that has the sound [m].* In a second set of items more than one of the pictured words contained the target sound, but then participants were instructed to find the picture with the sound *in the same position* (initial, medial or final) as in the model word. Adult scores with the second set of items have been published by Elbro, Nielsen, and Petersen (1994).

Receptive vocabulary was measured by means of a Danish version of the Peabody Picture Vocabulary Test (Dunn and Dunn 1981). It should be noted here that the words in the Danish translation of the PPVT are mostly morphologically simple.

Reading and spelling measures.

Reading words of varying morphological structure. This experimental measure consisted of 80 isolated words to be read aloud.

The words were based on 20 different roots each of which occurred four times: as a separate word (e.g., *rain*), as a part of a compound (*rainwater*), in a derived word (*rainy*), and in an inflected word (*rained*). This selection of words allowed us to assess reading of each of the four types of words separately and in combination. We expected morphological awareness training not to have an effect on reading of morphologically simple words, but to have a positive effect on morphologically complex words.

Reading nonwords (Elbro 1990). The participants were asked to read aloud 40 non-words of increasing length and phonological complexity. These words were given as a control measure, so as to make sure that a possible training effect on morphologically complex words could not be due to an increase in phonological recoding skills in reading.

Reading comprehension of short passages. (SL60, Nielsen, Kreiner and Søegård, 1986). This is a standard reading comprehension test consisting of 60 short passages each followed by picture selection. The score was number of correct items per minute within a 15 minute limit. We expected the morphological awareness training to have a positive effect on this measure because of its modest demands on reading accuracy and its focus on meaning.

Spelling words of varying morphological structure. Participants were asked to spell the same 80 words of varying morphological structure as in the reading task mentioned above. The experimenter spoke each word in a sentence context and then repeated the word. As with reading, we hypothesized that morphological awareness training would have a positive effect on spelling of morphologically complex words but not on spelling of morphologically simple words. Furthermore, we expected that morphological training would help students improve their spelling of less semantically salient morphemes such as derivations and inflections. In order to test this hypothesis we planned to carry out detailed analyses of the misspelled words and to calculate the percentage of various types of morphemes that were spelled correctly in spite of a misspelling of another part of the word. In addition to scores for each word type, we also scored the misspelled words in terms of sound-letter-appropriateness (phonologically acceptable or "sound-preserving" errors).

Assessment procedure. Participants were tested individually in a quiet room at their school. The words of the oral reading tests were presented one at a time on a computer screen, and response times were measured by means of an electronic stop watch and scored as correct or incorrect by the experimenter. The 80 words of varying morphological structure were presented in the same random order to all participants. School psychologists were responsible for the administration of the Raven test.

RESULTS

Data from each of the experimental and control measures were submitted to a 2 groups (experimental and control) x 2 (test occasions) MANOVA with repeated measures on groups. Instructional groups were used as the unit of analysis. Looking first at the measures of morphological awareness, training effects were detectable, but not impressive (table IV). With the exception of the compounding task, all main effects of test occasion were significant, suggesting an improvement over time. Although none of the main effects of group was significant, a significant interaction was found in the morphological analogy test, and a marginally significant interaction was found in the compounding task, suggesting that the experimental group gained more than the controls with these tasks. The interaction terms were nonsignificant in both the phoneme awareness test and in the mea-

Table IV. Pretest and posttest performance on measures of oral language awareness and skills. Standard deviations are given in parentheses. Significance levels of interactions between groups (repeated measures) and time of testing from MANOVAs are added in the last coloumn. Schools were used as units of analysis ($N = 17$).

		Test occasion		
Measure	Teaching condition	Pre-test *M* (*SD*)	Post-test *M* (*SD*)	Significance of interaction *F*(1,15), *p*
Add inflections	Morph.	7.4 (2.3)	7.9 (1.9)	<1, *ns*
(max 13)	Control	6.7 (1.9)	7.7 (2.1)	
Compound	Morph.	1.5 (1.3)	2.2 (1.5)	4.3, <.1
formation (max 5)	Control	1.6 (1.2)	1.4 (1.5)	
Morph. analogies	Morph.	9.3 (5.1)	12.4 (3.2)	4.7, <.05
(max 20)	Control	7.8 (5.0)	10.4 (4.7)	
Morph. subtraction	Morph.	9.4 (2.4)	10.0 (2.5)	<1, *ns*
(max 20)	Control	8.7 (2.4)	9.8 (2.1)	
Phon. identification	Morph.	11.8 (3.3)	12.9 (3.2)	<1, *ns*
(max 20)	Control	11.4 (3.6)	12.4 (2.7)	
Vocabulary (PPVT)	Morph.	88.8 (9.5)	92.1 (11.0)	2.2, *ns*
(max. 150)	Control	84.2 (10.6)	88.3 (8.0)	

sure of receptive vocabulary. This suggests that the experimental group did not gain significantly more than the controls with these control measures.

As can be seen in table V, training effects on reading were small. No significant effects were found on accuracy of single word reading. With nonwords there was even a nonsignificant tendency for the controls to progress more than the experimental group. However, when subjects in the experimental group misread a real word they replied with a real word about half of the time (and a nonsense word the other half of the time). During the experiment the experimental group tended to increase the percentage of real word responses more than the controls did. This difference suggests that the morphological awareness training may have resulted in a more meaning-focused reading strategy. Finally, it is interesting to note that the experimental group gained more in written passage comprehension than the controls—despite the fact that they did not advance more than the controls in word decoding or nonword naming.

As far as spelling is concerned, the experimental groups appeared to gain significantly more than the controls with compound words, but not with any other word type (table VI). The gain on total number of correctly spelled words was significantly higher for the experimental group than the controls in an analysis by subjects, $F(1,58) = 5.3$, $p < 0.05$, but the difference

Table V. Pretest and posttest performance on measures of reading skills and strategies. Standard deviations are given in parentheses. Significance levels of interactions between groups (repeated measures) and time of testing from MANOVAs are added in the last coloumn.

Measure	Teaching condition	Test occasion: Pretest *M* (*SD*)	Test occasion: Posttest *M* (*SD*)	Significance of interaction *F*(1,15), *p*
Total number correct words (max = 80)	Morph.	29.4 (16.4)	37.1 (20.0)	1.7, *ns*
	Control	27.8 (13.3)	38.5 (17.8)	
Real word responses of misreadings (%)	Morph.	55.6 (15.8)	61.7 (13.5)	7.2, <.05
	Control	56.0 (19.4)	52.3 (19.7)	
Nonwords correct (of 40)	Morph.	17.0 (8.2)	17.8 (9.2)	1.9, *ns*
	Control	16.6 (8.5)	19.8 (9.6)	
Passage comprehension (correct/min.)	Morph.	3.3 (1.4)	4.4 (1.9)	5.6, <.05
	Control	3.3 (1.4)	4.1 (1.7)	

was not significant in the analysis by schools. The error analyses indicated that the experimental group progressed more than the controls with spelling of derivations, and in terms of phonologically acceptable spelling ("sound-preserving" errors).

DISCUSSION

To sum up, it appears that it may be possible to train morphological awareness even in dyslexic students. The direct effects were not large, however. This was due to the fact that a few experimental classes did not gain in morphological awareness at all. The only thing that we know is that these apparently inefficient classes were also those with relatively many students. We did not make observations in the classrooms so we do not know

Table VI. Pretest and posttest performance on measures of spelling skills and strategies. Standard deviations are given in parentheses. Significance levels of interactions between groups (repeated measures) and time of testing from MANOVAs are added in the last column.

Measure	Teaching condition	Test occasion: Pretest *M* (*SD*)	Test occasion: Posttest *M* (*SD*)	Significance of interaction *F*(1,15), *p*
Simple words correct (max. 20)	Morph.	7.7 (4.2)	10.4 (4.9)	<1, *ns*
	Control	7.4 (5.3)	9.1 (4.9)	
Compounds correct (max. 20)	Morph.	4.4 (3.4)	7.4 (4.5)	6.8, <.05
	Control	5.2 (4.0)	6.3 (4.6)	
Derived words correct (max. 20)	Morph.	2.6 (2.6)	5.1 (4.3)	1.7, *ns*
	Control	2.8 (2.6)	4.1 (3.9)	
Derivations preserved (% of misspelled words)	Morph.	26.8 (18.2)	45.3 (25.1)	16.9, <.01
	Control	27.5 (14.1)	30.7 (17.5)	
Inflected words correct (max. 20)	Morph.	2.8 (2.5)	4.5 (3.3)	<1, *ns*
	Control	3.0 (2.3)	3.6 (3.6)	
Inflections preserved (% of misspelled words)	Morph.	33.5 (20.3)	39.4 (20.3)	<1, *ns*
	Control	33.9 (23.6)	35.2 (20.7)	
Total number correct (max. 80)	Morph.	17.6 (12.3)	27.6 (16.3)	1.4, *ns*
	Control	18.6 (13.9)	23.4 (16.4)	
Sound-preserving errors (% of misspelled words)	Morph.	19.0 (14.5)	29.1 (18.8)	11.9, <.02
	Control	20.4 (17.7)	21.8 (16.1)	

what may be the cause. These modest direct effects make the results more suggestive than conclusive. However, one important aspect of the results is that almost all the positive training effects are related to morphological aspects of language processing in speech, reading, and writing. None of the control measures (of phonological skills or of reading and spelling morphologically simple words) indicated significant effects that could have been indicative of expectancy (Hawthorne) effects.

Since the direct training effects were modest, it is difficult to be sure that the superior gains in reading and spelling of the experimental group should be attributed to the morphological awareness training per se. We cannot exclude the possibility that teachers linked morphological awareness training to reading and spelling. After all it was the same teachers who were responsible for both aspects of the teaching.

The significant effect on reading comprehension suggests that the participants in the experimental group learned to make better use of their decoding skills—however poor they were—presumably by paying more attention to significant morphemes as they read along. As to spelling, the improved sound-to-letter conventionality suggests that clearer perception of the morphological structure of the words may lead to an improved application of sound-to-spelling conventions.

CONCLUDING DISCUSSION

This paper has raised a number of specific questions about the importance of morphology for reading and spelling with special reference to dyslexia.

The first pair of related questions concerned whether morpheme recognition contributes to reading success in dyslexia, and whether this contribution is greater or smaller than in normal readers at the same level of reading ability. First of all, it should be noted that there are several indications from a growing body of research that morphology is important to reading and spelling. So far, however, the effects of morphological structure and of morphological awareness appear to be smaller than the effects of phonology and phonological awareness. This should probably not come as a surprise, since the units of the alphabetic languages, the letters, represent abstract sounds, and not units of meaning. But there *are* effects of morphology, and for very good reasons, since the second most important principle of many writing systems is morpheme constancy. With respect to dyslexia we have briefly presented results from two studies from our research group. Data from the first study suggested that dyslexic teenagers are indeed affected by morphological structure in word decoding. Their accuracy and speed in reading complex words depends to some extent on the semantic transparency of the structure of the words. Data from the second study suggested that dyslexic adolescents are relatively more supported than younger normal readers during reading of coherent text when the morphological structure is displayed explicitly.

Our next question concerned the causes of differences in morpheme analysis as a strategy in reading: Does morpheme recognition in reading depend on the level of awareness of morphemes in spoken language? A number of studies, including one of our own, have indicated a correlation between morphological awareness and decoding. One of these studies (Tornéus 1987) was even a longitudinal prediction study. This positive correlation appeared to be particularly strong in readers of above average IQ. This could simply mean that the relation between morphological awareness and morphological analysis in reading is not an automatic one. One does not automatically become morphologically aware by being a good reader and, vice versa, being more aware of morphemes in spoken words does not automatically lead to better reading. This lack of automaticity would be true regardless of the causal direction between morphological awareness and reading. And it may be important when one considers the results from the training study of morphological awareness.

The training study with morphological awareness provided a preliminary indication that morpheme awareness can, in fact, be specifically trained in dyslexic students. The gains in morphological awareness were rather small with a large variation between classes suggesting that the naturalistic design probably did not work very well in some classrooms.

The final and most interesting question was whether morpheme awareness training leads to better reading and spelling skills and strategies. Clearly, there was an effect on accuracy in spelling that was not found in reading. At first this result came as a surprise to us. But there may be very good reasons why this is so. One reason is that spelling is a slower process than reading and thus gives the speller more time to consult his or her linguistic knowledge than reading does.

Another, and probably more important reason is that the morphological structure of the word is available to the speller, but not to the reader. In reading there is no certain way to know the morphological structure of the word before the whole word is identified. A letter string (e.g., *re-*) which is a prefix in many words (*reappear, regain,* etc.) need not be one in the word being read (e.g., *reaping, regular*). And what looks like a root when the word is scanned from left to right, need not be a root when the whole word is recognized (e.g., *read/y, car/pet, bar/on, non/ce*). In spelling, on the other hand, the whole word is present and the morphological structure available (in principle) right from the beginning of the process. If the word is morphologically complex, a morphological analysis may be a significant aid.

Morphological analysis may be not only an important means to the spelling of phonologically ambiguous segments of the word (see the introduction), it may also be a useful way of segmenting the word before spelling-to-sound conventions are applied to each of the segments. Each of the morphological segments is meaningful and thus easier to hold in working memory while spelled. This latter morphologically based strategy may, in fact, explain why the experimental group improved their spelling more than the controls in terms of sound-preserving (or phonetic) errors. If the dyslexics in the experimental group learned to use morphological segmentation as a process in spelling, then this strategy may have eased the burden on their phonological working memory because the strategy allowed them to concentrate on one meaningful segment at a time.

The results regarding spelling are promising and warrant replication studies. Further studies, including normal controls, are also needed in order to reveal to what extent morphological decomposition in spelling is a compensatory strategy in dyslexia and to what extent it is a part of the normal development of spelling ability.

In one important aspect of reading, written passage comprehension, the subjects in the experimental group improved more than the controls. This was true despite their failure to gain more in word decoding than the controls. This very interesting pattern of results suggests that the teaching of morphology helped the dyslexics to make better, more strategic, use of whatever, generally poor, decoding skills they have. If this is accurate, the result could be interpreted as an experimental validation of the hypothesis put forward in Study 2 that morpheme recognition may be a compensatory strategy in reading comprehension in dyslexia.

Training morphological awareness on a primarily oral basis may be of central theoretical importance because it rules out the possibility that positive gains in reading and spelling could stem mainly from print exposure. However, for practical purposes, we strongly believe that a more integrated approach would yield better results. We even suspect that the observed training effects on reading and writing in the present experiment may have been caused, at least in part, by an unplanned linking of morphological awareness to the teaching of reading and spelling in the experimental group. Students should hear, see, and write the morphemes they are supposed to learn to read and to write. What seems to be an outcome from the training study is that the focus on the semantic aspects of morphology may be helpful to dyslexic students. Teaching of morphology would lose an important dimension if it were reduced to training in recognition of meaningless orthographic patterns.

ACKNOWLEDGMENTS

The research reported here was supported by a grant from The Danish Research Council to the first author. The authors wish to thank Annelise Petersen for help with data collection. The editor, C. K. Leong, Jane Oakhill, and an anonymous reviewer also deserve our gratitude for many thoughtful comments and suggestions. We are greatly indebted to the many students and their teachers for their participation and enthusiasm.

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References

Arnbak, E. 1993. *Er mor-femdeling mord? I-III.* ('Is morpheme analysis'—or 'cutting mother in five pieces'—'murder?' In Danish). Herning, Denmark: Special-pædagogisk Forlag.

Berko, J. 1958. The child's learning of English morphology. *Word* 14:150–77.

Bon, W. H. J. van, Dierx, M. H. G., and Klerkx, J. J. M. P. 1990. De morfologische competentie van kinderen met leerproblemen. *Pedagogische Studiën* 67:59–69.

Borgen, J., and Lorenzen, G. 1995. *Automatic Learning of Danish Word Pronunciation.* Copenhagen: University of Copenhagen, Department of Computational Sciences.

Bradley, D. 1980. Lexical representation of derivational relation. In M. Aronoff and M. -L. Kean (eds.), *Juncture. A collection of original papers.* Saratoga: Anma Libri.

Brittain, M. M. 1970. Inflectional performance and early reading achievement. *Reading Reasearch Quarterly* 6:34–48.

Caramazza, A., Laudanna, A., and Romani, C. 1988. Lexical access and inflectional morphology. *Cognition* 28:297–332.

Carlisle, J. F. 1987. The use of morphological knowledge in spelling derived forms by learning-disabled and normal students. *Annals of Dyslexia* 39:90–108.

Carlisle, J. F. 1995. Morphological awareness and early reading achievement. In L. B. Feldman (ed.), *Morphological Aspects of Language Processing*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Carlisle, J. F., and Nomanbhoy, D. M. 1993. Phonological and morphological awareness in first graders. *Applied Psycholinguistics* 14:177–95.

Elbro, C. 1990. *Differences in Dyslexia. A Study of Reading Strategies and Deficits in a Linguistic Perspective.* Copenhagen: Munksgaard.

Elbro, C. 1991. Computer-based techniques in remediation of dyslexia. In I. Lundberg and T. Høien (eds.), *Literacy in a World of Change. Perspectives on Reading and Reading Disability.* Stavanger: Center for Reading Research.

Elbro, C., and Arnbak, E. In preparation. *Reading of Compounds: Effects of Semantic Structure.* Copenhagen: University of Copenhagen, Department of General and Applied Linguistics.

Elbro, C., Nielsen, I., and Petersen, D. K. 1994. Dyslexia in adults: Evidence for deficits in non-word reading and in the phonological representation of lexical items. *Annals of Dyslexia* 44:205–26.

Elbro, C., and Petersen, T. 1993. *Udviklingsarbejde om undersøgelse af ordblinde elevers læsestrategier* ('A Study of Reading Strategies in Dyslexic Students'. In Danish). Copenhagen: Det tværkommunale projektsamvirke.

Feldman, L. B., and Andjelkovic, D. 1992. Morphological analysis in word recognition. In R. Frost and L. Katz (eds.), *Orthography, Phonology, Morphology, and Reading.* Amsterdam: Elsevier.

Fischer, F. W., Shankweiler, D., and Liberman, I. Y. 1985. Spelling proficiency and sensitivity to word structure. *Journal of Memory and Language* 24:423–41.

Fowler, A. E., and Liberman, I. Y. 1995. The role of phonology and orthography in morphological awareness. In L. B. Feldman (ed.), *Morphological Aspects of Language Processing.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Henderson, L. 1985. Toward a psychology of morphemes. In A. W. Ellis (ed.), *Progress in the Psychology of Language, Vol 1.* London: Lawrence Erlbaum Associates.

Henry, M. K. 1988. Beyond phonics: Integrated reading and spelling instruction based on word origin and structure. *Annals of Dyslexia* 38:258–75.

Henry, M. K. 1989. Children's word structure knowledge: Implications for decoding and spelling instruction. *Reading and Writing: An Interdisciplinary Journal* 2:135–52.

Henry, M. K. 1990. *Words: Integrated Decoding and Spelling Instruction Based on Word Origin and Structure.* Los Gatos, CA: Lex press.

Jacobsen, B. 1995. *Grønlandsk læseundersøgelse. En ortografisk, fonologisk og morfologisk undersøgelse* ('A Study of Reading in Greenlandic: An orthographic, phonological, and morphological study'. In Danish). Copenhagen: University of Copenhagen. Unpublished Ph.D. thesis.

Jarvella, R. J., and Meijers, G. 1983. Recognizing morphemes in spoken words: Some evidence for a stem-organized mental lexicon. In G. B. Flores d'Arcais and R. J. Jarvella (eds.), *The Process of Language Understanding.* London: Wiley.

Leong, C. K., and Parkinson, M. E. 1995. Processing of English morphological structure by poor readers. In C. K. Leong and R. M. Joshi (eds.), *Developmental and Acquired Dyslexia: Neuropsychological and Neurolinguistic Perspectives.* Dordrecht: Kluwer.

Libben, G. 1994. How is morphological decomposition achieved? *Language and Cognitive Processes* 9:369–391.

Lyster, S.-A. H. 1995. Preventing reading and spelling failure: The effects of early intervention promoting metalinguistic abilities. Unpublished Ph.D. thesis. Oslo, Norway: Institute for Special Education, University of Oslo.

Lyster, S.-A. H. (submitted). The effects of metalinguistic training in kindergarten on reading development. Paper submitted to *Reading and Writing: An Interdisciplinary Journal.*

Mahony, D. L., and Mann, V. A. 1992. Using children's humor to clarify the relationship between linguistic awareness and early reading ability. *Cognition* 45:163–86.

Marslen-Wilson, W., Tyler, L. K., Waksler, R., and Older, L. 1994. Morphology and meaning in the English mental lexicon. *Psychological Review* 101:3–33.

Mattingly, I. G. 1987. Morphological structure and segmental awareness. *Cahiers de Psychologie Cognitive* 7:488–93.

Nielsen, I., and Petersen, D. K. 1992. *Diavok. Et materiale der afdækker eventuelle læse- og stavevanskelig-heder.* ('Diavok. A screening material of possible reading and spelling difficulties.' In Danish). Copenhagen: AOF.

Nielsen, J. C., Kreiner, S., Poulsen, A., and Søegaard, A. 1986. *Sætningslæseprøverne SL60 og SL40. SL-håndbog.* ('The sentence reading tests SL60 and SL40. SL-handbook'). Copenhagen: Dansk Psykologisk Forlag.

Nagy, W., and Anderson, R. C. 1984. How many words are there in printed school English? *Reading Research Quarterly* 19:304–330.

Raven, J. C. 1960. *Guide to the standard progressive matrices sets A, B, C, D, and E.* London: H. K. Lewis.

Rubin, H., Patterson, P. A., and Kantor, M. 1991. Morphological development and writing ability in children and adults. *Language, Speech, and Hearing Services in Schools* 22:228–35.

Seidenberg, M. S., and McClelland, J. L. 1989. A distributed, developmental model of word recognition and naming. *Psychological Review* 96:523–68.

Stolz, J. A., and Feldman, L. B. 1995. The role of orthographic and semantic transparency of the base morpheme in morphological processing. In L. B. Feldman (ed.), *Morphological Aspects of Language Processing.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Taft, M. 1981. Prefix stripping revisited. *Journal of Verbal Learning and Verbal Behavior* 20:289–97.

Taft, M. 1984. Evidence for an abstract lexical representation of word structure. *Memory and Cognition* 12:264–69.

Taft, M., and Forster, K. I. 1975. Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behavior* 14:638–47.

Tornéus, M. 1987. The importance of metaphonological and metamorphological abilities for different phases of reading development. Paper presented at The Third World Congress of Dyslexia. Crete.

White, T. G., Power, M. A., and White, S. 1989. Morphological analysis: Implications for teaching and understanding of vocabulary growth. *Reading Research Quarterly* 24:283–304.

Wysocki, K., and Jenkins, J. R. 1987. Deriving word meanings through morphological generalization. *Reading Research Quarterly* 22:66–81.

Zwitserlood, P. 1994. The role of semantic transparency in the processing and representation of Dutch compounds. *Language and Cognitive Processes* 9:341–68.