Do good and poor readers make use of morphemic structure in English word recognition?

LYNNE G. DUNCAN
ELAINE GRAY
PAULINE QUÉMART
SÉVERINE CASALIS

Abstract

The links between oral morphological awareness and the use of derivational morphology are examined in the English word recognition of 8-year-old good and poor readers. Morphological awareness was assessed by a sentence completion task. The role of morphological structure in lexical access was examined by manipulating the presence of embedded words and suffixes in items presented for lexical decision. Good readers were more accurate in the morphological awareness task but did not show facilitation for real derivations even though morpho-semantic information appeared to inform their lexical decisions. The poor readers, who were less accurate, displayed a strong lexicality effect in lexical decision and the presence of an embedded word led to facilitation for words and inhibition for pseudo-words. Overall, the results suggest that both good and poor readers of English are sensitive to the internal structure of written words, with the better readers showing most evidence of morphological analysis.

Introduction

Improvement in children's understanding of derivational morphology has been associated with vocabulary growth during oral language development (Anglin, 1993), leading to interest in the possibility that increasing morphological knowledge may also lead to improvements in lexical access during reading (see Sénéchal and Kearnan (2007) for a review). The present study of the English language is an attempt to draw links between awareness of derivational suffixes in their oral and written forms among participants who differ in reading level.

Journal of Portuguese Linguistics, 9-2 (2010)/10-1 (2011), 143-160 ISSN 1645-4537

Visual recognition of morphologically complex words

Adult readers

In the interactive-activation model developed by Taft (1994), suffixes are represented at the morphemic level, separately from the word level representations of the derivations in which they occur. Stems are also represented independently, but at the word level if they are free and at the morphemic level if they are bound. This decompositional perspective can be contrasted with the view that morphologically complex words are recognised through the convergence of codes representing phonological, orthographic and semantic information about those words (e.g. Seidenberg & Gonnerman, 2000; Gonnerman, Seidenberg & Andersen, 2007). Here morphemes are not stored separately from words; instead the morphological characteristics of a word are due to the weighted connections between orthography, phonology and semantics in the model. Further that during development the frequent occurrence of a suffix like "er" in real derivations like "baker" helps to strengthen the connections between orthography, phonology and semantics, whereas the occurrence of pseudo-derivations such as "corner" reinforces only the orthographic and phonological aspects of the spelling pattern.

Rastle, Davis and New (2004) used priming to examine the organisation of morphological information in the lexicon in an experiment which contrasted three different kinds of relationship between primes and targets: a) semantically transparent (e.g. cleaner → CLEAN); b) semantically opaque (e.g. corner → CORN); and c) orthographic form only (e.g. brothel → BROTH). With a short SOA, Rastle et al observed priming in both the semantically transparent and opaque conditions relative to the form condition. However, with a longer SOA only priming in the semantically transparent condition was significant. The authors interpreted these results as evidence of an early phase of purely structural decomposition driven by morpho- -orthographic analysis, followed by a later phase in which semantic processing takes place (see similar work in French by Longtin, Segui and Hallé (2003) and Meunier and Longtin (2007)).

This outcome is compatible with Schreuder and Baayen's (1995) account of lexical access for morphologically complex words which comprises two interactive routes: a direct access route based on the whole-word form and an indirect route based on component morphemes. Indirect route processing involves three procedures: (1) segmentation – items are divided into their component morphemes; (2) licensing – the combination of these morphemes is checked to establish that their integration is permissible; and (3) combination – the lexical representation of the whole-word is computed from the syntactic and semantic representations of its constituents. This route can also deal with novel and interpretable combinations of morphemes and accounts for findings that derived pseudo-words such as "quickify" can facilitate processing of their pseudo-root, "quick", whereas non-interpretable pseudo-words such as "sportation" do not facilitate processing of their pseudo-root "sport" (Meunier & Longtin, 2007).

What can be summarised from this research is that the evidence implies that word recognition involves the decomposition of words into morpheme--like units. Initially, morphological analysis appears to be closely related to orthographic pattern, but later, semantic information helps to distinguish whether the combination of these morpheme-like units constitutes a real derivation or not.

Young readers

Developmental research has focused largely on how children learn about the morphological structure of derivations in spoken language. Awareness of very frequent suffixes such as '–er' appears to develop relatively early in English, although the process of meta-morphological development appears to be quite a lengthy process which continues to develop well into adulthood (Derwing & Baker, 1979; Clark & Hecht, 1982; Carlisle & Nomanbhoy, 1993; Carlisle, 1995; Mahony, Singson & Mann, 2000; Singson, Mahony & Mann, 2000; Duncan, Casalis & Colé, 2009). This type of knowledge about derivational morphology is related to children's spoken vocabulary size, especially their ability to understand morphologically complex words (Anglin, 1993).

This developmental profile appears to be slower in pace than is the case in Romance languages like French, where morphological awareness is well--established by the early school years (Casalis & Louis-Alexandre, 2000; Colé, Royer, Leuwers & Casalis, 2004; Casalis & Colé, 2009). Cross--linguistic comparison appears to confirm the French advantage during the first three years of schooling and the explanation that has been provided for this is the greater prevalence of derivations in Romance languages compared to more Germanic languages like English where word formation via compounding is much more frequent (Clark, 1993; Duncan et al, 2009).

In 1995, Schreuder and Baayen discussed how representations might develop for the constituents of morphologically complex words, labelling this the "affix discovery procedure". They suggested that if a common sequence is consistently encountered in spoken language (for example, the '–er' suffix for describing an agent as in 'teacher'), then a concept node representing this idea will be created. Gradually, an access representation develops for this unit ('er'), and the nodes become linked to representations which incorporate semantic and syntactic information about the word. Taking this theory as their starting point, Carlisle & Fleming (2003) compared the morphological awareness of first and third graders and found that the younger children did not always pay attention to the semantic correspondence between similar sounding sequences. Third graders, on the other hand, were better able to define morphologically complex words and to use them in sentences, and this ability was related to reading comprehension in fifth grade.

Evidence generally suggests that children's morphological awareness is linked to reading progress. Knowledge about derivational morphology accounts for a significant and increasing amount of variance in reading comprehension between third and ninth grade (Leong, 1988; Carlisle, 2000; Singson et al, 2000; Carlisle & Fleming, 2003; Carlisle & Stone, 2005; Nagy, Berninger & Abbott, 2006; Siegel, 2008). It should be noted, however, that some of these latter studies assessed morphological awareness using tests with a written component that may overestimate the relation with reading. Mann and Singson (2003) were careful to control for this factor and demonstrated that oral morphological skills made an increasing contribution to decoding ability between Grades 3 and 6, even after controlling for phonological awareness and vocabulary. By third grade, there was also evidence of decomposition of morphologically complex words in the form of a base word frequency effect, and morphological awareness was a significant predictor of the reading of the derivations that contained low frequency bases.

Carlisle and Stone (2005) looked at whether children read words as sequences of graphemes or whether they showed sensitivity to morphemic structure. They found that Grade 2 and 3 children read words with real suffixes (e.g. hilly) faster and more accurately than words with pseudo--suffixes (e.g. silly), adding to the body of work suggesting that children do break down words into morphemes. However, the frequency of the smaller word in these items (i.e. hill vs. sill) was not matched between suffixed and pseudo-suffixed items which complicates Carlisle and Stone's conclusion that morphemic structure facilitates lexical access amongst developing readers.

In summary, English-speaking children appear to become increasingly efficient at interpreting the constituent morphemes within words but this is a gradual process of development and morphological awareness appears to become more closely associated with reading during the later phases of acquisition (Carlisle, 2000; Carlisle & Fleming, 2003; Mann & Singson, 2003; Roman, Kirby, Parrila, Wade-Woolley & Deacon, 2009). Of interest is the relationship between morphological development and reading exposure and whether in addition to the benefits of morphological knowledge for reading comprehension, the repeated encounters with morphemes in print also adds another component to the affix discovery procedure.

Poor readers

If morphological awareness is indeed related to reading progress, it might be expected that children with reading problems would exhibit poor morphological awareness and poor recognition of morphemes in reading. Nonetheless, research has produced conflicting evidence on this point.

Elbro and Arnbak (1996) observed the use of morphemes in reading by dyslexic children. In a single word reading task which compared words with a semantically opaque structure (e.g. window) with a mixture of derived and compound words with a morphologically transparent structure (e.g. sunburn), dyslexic readers benefited more from the transparent words than did younger controls who were matched to them on reading comprehension level. The dyslexics were significantly slower on the opaque words whose meaning was not obvious and thus, appeared to be relying on the transparent morphological structure to help with their reading. It was also found that within the dyslexic group (but not the normal reader group), a greater reliance on morphology was associated with better reading comprehension. The authors concluded that morphological information could be used by dyslexic readers in order to compensate for poor phonological skills. Nevertheless, they also found that the dyslexic children performed worse than the reading comprehension matched controls on several morphological awareness tasks including morpheme reversal (i.e. postman → manpost).

This latter finding was hard to explain and Elbro and Arnbak (1996) suggested that morphological and phonological awareness may have been confounded in these tasks. Other studies have reported that poor readers are impaired for chronological age in morphological awareness tasks (Siegel, 2008), especially when a phonological change was involved (e.g. "Five. This prize would be her ______?" (fifth)) (Shankweiler et al, 1995). However, other studies have found reading-age appropriate performance on morphological awareness tasks amongst children with dyslexia and that the extent of the disruption by phonological change conditions was consistent with reading age (Tsesmeli & Seymour, 2006). Reading-level performance was also observed in a study of French children with dyslexia by Casalis, Colé and Sopo (2004) for tasks involving judgements about the relationship between base and derived forms in meaningful contexts but performance was worse than reading level in morphological segmentation tasks which may have been related to their phonological impairment.

A recent study by Deacon, Parrila and Kirby (2006) examined whether morphology is used for lexical access by young adult dyslexics with age--appropriate reading comprehension. Comparison with a control group with matched comprehension skills but normal reading ability indicated that participants with dyslexia also had weak phonological processing skills. To assess visual word recognition, a lexical decision task was devised in which responses to stimuli containing a real base and suffix were contrasted with responses to pseudo-derivations in each of two conditions: 1) no orthographic change (e.g. "reader" derived from "read" versus "offer", a pseudo-derivation related to "off"); and 2) orthographic change ("ably" derived from "able" versus "gravy", a pseudo-derivation related to "grave"). The controls showed faster reaction times for derived than pseudo-derived words involving no orthographic change, indicating that morphological structure facilitated lexical access for these participants; when there was an orthographic change, control responses were slower to derived than to pseudo-derived items. In contrast, the dyslexic adults showed no difference between the conditions which implies that these poor readers were not as sensitive to the morphological complexity of the words as the control group.

Thus, the evidence is somewhat contradictory as to the role that morphemes play in lexical access amongst poor readers. Teenage dyslexics performed poorly relative to younger reading-age controls in a test of morphological awareness in the Elbro and Arnbak (1996) study but, surprisingly, made more use of morphological structure in reading, possibly as a compensatory strategy. One explanation may be that the participants with dyslexia benefited from Elbro and Arnbak's inclusion of items with a compound structure in the reading task. The presence of the smaller words or lexemes within these compound items (e.g. sunburn, lovebird) may have helped to make the reading task more tractable for the dyslexic readers. When morphological structure was marked by suffixes which are bound morphemes (e.g. reader, foggy), as is the case for the derivations used by Deacon et al (2006), adult dyslexics proved not to be as sensitive to this aspect of sub--lexical structure as their peers. However, this problem was restricted to the reaction time analysis as there were ceiling effects in the accuracy data. Furthermore, Deacon et al (2006) did not assess morphological awareness so it was not clear whether the participants with dyslexia had a general difficulty with derivational morphology or whether the problem was restricted to timed reading tasks.

The present study

The present study explores the relation between morphological awareness and the use of morphemes for lexical access. The objective is to investigate how sensitive 8-year-olds of differing reading abilities are to derivational suffixes in oral language (sentence completion) and written language (lexical decision) tasks. This age group were selected to avoid ceiling effects in reading and because it is known that morphological awareness in English is measurable and undergoing growth at this point (Derwing & Baker, 1979; Mahony et al, 2000).

Sentence completion is a test of morphological awareness in which the child is asked to complete a sentence with a derivation. The explicitness of knowledge about derivational morphology that is required will be manipulated by varying the lexicality of the stimuli (e.g. Someone who juggles is a…? (juggler) versus Someone who bafts is a…? (bafter), see Berko (1958)). In the lexical decision task, the composition of the stimuli will be varied according to presence or absence of a smaller word and a suffix in order to compare the processing of real derivations (e.g. farmer) with other words that contain an orthographic base (e.g. window), an orthographic suffix (e.g. murder) or neither (e.g. meadow).

It is expected that a link between morphological awareness and reading will be found in the control data and that morphemic structure will facilitate lexical access for the good readers. On the basis of Deacon et al's (2006) study, which is most similar in design to the present study, it is expected that poor readers will be less sensitive to morphological structure than their peers but it is possible that such an effect may be modified by individual differences in morphological awareness amongst the poor reader group.

Method

Participants

Twenty good readers in their third or fourth year of schooling were recruited from a Scottish Primary school with a middle-class catchment area. The children were seen individually for 10-15 minutes on four occasions between January and March. A small group of ten poor readers were identified by the experimenters via a standardised assessment of reading performance from Primary 3 and 4 classrooms in the same school, and from other local schools with similar catchment areas. School confirmation of poor reader status was also obtained.

The small size of the poor reader group made statistical comparison with the good readers problematic. Each group's performance will be presented side by side for the purpose of comparison and the group comparison will be presented for information only.

Materials and Procedure

Background Measures

(1) Raven's Coloured Progressive Matrices (Raven, 1962); (2) British Ability Scales (BAS) Word Reading Test (Elliot, Murray & Pearson, 1983); and (3) Wechsler Intelligence Scale for Children- Revised (WISC-R) Expressive Vocabulary Test (Wechsler, 1981).

Experimental tasks

(1) Morphological Awareness task – children supplied either a real or a made-up derivation to complete a sentence according to three conditions: (i) real derivations – the answer was a real derivation (e.g. A brave person behaves very…? (bravely)); (ii) real word "base"– the answer was a nonsense derivation with a real word "base" (e.g. A lost person behaves very…? (lostly)); and (iii) pseudo-word "base"– the answer was a nonsense derivation with a nonsense word "base" (e.g. A gress person behaves very…? (gressly)). Three examples of each of six suffixes (-ly, -y, -er, -ie, -tion,–ment) were used in each condition (18 trials per condition).

The real derivation condition was administered first and the order of the other two conditions containing "made-up" derivations was counterbalanced. Within each condition, order was randomised and each sentence frame was read aloud to the children for completion. There were two practice items and a similar sentence template was used in each condition. There was no significant difference between the Children's Printed Word Database (CPWD, Masterson, Dixon and Stuart, 2003) frequency of the word bases in the real derivation and the real word "base" conditions, F<1.

(2) Lexical Decision Task – The presence/absence of an embedded word and a suffix was manipulated to form four lexical conditions: (i) W+S+ (embedded word (base) and suffix, e.g. farmer); (ii) W+S- (embedded word but no suffix, e.g. window); (iii) W-S+ (no embedded word but an (orthographic) suffix, e.g. murder); and (iv) W-S- (no embedded word and no suffix, e.g. narrow). The items in condition (i) were the only real derivations. Analogous conditions were formed for the non-lexical items: (i) W+S+ (e.g. gifter); (ii) W+S- (e.g. puffow); (iii) W-S+ (e.g. gopter); and (iv) W-S- (e.g. ferbow).

There were 29 items per condition (232 items in total). Word conditions were matched on whole word frequency using CPWD, F<1. Embedded word frequency was matched in the W+S+ and W+S- conditions for real words, $t(56) = 1.45$, $p > .05$, and for pseudo-words, $t(56) = .56$, $p > .05$. All four conditions were matched on number of letters for words, $F(3, 112) = 2.08$, $p > .05$, and for pseudo-words, $F(3, 112) = 1.59$, $p > .05$).

The lexical decision task was administered using Cognitive Workshop software (Seymour, 1994-1999). Items were presented centrally in lower case Courier New font, size 42. A fixation cross was shown 1500 milliseconds after the previous item and remained on screen for 1000 milliseconds. After a 1000 millisecond interval, the target was presented and remained on screen for 5000 milliseconds if no response was given. Reaction times were recorded via the keyboard. There were two (counterbalanced) sessions containing 6 practice items with feedback, followed by 116 experimental items in a random order with 4 rest periods.

Results

Background Measures

The mean chronological age of the good readers was 8 years 2 months (range: 7 years 4 months to 8 years 10 months). These children acted as a chronological-age match (F<1) for the poor readers whose average age was 8 years 0 months (range: 7 years 7 months to 8 years 9 months).

Table I contains the participants' mean performance on the background measures: BAS Word Reading, Raven's Coloured Progressive Matrices and WISC-R Vocabulary. The Reading age of the good readers was more than one year above their mean chronological age which was consistent with their excellent mean performance in the Ravens Coloured Progressive Matrices task (80^{th} percentile). The poor readers showed a discrepancy between their reading and their mean performance on the Ravens Matrices (70^{th} percentile). Average reading age was at least 11 months behind their chronological age, significantly worse than the good readers: $F(1, 28) = 46.40$, $p < .001$, and all of the poor readers performed below the 40th centile on the BAS Word Reading test

Table I: Mean chronological age (CA), mean BAS Reading Age (RA) and mean performance on Raven's Coloured Progressive Matrices and WISC-R Vocabulary tests for each reading group (standard deviations in parentheses)

	CA (years)	RA (years)	Ravens (percentile)	WISC Vocabulary (standard score)
Good Readers	8.13	9.93	81	11.00
	(0.50)	(1.54)	(23)	(2.64)
Poor Readers	8.00	6.55	70	8.30
	(0.33)	(0.33)	(27)	(1.89)

The groups did not differ in Raven's percentile scores, $F(1, 28) = 1.34$, $p > .05$ and both groups obtained mean standardised scores within the average range on the WISC-R expressive vocabulary test, although these scores were significantly lower in the poor reader group, $F(1, 28) = 8.29$, $p < .01$.

Sentence Completion task

Good Readers

Mean percentage accuracy was 84.11% (SD = 10.89%) for real derivations, 66.11% (SD = 17.28%) for the real word "base" condition and 58.06% (SD = 18.00%) for the pseudo-word "base" condition. A one-way within-participants ANOVA found a significant effect of condition, $F(2, 38) = 31.36$, $p < .001$, $\eta_p^2 = .62$. A Tukey test ($\alpha = 0.05$, here and throughout) showed that accuracy was significantly higher for real derivations than for made-up derivations (real derivations > real word "base" and real derivations > pseudo-word "base"). There was a marginal advantage for made-up derivations with a real word "base" over those with a pseudo-word "base" ($p = .06$).

For the real derivations condition, the only Pearson correlation to approach significance was with chronological age ($r^{\text{real derivations}}(18) = .44$, $p = .05$). However, significant correlations were observed between the production of made-up derivations and Reading Age ($r^{\text{word base}}(18) = .50$, $p < .05$; $r^{\text{pseudo-word base}}(18) = .49$, $p < .05$), and the standard score for WISC Vocabulary ($r^{\text{word base}}(18) = .47$, $p < .05$; $r^{\text{pseudo-word base}}(18) = .51$, $p < .05$). Partial correlations showed that the relation with reading survived partialling out vocabulary in each case ($r^{\text{word base}}(17) = .48$, $p < .05$; $r^{\text{pseudo-word base}}(17) = .47$, $p < .05$). The real word base condition also correlated with the percentile score for the Ravens Matrices, $r^{\text{word base}}(18) = .55$, $p < .05$, and when this score was partialled out the relation between the real word base condition and Reading Age was marginally non-significant, $r^{\text{word base}}(17) = .45$, $p = .06$.

Poor Readers

Mean percentage accuracy was 53.89% (SD = 17.96%) for the real derivations, 29.44% (SD = 12.84%) for the real word "base" condition and 20.56% (SD = 11.43%) for the pseudo-word "base" condition. This was a lower level of performance than the good readers, $F(1, 28) = 50.13$, $p < .001$. A one-way within-participants ANOVA for the poor reader data revealed that the effect of condition was significant, $F(2, 18) = 33.67$, $p < .001$, $\eta_p^2 = .79$, and a Tukey HSD test confirmed that accuracy for real derivations was significantly higher than for made-up derivations.

There were no significant correlations between Sentence Completion performance and the background measures for the poor readers.

Lexical Decision Task

The mean percentage accuracy and mean reaction times (in milliseconds) for the lexical decision task are shown below in Table II.

Good Readers

Accuracy

Words. A two-way ANOVA was carried out on the accuracy data by participants (F1) and by items (F2) with factors, embedded word (present, absent), and suffix (present, absent). The ANOVA showed that the main effect of embedded word was non-significant ($F1(1, 19) = 2.96$, $p > .05$, $F2<1$), however, the main effect of suffix was significant by participants, $F1(1, 19) = 7.92$, $p < .05$, $\eta_p^2 = .29$, $F2 <1$. The interaction embedded word by suffix was also significant by participants, $F1(1, 19) = 29.60$, $p < .001$, $\eta_p^2 = .61$; $F2(1, 112) = 2.99$, $p = .09$. A post-hoc Tukey HSD test showed no advantage for derived words like "farmer" over other words which also contained an embedded word but no suffix, like "window", and if anything there was a slight tendency for accuracy to be lower in response to the derivations. In the absence of a real embedded word, accuracy was higher when words contained an orthographic suffix ("murder" versus "narrow").

Pseudo-words. A two-way ANOVA was carried out with factors, embedded word (present, absent), and suffix (present, absent). The main effect of embedded word was significant by participants and marginal by items ($F1(1, 19) = 9.88$, $p < .01$, $\eta_p^2 = .34$, $F2(1, 112) = 3.32$, $p = .07$), and the effect of suffix was significant in both analyses, $F1(1, 19) = 35.61$, $p < .001$, $\eta_p^2 = .65$, $F2(1, 112) = 11.32$, $p < .01$, $\eta_p^2 = .09$. The interaction embedded word by suffix was also significant, $F1(1, 19) = 12.89$, $p < .01$, $\eta_p^2 = .40$; $F2(1, 112) = 9.95$, $p < .01$, $\eta_p^2 = .08$). A Tukey HSD test revealed that pseudo--words which contained an embedded word were responded to less accurately when they also contained an orthographic suffix (e.g. gifter) than when they did not (e.g. puffow). When there was no embedded word there was no effect of the presence of an orthographic suffix (e.g. gopter versus ferbow).

Table II: Mean percentage accuracy and mean reaction time for each reading group in each condition of the lexical decision task (standard deviations in parentheses)

		Good Readers		Poor Readers	
		% Acc.	RT (ms)	% Acc.	RT (ms)
Words	W+S+ (e.g. farmer)	75.12 (10.06)	1487.32 (336.74)	56.21 (13.21)	1298.85 (452.11)
	W+S- (e.g. window)	79.37 (9.34)	1453.34 (354.59)	62.07 (11.82)	1385.44 (547.83)
	W-S+ (e.g. murder)	79.38 (15.57)	1414.66 (345.32)	53.78 (11.87)	1312.98 (501.75)
	W-S- (e.g. narrow)	69.44 (15.19)	1477.02 (400.80)	51.02 (16.50)	1287.16 (679.07)
Pseudo-words	W+S+ (e.g. gifter)	66.77 (12.52)	1833.71 (419.59)	34.47 (15.36)	1455.02 (597.35)
	W+S- (e.g. puffow)	83.09 (14.23)	1705.69 (370.92)	31.72 (13.29)	1407.83 (545.44)
	W-S+ (e.g. gopter)	80.18 (17.75)	1753.92 (401.12)	33.80 (15.17)	1239.87 (524.93)
	W-S- (e.g. ferbow)	80.72 (15.66)	1714.14 (455.35)	30.33 (13.99)	1153.59 (449.00)

Finally, note that the least accurate word condition was where there was least semantic support (no embedded word and no suffix, e.g. narrow) and the least accurate pseudo-word condition was where there was most semantic support (an embedded word and an orthographic suffix, e.g. gifter).

Reaction Times

Words. A two-way ANOVA was carried out on reaction times by participants (F1) and by items (F2) with factors, embedded word (present, absent), and suffix (present, absent). There were no significant effects (embedded word: F1<1, $F2(1, 112) = 1.97$, $p > .05$; suffix: F1<1, F2<1; embedded word by suffix: $F1(1, 19) = 2.36$, $p > .05$, F2<1).

Pseudo-words. A two-way ANOVA with factors, embedded word (present, absent), and suffix (present, absent) revealed a significant effect of suffix by participants, reflecting the slower reaction times that occurred when an orthographic suffix was present in the stimulus ($F1(1, 19) = 7.55$, $p < .05$, $\eta_p^2 = .28$, $F2(1, 112) = 2.56$, $p >.05$). No other effects achieved significance (embedded word: $F1(1, 19) = 1.74$, $p > .05$, $F2<1$; embedded word by suffix: $F1(1, 19) = 1.44$, $p > .05$, $F2<1$).

Poor readers

Accuracy

Words. A two-way ANOVA was carried out on the accuracy data by participants (F1) and by items (F2) with factors, embedded word (present, absent), and suffix (present, absent). The main effect of embedded word was significant by participants and marginal by items, $F1(1, 9) = 12.10$, $p < .01$, $\eta_p^2 = .57$, $F2(1, 112) = 3.43$, $p = .07$, $\eta_p^2 = .03$, with higher accuracy in the presence of an embedded word. There was no effect of suffix, $F1<1$, $F2<1$, and the interaction between embedded word and suffix was marginal by participants but non-significant by items, $F1(1, 9) = 4.19$, $p = .07$, $\eta_p^2 = .32$, $F2(1, 112) = 1.14$, $p > .05$.

Pseudo-words. There were no significant effects in a two-way ANOVA (embedded word: $F1<1$, $F2<1$; suffix: $F1(1, 9) = 1.58$, $p > .05$, $F2<1$, F2; embedded word by suffix: $F1<1$, $F2<1$).

Reaction Times

Words. A two-way ANOVA on reaction times by participants (F1) and by items (F2) with factors, embedded word (present, absent), and suffix (present, absent) found no significant effects (all $Fs<1$)

Pseudo-words. A two-way ANOVA indicated that the main effect of embedded word was significant by participants such that responses were slower when an embedded word was present, $F1(1, 9) = 7.55$, $p < .05$, $\eta_p^2 = .46$, $F2<1$. The interaction embedded word by suffix was significant by items, $F1<1$, $F2(1, 112) = 5.53$, $p < .05$, $\eta_p^2 = .05$, but a Tukey HSD test failed to resolve the interaction. The effect of suffix was not significant, $F1<1$, $F2<1$.

Poor Readers showed a lexicality effect for lexical decision accuracy in favour of words, $F1(1, 9) = 9.05$, $p < .05$, $\eta_p^2 = .50$, $F2(1, 230) = 120.48$, $p < .001$, $\eta_p^2 = .34$, but no lexicality effect for reaction time, $F1<1$, $F2<1$. Good Readers showed the opposite pattern, an overall lexicality effect for reaction time in favour of words, $F1(1, 19) = 45.59$, $p < .001$, $\eta_p^2 = .71$, $F2(1, 230) = 104.54$, $p < .001$, $\eta_p^2 = .31$, but no effect for accuracy, $F1<1$, $F2<1$.

The reading groups differed significantly in their discrimination in the lexical decision task, $F(1, 28) = 10.64$, $p < .01$. While the good readers scored above chance in every condition (all $ps < .001$), the poor readers only scored above chance when responding to the W+S- words (see Figure 1).

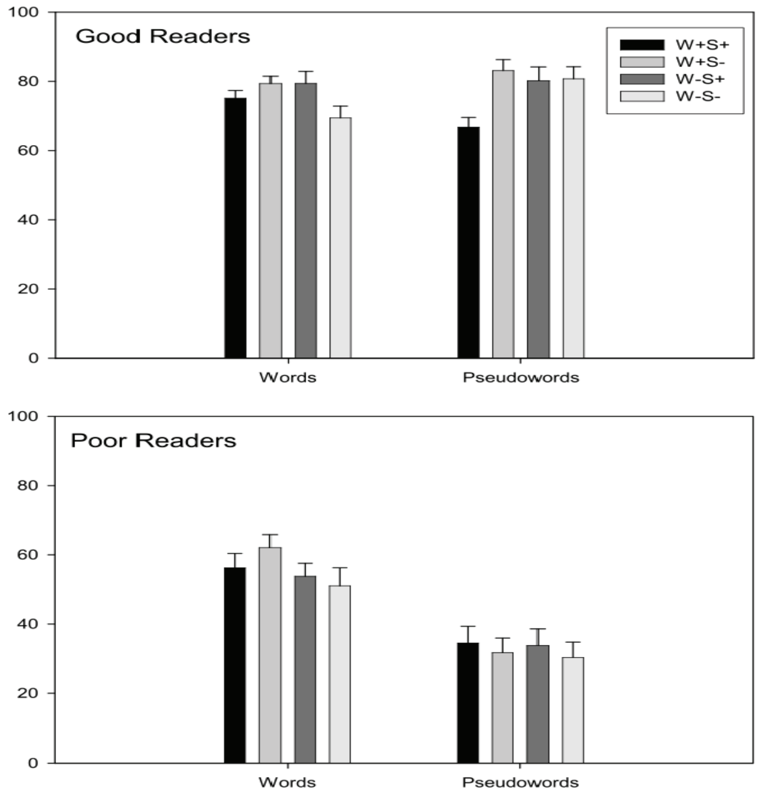

Figure 1: Percentage accuracy for the good and poor readers in each condition of the lexical decision task (error bars represent +1 SEM)

Discussion

This study aimed to examine the link between morphological awareness and the use of morphemic structure in reading complex words. A positive association was expected between awareness of derivational morphology and sensitivity to morphemic structure in lexical decision. Further poor readers who possess a good oral awareness of morphology may be able to capitalise on the presence of morphemes in reading complex words.

Good reader performance in the sentence completion task indicated that the ability to manipulate real derivations was high (80%) in the third and fourth years of schooling. These children also demonstrated that they possessed considerable meta-linguistic knowledge about derivational morphology as they could produce made-up derivations, marginally better when they had the semantic support of a real word "base" (66%) compared to a pseudo-word "base" (58%). These findings compare favourably with previous research with younger participants (Derwing & Baker, 1979; Carlisle, 1995; Duncan et al, 2009). There was also support for a link between morphological awareness and reading as performance in the more explicit (non-lexical) conditions of the sentence completion task correlated with Reading Age even after partialling out vocabulary knowledge. Amongst the poor readers, performance was significantly worse which is consistent with their lower level of vocabulary skill in spite of being matched to the good readers on Raven Matrices performance. Sentence completion performance did not correlate with either Reading Age or WISC vocabulary amongst the poor readers. Nevertheless, the poor readers did show a similar pattern of performance as the good readers in the sentence completion task but at a lower level of accuracy.

Examination of lexical decision accuracy indicated that the good readers appeared sensitive to the presence of both embedded words and suffixes in the lexical and non-lexical stimuli. In response to words, when items contained an embedded word there was no advantage for the W+S+ items which were derivations (e.g. farmer) over the W+S- items (e.g. window), but when items did not contain an embedded word, responses were more accurate to words that contained an orthographic suffix (e.g. murder) than to those that did not (e.g. narrow). With pseudo-words, the converse pattern was observed: there was no effect of suffix for non-lexical items that did not contain an embedded word (W--S+, W-S-), but when an embedded word was present, accuracy was lower in rejecting those W+S+ items that also contained an orthographic suffix (e.g. gifter) than those that did not (W+S-, e.g. puffow). Furthermore, reaction times to reject pseudo-words were slower when an orthographic suffix was present.

The poor readers, on the other hand, showed far less interaction between the two variables and the strongest effects related to the presence of an embedded word, which was associated with increased accuracy in accepting words and slower reaction times in rejecting pseudo-words.

In spite of the evidence of emerging and explicit morphological knowledge in the sentence completion task, neither group showed evidence of a relationship between performance in this task and the processing of real derivations (W+S+) or any of the other lexical decision word types. However, in previous work by Mann & Singson (2003), correlations with morphological awareness were only observed for the reading of derivations with low frequency bases and the W+S+ derivations in the present study contained bases which would be considered high frequency.

Surprisingly, there was little evidence of a facilitation effect for recognition of the W+S+ words, which according to several models ought to be advantaged by having both whole-word and morphemic-level representation (Taft, 1994; Schreuder & Baayen, 1995). Nevertheless, the results do not fit with theories which propose that only whole-word representations are stored in the mental lexicon because the interactions in the accuracy data give some support to the idea that good readers are breaking the items down according to the presence of embedded words and suffixes. The combination of a real base and a real suffix in the derived (W+S+) words did not appear to facilitate lexical access any more than the presence of either an embedded word or a suffix, but the absence of sublexical morphemic information in W-S- words did seem to be detrimental to the processing of these items.

Although "segmentation" of words appeared to be occurring amongst the good readers, there was not good evidence that the processes of "licensing" or "combination" were taking place. When a whole-word representation did not exist, as in the case of pseudo-words, performance was more consistent with these checks being applied as good readers were poor at rejecting W+S+ pseudo-words like "gifter" that could be licensed and also have some semantic interpretability. These effects may reflect the emergent status of morphemic representations in the children's developing lexical system. After all, it is around the age of 8 years that there is known to be a sharp rise in the number of derivations in English-speaking children's vocabulary (Anglin, 1993) and the sentence completion task indicates that oral knowledge about derivational morphology is still undergoing consolidation even amongst our good readers.

In contrast, the poor readers in our study did not show the same sensitivity to morphological composition in keeping with their lower level of morphological awareness. Although matched with the good readers in terms of Raven's matrices performance, the poor readers were disadvantaged in terms of their reading experience and oral vocabulary, both of which are factors that are associated with increases in morphological processing skill (Anglin, 1993; Carlisle, 2000; Mann & Singson, 2003; Roman et al, 2009). Thus, the results do not seem to lend support to Elbro and Arnbak's (1996) claim that dyslexic children compensate for poor decoding skills by using a morphemic strategy, and instead, are more similar to the findings of Deacon et al. (2006), who failed to find evidence that poor readers were more sensitive to the morphological structure contained in real derivations (e.g. reader) in comparison with pseudo-derivations (e.g. offer).

Unfortunately, the small number of poor readers in our study is an important limitation that must be borne in mind in comparing the results from the two reader groups. What did emerge from the poor reader data, however, was the importance of embedded words in shaping responses in the lexical decision task. The presence of an embedded word was associated with increased accuracy in processing words and slower reaction times in rejecting pseudo-words. This may relate to Elbro & Arnbak's (1996) findings as it suggests that the presence of small lexemes within the compound and derived forms was detected by the dyslexic children and somehow used to ease the reading process. In this respect, the poor readers' may be similar to younger children with an equivalent level of reading exposure and experience. Nation and Cocksey (2009) have recently demonstrated that 7-year-old good readers are responsive to the semantics of such embedded words and activate this information during lexical access. The authors speculated that the use of such print-meaning associations may be a precursor to the use of morphological structure in reading. This would be consistent with observations that base words within derivations become salient for good readers by the age of 8 years resulting in base frequency effects in reading (Mann & Singson, 2003).

Therefore, the detection of embedded words may be an important part of reading development which contributes to the representation in memory of links between orthographic, phonological, and semantic information which ultimately allows aspects of language such as derivational morphology to inform lexical access (Reichle & Perfetti, 2003; Gonnerman et al, 2007).

Acknowledgements

We would like to express our gratitude to Fife Council and to the staff and pupils of Canongate Primary School in St. Andrews, Scotland, for their participation in this study. This research was supported by a grant from the Agence Nationale de la Recherche (A.N.R.) for a project entitled "Les traitements morphologiques dans l'apprentissage de la lecture et ses troubles" (ANR-06-APPR-006).

References

Anglin, J. M. (1993). Vocabulary development: A morphological analysis. *Monographs of the Society of Research in Child Development*, 58 (Serial No. 238, No. 10), 1–166.

Berko, J. (1958). The child's learning of English morphology. *Word*, 14, 150–177.

Carlisle, J. F. (1995). Morphological awareness and early reading achievement. In *Morphological aspects of language processing* (L. B. Feldman, editor), pp. 189–209. Hillsdale, NJ: Erlbaum.

Carlisle, J. F. (2000). Awareness of the structure and meaning of morphologically complex words: Impact on reading. *Reading and Writing*, 12, 169-190.

Carlisle, J.F. & Fleming, J. (2003). Lexical processing of morphologically complex words in the elementary years. *Scientific Studies of Reading*, 7, 239-253.

Carlisle, J. F. & Nomanbhoy, D. M. (1993). Phonological and morphological awareness in 1st-graders. *Applied Psycholinguistics*, 14, 177–195.

Carlisle, J.F. & Stone, C.A. (2005). Exploring the role of morphemes in word reading. *Reading Research Quarterly*, 40, 428-449.

Casalis, S. & Colé, P. (2009). On the relationship between morphological and phonological awareness: Effects of training in kindergarten and in first grade reading. *First Language*, 29, 113–142.

Casalis, S., Colé, P. & Sopo, D. (2004). Morphological awareness in developmental dyslexia. *Annals of Dyslexia*, 54, 114–138.

Casalis, S. & Louis-Alexandre, M.-F. (2000). Morphological analysis, phonological analysis and learning to read French: A longitudinal study. *Reading and Writing*, 12, 303-335.

Clark, E. V. (1993). *The lexicon in acquisition*. Cambridge: Cambridge University Press.

Clark, E. V. & Hecht, B. F. (1982). Learning to coin agent and instrument nouns. *Cognition*, 12, 1–24.

Colé, P., Royer, C., Leuwers, C. & Casalis, S. (2004). Derivational knowledge and reading acquisition for French beginning-readers from Grade 1 to Grade 3. *Année Psychologique*, 104, 701–750.

Deacon, S.H., Parilla, R. & Kirby, J.R. (2006). Processing of derived forms in high--functioning dyslexics. *Annals of Dyslexia*, 56, 103-130.

Derwing, B. L. & Baker, W. J. (1979). Recent research on the acquisition of English morphology. In *Language acquisition* (P. Fletcher & M. Garman, editors), pp. 209–223. Cambridge: Cambridge University Press.

Duncan, L. G., Casalis, S. & Colé, P. (2009). Early metalinguistic awareness of derivational morphology: Observations from a comparison of English and French. *Applied Psycholinguistics*, 30, 405-440.

Elbro, C. & Arnbak, E. (1996). The role of morpheme recognition and morphological awareness in dyslexia. *Annals of Dyslexia*, 46, 209-240.

Elliot, C., Murray, D. & Pearson, L. (1983). *British Abilities Scales*, Manual 4. Windsor: NFER-Nelson Publishing.

Gonnerman, L.M., Seidenberg, M.S. & Andersen, E.S. (2007). Graded semantic and phonological similarity effects in priming: evidence for a distributed connectionist approach to morphology. *Journal of Experimental Psychology: General*, 136, 323--345.

Leong, C. K. (1988). A Componential Approach to Understanding Reading and Its Difficulties in Preadolescent Readers. *Annals of Dyslexia*, 38, 95-119.

Longtin, C. M., Segui, J. & Hallé, P. A. (2003). Morphological priming without morphological relationship. *Language and Cognitive Processes*, 18, 313–334.

Mahony, D., Singson, M. & Mann, V. (2000). Reading ability and sensitivity to morphological relations. *Reading and Writing*, 12, 191–218.

Mann, V. & Singson, M. (2003). Linking morphological knowledge to English decoding ability: Large effects of little suffixes. In Re*ading complex words: Cross--language studies* (E. M. H. Assink & D. Sandra, editors), pp. 1–25. New York: Kluwer Academic/Plenum Press.

Meunier, F. & Longtin, C. (2007). Morphological decomposition and semantic integration in word processing. *Journal of Memory and Language*, 56, 457-471.

Nagy, W., Berninger, V.W. & Abbott, R. D. (2006). Contributions of morphology beyond phonology to literacy outcomes of upper elementary and middle-school students. *Journal of Educational Psychology*, 98, 134–147.

Nation, K. & Cocksey, J. (2009). The relationship between knowing a word and reading it aloud in children's word reading development. *Journal of Experimental Child Psychology*, 103, 296-308.

Rastle, K., Davis, M.H. & New, B. (2004). The broth in my brother's brothel: Morpho--orthographic segmentation in visual word recognition. *Psychonomic Bulletin and Review*, 11, 1090-1098.

Raven, J.C. (1962). *Coloured progressive matrices*. London: H.K. Lewis & Co. Ltd.

Reichle, E. D. & Perfetti, C. A. (2003). Morphology in word identification: A word--experience model that accounts for morpheme frequency effects. *Scientific Studies of Reading*, 7, 219-237.

Roman, A. A., Kirby, J. R., Parrila, R. K., Wade-Woolley, L. & Deacon, S. H. (2009). Toward a comprehensive view of the skills involved in word reading in Grades 4, 6, and 8. *Journal of Experimental Child Psychology*, 102, 96-113.

Schreuder, R. & Baayen, R.H. (1995). Modelling morphological processing. In *Morphological Aspects of Language Processing* (L.B. Feldman, editor), pp. 131--154. Hillsdale, NJ: LEA.

Seidenberg, M. S. & Gonnerman, L. M. (2000). Explaining derivational morphology as the convergence of codes. *Trends in Cognitive Sciences*, 4, 353–361.

Sénéchal, M. & Kearnan, K. (2007). The role of morphology in reading and spelling. *Advances in Child Development and Behavior*, 35, 297-325.

Seymour, P.H.K. (1994-1999). *Cognitive Workshop Software*. Developed at the School of Psychology, University of Dundee by Software Interventions Ltd. in cooperation with The Child Research Centre at the University of Jyväskylä, Finland.

Shankweiler, D., Crain, S., Katz, L., Fowler, A. E., Liberman, A. M., Brady, S. A. et al. (1995). Cognitive Profiles of Reading-Disabled Children: Comparison of Language Skills in Phonology, Morphology, and Syntax. *Psychological Science*, 6, 149-156.

Siegel, L. S. (2008). Morphological awareness skills of English language learners and children with dyslexia. *Topics in Language Disorders*, 28, 15-27.

Singson, M., Mahony, D. & Mann, V. (2000). The relation between reading ability and morphological skills: Evidence from derivational suffixes. *Reading and Writing*, 12, 219–252.

Stuart, M., Dixon, M., Masterson, J. & Gray, B. (2003). Children's early reading vocabulary: Description and word frequency lists. Br*itish Journal of Educational Psychology*, 73, 585-598.

Taft, M. (1994). Interactive-activation as a framework for understanding morphological processing. *Language and Cognitive Processes*, 9, 271-294.

Tsesmeli, S. N. & Seymour, P. H. K. (2006). Derivational morphology and spelling in dyslexia. *Reading and Writing*, 19, 587-625.

Wechsler, D. (1981). *The Wechsler intelligence scale for children- Revised*. Berks: The NFER-Nelson Publishing Company.

Lynne G. Duncan
School of Psychology
University of Dundee
Dundee DD1 4HN
United Kingdom
l.g.duncan@dundee.ac.uk

Elaine Gray
School of Psychology
University of Dundee
Dundee DD1 4HN
United Kingdom
e.z.gray@dundee.ac.uk

Pauline Quémart
Laboratoire URECA
Université Charles-de-Gaulle Lille III
Domaine universitaire du Pont de Bois
BP 60149
59653 Villeneuve d'Ascq Cedex
France
pauline.quemart@univ-lille3.fr

Séverine Casalis
Laboratoire URECA
Université Charles-de-Gaulle Lille III
Domaine universitaire du Pont de Bois
BP 60149
59653 Villeneuve d'Ascq Cedex
France
severine.casalis@univ-lille3.fr