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Unexpected poor comprehenders: An investigation of multiple aspects of morphological awareness

Elizabeth Jean MacKay, Kyle Levesque and S. Hélène Deacon

Department of Psychology and Neuroscience, Dalhousie University

Poor comprehenders have age-appropriate word reading skills but struggle with understanding what they read. The purpose of this study was to investigate how poor comprehenders perform on multiple aspects of morphological awareness, a skill implicated in reading comprehension. In keeping with current research and theory, we look at three aspects of morphological awareness: morphological structure awareness, morphological analysis and morphological decoding. Using a regression-based approach, we identified 64 poor and average comprehenders out of a large sample of children in grade 3. Our results show that poor comprehenders and average comprehenders performed remarkably similar on morphological structure awareness, analysis, and decoding. Poor comprehenders performed more poorly than average comprehenders only on word analogy, a specific measure of morphological awareness. These results identify an area with which poor comprehenders are likely to struggle, while simultaneously providing evidence for areas of relative strength within this population.

Highlights

What is already known about this topic

- Poor comprehenders are individuals who have age-appropriate word reading and phonological processing skills, but have specific impairments in understanding text
- Poor comprehenders seem to have impairments in certain aspects of morphological awareness

What this paper adds

- Here, we investigated the one aspect of morphological awareness studied in past research, but with a larger sample size. This allowed us to clarify mixed results of past research
- We also investigated two other aspects of morphological awareness, morphological analysis and morphological decoding, that have not yet been studied in poor comprehenders

- We provide a complete description of the regression method used to select poor comprehenders

Implications for theory, policy or practice

- This study suggests a re-envisioning of Perfetti, Landi, & Oakhill's (2005) model of reading comprehension when applied to poor comprehenders
- This study also informs practice by pointing to areas of relative weakness in poor comprehenders that could be used for effective intervention

Reading comprehension, or the understanding of written text, is an imperative skill for success in both school and society (e.g., Kamil, 2003). Poor comprehenders have difficulties comprehending text despite average word reading and phonological processing abilities (e.g., Nation & Angell, 2006). Approximately 10% of school-aged children can be classified as poor comprehenders, making this impairment as common as dyslexia (e.g., Nation, Snowling, & Clarke, 2005) and yet with surprisingly little associated empirical knowledge (Snow, 2002). The goal of the current study is to provide a comprehensive examination of poor comprehenders' morphological awareness, or the awareness of and ability to manipulate morphemes (Carlisle, 1988). We focus on morphological awareness because of increasing evidence of its role in reading comprehension (e.g., Carlisle, 2003).

According to Perfetti, Landi, and Oakhill's (2005) model, morphology is represented as having two roles in reading comprehension. As part of the linguistic system, morphology contributes directly to reading comprehension. This direct contribution likely reflects the role of morphology in language comprehension more generally, the latter of which is crucial for reading comprehension (Gough & Tunmer, 1986). As part of the lexical organisation, morphology impacts word reading, which in turn affects reading comprehension. This model suggests direct and indirect effects of morphology on reading comprehension.

The predictions of Perfetti et al. (2005) fit well with recent distinctions made within the construct of morphological awareness (Carlisle, 2000), specifically between morphological structure awareness, morphological analysis, and morphological decoding (e.g., Deacon, Tong, & Francis, 2015). Morphological structure awareness is the awareness of the morphological structure of a word (Carlisle, 2000), effectively reflecting morphological awareness more traditionally. Tasks evaluating morphological structure awareness typically assess the manipulation of morphemes in the oral domain. Adding the suffix *able* to the base word *reason* to fit the sentence *her idea was quite reasonable* is an application of morphological structure awareness. In contrast, morphological analysis is the ability to use the morphological structure of a complex word to infer its meaning (Anglin, 1993). For example, one could use morphological analysis to determine the meaning of *forgetful* based on the meaning of the base word (*forget*) and suffix (*ful*). Both of these constructs could be conceptualised as part of the linguistic system, or the direct pathway in the model of Perfetti et al. (2005). Finally, morphological decoding is the use of morphemic structure to produce the correct pronunciation of a word (e.g., the *re* in *react* vs *reading*; Kuo & Anderson, 2006). This skill could be considered part of the indirect pathway in the model of Perfetti et al.. According to said model, difficulties in any one of these areas could have downstream effects on reading comprehension. As such, we evaluate poor comprehenders' skills in each of these domains.

To date, studies with poor comprehenders have examined specifically morphological structure awareness, revealing a complex picture. Tong and colleagues demonstrated that third and fifth grade poor comprehenders had difficulties with the derived (e.g., *questionable*), but not inflected, items in word analogy tasks as compared with average comprehenders. No differences emerged on derived items in a sentence completion task (Tong, Deacon, & Cain, 2014; Tong, Deacon, Kirby, Cain, & Parrila, 2011). In contrast, Nation et al. (2005) found that third grade poor comprehenders performed more poorly than average comprehenders on inflexions of high and low frequency irregular verbs, but not regular or novel verbs. Thus, to date, poor comprehenders sometimes perform worse than average comprehenders on morphological structure awareness, but the tasks on which they perform worse are not consistent.

To our knowledge, there are no studies of morphological analysis in poor comprehenders; as such, we turn to relevant studies of typical readers (e.g., McCutchen & Logan, 2011). Deacon et al. (2015) showed that morphological analysis uniquely predicted reading comprehension in third and fifth graders beyond word reading and morphological structure awareness. Similar results emerged in a study of fifth grade readers (McCutchen & Logan, 2011). Based on this relation to reading comprehension, we suspect weaker morphological analysis skill for poor than average comprehenders.

Similarly, to our knowledge, there are no available studies of morphological decoding, and so we turn to studies of typical readers. Nunes, Bryant, & Barros (2012) showed that morphological decoding at 8 years contributed uniquely to reading comprehension at 12 years beyond age and nonverbal IQ. Similarly, Deacon et al. (2015) found that, for third and fifth graders, morphological decoding contributed to reading comprehension beyond word reading and morphological analysis. Morphological decoding could help the child to accurately recognise morphemes in complex words, which could offer key relevant information towards text comprehension. These studies allude to the possibility that poor comprehenders might have impaired morphological decoding. This possibility further fits with evidence that poor comprehenders have difficulties reading irregular and exception words (Nation & Snowling, 1998). It also fits with predictions from Perfetti et al.'s model (2005) that morphology has an indirect effect on reading comprehension through word reading. Despite the need to test these possibilities, poor comprehenders' morphological decoding might be intact, like their general word reading skills. And yet word reading models, such as Ehri's (2005), encourage us to consider separable word reading skills. In the final phase of Ehri's theory, children should be able to 'chunk' individual grapheme-phoneme correspondences into letter-patterns, which include morphemes as well as orthographic units. Based on these two predicted skills, we evaluate both morphological and orthographic decoding skills in poor comprehenders.

To determine poor comprehenders' skills in three aspects of morphological awareness, we identified poor and average comprehenders from a larger study of reading development. Poor and average comprehenders were matched on chronological age, phonological awareness, nonverbal reasoning, vocabulary, and word reading (e.g., White & Kirby, 2008; see also Tong et al., 2014). We matched on word reading skills to account for the conceptual overlap between word reading and morphological decoding. We matched for vocabulary given evidence that poor comprehenders have vocabulary deficits (Nation & Snowling, 1998), allowing us more confidence in results should we identify deficits in morphological analysis.

We measured morphological structure awareness with both sentence completion and word analogy tasks (e.g., Tong et al., 2014). Our larger sample allows us to investigate whether the prior mixed pattern of results holds with a more adequately powered sample. A power analysis suggests that a sample of 25 is needed to detect a small to medium effect; therefore, the small sample sizes in each of Tong's studies (Tong et al., 2011; Tong et al., 2014) likely played a role in finding their effects on the relevant morphological structure awareness tasks as non-significant. Thus, if we replicate the work of Tong et al. with larger samples, we should expect to find a difference on the measures of morphological structure awareness if differences do exist.

Morphological analysis has been measured by asking participants to choose the best definition of morphologically complex words (Anglin, 1993; Deacon et al., 2015). Here, the morphologically complex words were all low frequency, but varied on base frequency. Morphological analysis is indicated by greater accuracy with high than low frequency bases. If poor comprehenders can employ morphological analysis skill like typically developing readers (e.g., Deacon et al., 2015), we would expect to see infrequent morphologically complex words with high frequency bases defined more accurately than those with low frequency bases (i.e., a base frequency effect), as the high frequency base should aid the children in determining the meaning of the whole word, while the low frequency base should not. Yet, based on the relatedness of morphological analysis to reading comprehension (e.g., Deacon et al., 2015) and evidence of poor comprehenders' difficulties on other tasks of morphological awareness (e.g., Tong et al., 2014), we expect poor comprehenders to perform worse than average comprehenders on our measure of morphological analysis.

Morphological decoding was assessed using two tasks. In the first task, children read low frequency derived words that varied in base frequency. As in morphological analysis, morphological decoding would be indicated by greater accuracy with high than low frequency bases. In the second task, children read words and non-words that could be read most accurately with an appreciation of the morpheme boundary (e.g., dis/honest, not dish/onest; Nunes et al., 2012). We included a parallel orthographic decoding task, to evaluate the second skill in Ehri's final phase. In this task, children had to accurately read orthographic units (e.g., a double consonant, like *tapped* vs *taped*) to correctly pronounce the target word. Based on Perfetti et al.'s (2005) model and research demonstrating the relatedness of morphological decoding to reading comprehension, we predict that poor comprehenders will have specific difficulties with the morphological but not orthographic decoding task.

Table 1. *The Means, Standard Deviations, and Reliabilities of the Ages and the Raw and Standard Scores for the Standardised Measures for the Poor and Average Comprehenders. Maximum Raw Score is in Brackets.*

	Poor Comprehenders	Average Comprehenders	Reliability
Measure	Mean (SD)	Mean (SD)	
Chronological Age	8.10 (.30)	8.11 (.37)	
Nonverbal Reasoning (35)	15.67 (6.25)	17.53 (5.39)	.89
	47.82 (10.94)	48.97 (7.84)	
Phonological Awareness (33)	12.21 (4.97)	12.31 (4.39)	.91
	9.72 (2.59)	9.77 (3.00)	
Vocabulary (175)	144.15 (12.16)	144.75 (12.21)	.93
	104.09 (9.39)	104.63 (10.24)	
Word Reading (104)	51.06 (6.02)	50.71 (5.46)	.90
	106. 67 (9.85)	106.41 (11.33)	
Reading Comprehension (48)	18.91 (5.87)	31.24 (7.47)	.96
	432.88 (20.02)	474.09 (28.22)	

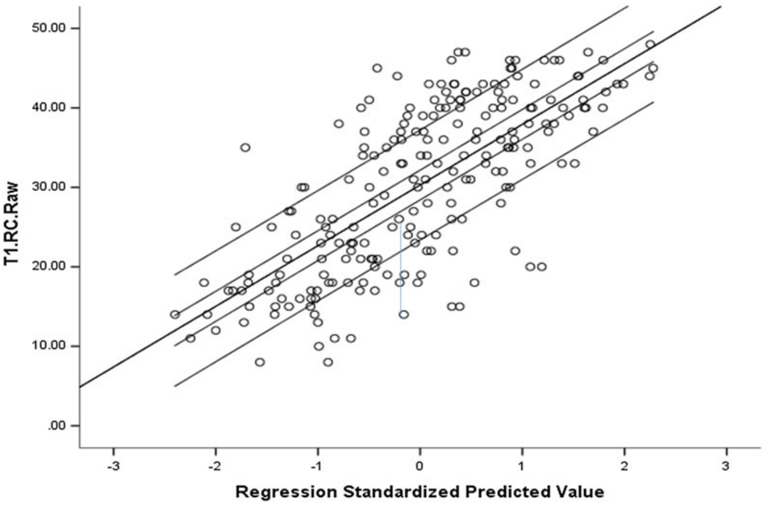

Figure 1. The raw reading comprehension scores of the sample of 230 third grade student plotted against reading comprehension scores predicted based on chronological age, phonological awareness, receptive vocabulary, nonverbal reasoning, and word reading. The 65% and 15% confidence intervals from the regression line are shown. T1.RC.Raw refers to the raw reading comprehension score from the Gates-MacGinitie test administered in Grade 3. [Colour figure can be viewed at wileyonlinelibrary.com]

Method

Participants

Participants were 32 poor and 32 average comprehenders selected from a sample of 230 third grade students (see Table 1 for age descriptives) recruited across 13 schools. Our data met the assumptions for univariate and multivariate outliers, linearity, independent observation, homoscedasticity, and normal distribution of residual errors (Tabachnick & Fidell, 2007).

To identify poor comprehenders, we employed a regression technique (Tong et al., 2014; White & Kirby, 2008). We predicted children's reading comprehension scores based on chronological age, phonological awareness, nonverbal reasoning, vocabulary, and word reading. These variables accounted for 52% of variance in reading comprehension. We then plotted participants' obtained reading comprehension scores against the scores predicted from the regression equation (Figure 1). Poor comprehenders were 32 children with reading comprehension scores below the lower 65% confidence interval of the regression line, reflecting substantially lower actual than predicted reading comprehension scores. Average comprehenders were 32 children within the 15% confidence intervals. Their predicted reading comprehension values were closest to the regression line, representing the least difference between their actual and predicted reading comprehension scores. Average and poor comprehenders were matched one-to-one on chronological age, nonverbal reasoning, phonological awareness, vocabulary, and word reading (e.g., vertical line in Figure 1).

We confirmed group selection with analyses of variance (ANOVA). Poor and average comprehenders differed significantly on their reading comprehension scores ($F(1, 63) = 54.60$, $p < .001$, $\eta_p^2 = .23$). Furthermore, a MANOVA with group (poor vs. average comprehenders) as the independent variable, and chronological age, nonverbal reasoning, phonological awareness, vocabulary, and word reading as the dependent variables showed that our two groups did not differ on the selection variables (Λ = .97; F(5, 59) = .32; p = .90; η_p^2 = .03).

Measures

Selection variables

Reading comprehension. Participants completed the Reading Comprehension subtest (Level 3) from the Gates-MacGinitie Reading Tests (MacGinitie, MacGinitie, Maria, & Dreyer, 2002). This test involves silent reading of 11 passages, each followed by 3 to 5 multiple-choice questions. Manual reliability is .96 (MacGinitie et al., 2002).

Nonverbal ability. On the Matrix Reasoning from Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999), participants saw a series of incomplete patterns and selected the picture that best completed the pattern. Manual reliability is .89 (Wechsler, 1999).

Word reading. On the sight word efficiency subtest from Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, and Rashotte, 1999), participants read aloud as many words as they could in 45 seconds from a set of 104 regular and irregular real words (e.g., *go, cat, her*). Manual reliability is over .90 (Torgesen et al., 1999).

Vocabulary. On the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4; Dunn & Dunn, 1997), participants pointed to the one of four pictures that best described the word the experimenter read aloud. Manual reliability is .93 (Dunn & Dunn, 1997).

Phonological awareness. On the Elision subtest from the Comprehensive Test of Phonological Processing (CTOPP; Torgesen et al., 1999), participants repeated aloud a word after deleting a specific sound, as instructed. Manual reliability is .79 (Torgesen et al., 1999).

Morphology

Morphological structure awareness

Sentence completion. Children heard a word and were asked to manipulate it in order to fit into an incomplete sentence. This measure included 28 items taken from Carlisle (2000); half of the items required the construction of a derived word (e.g., *Farm. My uncle is a ___ [farmer]*) and half involved the decomposition of a derived form (e.g., *Growth. She wanted her plant to ___ [grow]*). Items included a combination of phonologically transparent (e.g., *accept–acceptance*) and opaque items (e.g., *revise–revision*) (Table 2). The Cronbach's alpha reliability for this measure is .72.

Word analogy. This aural task follows an A:B::C:D pattern (Kirby et al., 2012). Children heard the first pair of words in the pattern, followed by the first word of the second pair. Participants then provided the last word of the second pair to complete the pattern (e.g., *run: ran:: walk: [walked].*). An equal number of inflected and derived items were included in the 20 test items. Approximately half of the items had no phonological change (e.g., *walk-walked*) and the remainder had phonological changes (e.g., *stood-stand*). The Cronbach's alpha reliability for this measure is .82.

Morphological analysis. The experimenter read aloud a target word followed by four short definitions (e.g., Deacon et al., 2015). Participants then circled the definition that best represented the meaning of the word. Of the 40 target words, all were low frequency

Table 2. *The Six Item Types in the Derived Word Reading Task.*

Item Type	Surface Frequency	Base Frequency
Transparent	Low	High
Transparent	Low	Low
Transparent	Low	High
Transparent	Low	Low
Opaque	Low	High
Opaque	Low	Low

morphologically complex words, half of which included a low frequency base morpheme (e.g., *confine* in *confinement*) and half of which included a high frequency base morpheme (e.g., *forget* in *forgetful*).

The four multiple-choice definitions included the correct definition among three distractor options. The correct definition included a higher frequency synonym of the most common definition of the word (as in Oxford English Dictionary, 1989). The distractor definitions were incorrect for all possible meanings of the word (Oxford English Dictionary, 1989; see Anglin, 1993). The distractor definitions were from the same grammatical category and of the same length as the correct definition. For example, for the morphologically complex word *confinement*, the four options were: a) a lack of being kept in, b) a lack of being pushed down, c) the act of being kept in, and d) the act of being pushed down. The Cronbach's alpha reliability for this measure is .65.

Morphological decoding

Derived word reading. Children read morphologically complex words aloud from a computer screen. Of the 120 words presented, there were three types of morphologically complex words: 40 high frequency phonologically transparent words (e.g., *addition*), 40 low frequency phonologically transparent words (e.g., *forgiveness*), and 40 low frequency phonologically opaque words (e.g., *similarity;* Table 2). High and low frequency complex words had surface frequencies of greater than 45 and less than 5 words per million, respectively (Zeno, 1995). Further, half of the complex words in each category contained a low frequency base (*glamourous*) and half contained a high frequency base (*effortful*). Critically, low and high base frequency groups were matched on surface frequency, type of suffix, number of letters, and number of syllables (F's < 3.41, p's $> .18$) within each category. The Cronbach's alpha reliability for this measure is .96.

Morphological unit decoding (Nunes et al., 2012). Children read aloud a randomly ordered set of real morphologically complex words (e.g., *dishonest*) followed by another randomly ordered set of morphologically complex pseudowords (e.g., *mishope*) from a computer screen. The Cronbach's alpha reliability for this measure is .89. The Cronbach's alpha reliabilities for the real and pseudo words are .85 and .74, respectively.

Orthographic decoding. Children read aloud real then pseudo words from a computer screen (also from Nunes et al., 2012). Correct pronunciation depends on specific orthographic cues (e.g., consonant doublets; *tapped* vs. *taped*). Unlike the morphological unit decoding task, incorrect pronunciation (e.g., ignoring the double p in *tapped* and pronouncing it *taped*) results in a real word. The Cronbach's alpha reliability for this measure is .87. The Cronbach's alpha reliabilities for the real and pseudo words are .89 and .75, respectively.

Procedure

Trained research assistants administered the testing in a quiet location in the child's school. Standardised measures were administered as per the manual. Children participated in two sessions on separate days. In the individual session, participants completed the morphological structure awareness and morphological and orthographic decoding tasks, as well as the phonological awareness, nonverbal ability, vocabulary, phonological awareness, and word reading tasks. For the group session, participants completed the reading comprehension and morphological analysis tasks.

Results

Morphological structure awareness

We conducted a MANOVA with group (poor vs. average comprehenders) as the independent variable and the raw scores from the sentence completion task and inflected and derived items of the word analogy task as the dependent variables (see Table 3 for descriptives). There was an overall effect of group ($\Lambda = .88$, $F(3, 61) = 2.84$, $p < .01$, $\eta_p^2 = .12$). No significant differences between groups emerged on the sentence completion task ($F(1, 62) = .98$, $p = .33$, $\eta_p^2 = .02$, $BF_{10} = 4.62$) nor on the inflected items of the word analogy task ($F(1, 62) = 1.39$, $p = .24$, $\eta_p^2 = .02$, $BF_{10} = 3.16$). Poor comprehenders performed significantly worse than average comprehenders on derived items of the word analogy task ($F(1, 62) = 5.09$, $p = .03$, $\eta_p^2 = .08$, $BF_{10} = 1.30$).

Morphological analysis

We conducted a 2 × 2 repeated measures ANOVA with group as the between-subjects factor and base frequency (low vs. high) as the repeated measure. There was a significant

Table 3. *The Means, Standard Deviations, and Reliabilities of the Raw Scores for the Morphological Awareness and Morphological Analysis Measures for the Poor and Average Comprehenders. Maximum Scores in Brackets.*

Measure	Poor Comprehenders Mean (SD)	Average Comprehenders Mean (SD)	Reliability
Sentence Completion (30)	13.35 (4.34)	15.09 (4.41)	.72
Derived	5.19 (2.34)	6.00 (2.50)	.74
Base	8.16 (2.57)	9.09 (2.45)	.78
Transparent	8.68 (2.66)	9.30 (2.38)	.75
Opaque	4.87 (2.39)	5.76 (2.55)	.73
Word Analogy (20)	9.42 (3.25)	11.12 (3.03)	.79
Inflected	4.45 (2.20)	5.18 (1.96)	.65
Derived	4.94 (1.63)	5.94 (1.62)	.67
Morphological Analysis (40)	16.28 (4.77)	19.58 (4.49)	.65
High Base Frequency	10.90 (3.19)	12.75 (3.14)	.72
Low Base Frequency	7.70 (2.78)	8.66 (3.01)	.69

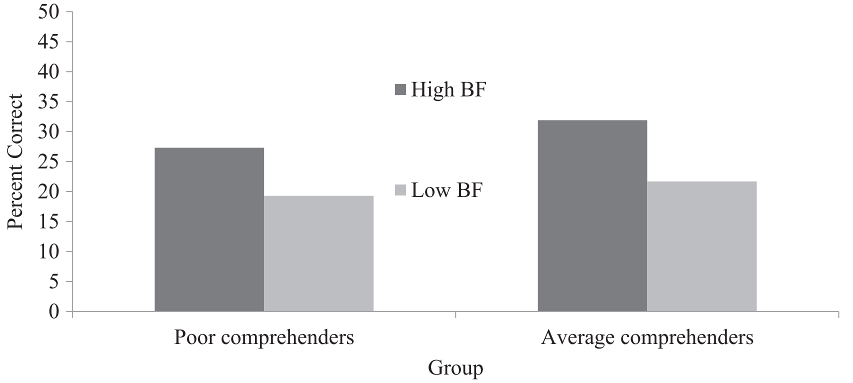

Figure 2. The base frequency effect of the morphological analysis task for the poor and average comprehenders.

Table 4. *The Means and Standard Deviations of the Accuracy Scores for the Different Word Types in the Morphological and Orthographic Decoding Tasks.*

	Poor Comprehenders		Average Comprehenders	
	Real	Pseudo	Real	Pseudo
Morphological	.45 (.25)	.23 (.19)	.54 (.22)	.26 (.19)
Orthographic	.73 (.18)	.57 (.22)	.78 (.16)	.58 (.19)

effect of group (F(1,60) = 4.51; p = .038; η_p^2 = .07, BF_{10} = 1.17), with lower scores for poor than average comprehenders. There was a significant effect of base frequency (F(1, 63) = 83.84, $p < .001$; η_p^2 = .58, BF_{10} = 1.01) with lower scores for items with a low than high frequency base word (Figure 2). There was no significant interaction between base frequency and group (F(1, 63) = 1.26, p = .266; η_p^2 = .02), suggesting higher accuracy for high than low frequency base items to a similar extent for both groups, thus profiting equally from the base frequency effect. When these analyses were conducted with the derived items from the word analogy task as a control, the same pattern of results emerged.

Morphological decoding

First, we present results from derived word reading (see Table 4 for descriptives). We conducted a 2 (poor vs. average comprehenders) × 3 (item type: transparent high frequency vs. transparent low frequency vs. opaque low frequency) × 2 (base frequency: high vs. low base frequency) ANOVA with accuracy scores. There was a significant effect of item type (F(2, 62) = 384.58, $p < .001$, η_p^2 = .93, BF_{10} = 1.07); children read transparent high frequency items most accurately, followed by transparent low surface frequency items, and then opaque low surface frequency items. There was also a significant effect of base frequency (F(1, 62) = 253.44, $p < .001$, η_p^2 = .80, BF_{10} = 2.29) with higher scores for high than low base frequency items. There was no significant effect of group (F(1, 62) = 1.48, p = .87, η_p^2 = .02, BF_{10} = 4.16), item type by group interaction (F(2, 61) = 1.66, p = .19, η_p^2 = .05), nor base frequency by group interaction (F(1, 62) = .38, p = .54, η_p^2 = .01). There was, however, a significant item type by base frequency interaction (F(2, 61) = 10.77,

Table 5. *The Means and Standard Deviations of the Accuracy Scores for the Different Word Types in the Derived Word Reading Task.*

	Poor Comprehenders		Average Comprehenders	
	High Base fq	Low Base fq	High Base fq	Low Base fq
Transparent				
High Surface fq	.68 (.25)	.62 (.25)	.77 (.23)	.69 (.21)
Low Surface fq	.58 (.19)	.40 (.22)	.61 (.18)	.45 (.21)
Opaque				
Low Surface fq	.30 (.16)	.20 (.14)	.37 (.22)	.23 (.18)

Note. fq = frequency (words per million); transparent = phonologically transparent; opaque = phonologically opaque. Numerical values represented *M* (and *SD*).

$p < .001$, $\eta_p^2 = .26$). Paired-sample *t*-tests showed that within the transparent high frequency words, scores were similar for the high and low frequency bases ($t(1, 63) = 1.85$, $p = .28$). Yet, a base frequency effect was found for the transparent ($t(1, 63) = 11.53$, $p < .001$, $d = 0.84$) and opaque ($t(1, 63) = 8.81$, $p < .001$, $d = 0.66$) low frequency words; morphologically complex words with a high, rather than low, frequency base were read more accurately in both word types. This interaction did not further interact with group ($F(2, 61) = .81$, $p = .45$, $\eta_p^2 = .03$), suggesting that both groups benefitted to a similar extent from the higher frequency base morphemes in these infrequent morphologically complex words.

Next, we present analyses of morphological and orthographic decoding (Nunes et al., 2012; Table 5 for descriptives). These data were analysed with a 2 (poor vs. average comprehenders) × 2 (word type: real vs pseudo) × 2 (item type: morphological vs orthographic) repeated measures ANOVA. There was an effect of item type, with higher scores for orthographic than morphological words ($F(1, 63) = 272.79$, $p < .001$, $\eta_p^2 = .812$, $BF_{10} = 0.97$), and an effect of word type, such that scores were higher for real than pseudo words ($F(1, 63) = 235.58$, $p < .001$, $\eta_p^2 = .789$, $BF_{10} = 1.14$). There was no effect of group ($F(1, 63) = .58$, $p = .359$, $\eta_p^2 = .014$, $BF_{10} = 4.36$), nor was there an interaction between group and item type ($F(2, 61) = 1.14$, $p = .314$, $\eta_p^2 = .012$). There was, however, an interaction between item type and word type ($F(1, 63) = 8.63$, $p = .005$, $\eta_p^2 = .120$); group did not further interact with these variables ($F(3, 60) = 2.42$, $p = .760$; $\eta_p^2 = .001$). Follow-up paired sample *t*-tests showed that children decoded the real words more accurately than the pseudo words, within both the morphological and orthographic words ($t(1, 63) = 13.52$, $p < .001$, $d = 1.14$; $t(1,63) = 10.22$, $p < .001$, $d = 0.96$, respectively). The interaction likely emerged from the slightly larger difference in accuracy between the real and pseudo words within the morphological than orthographic condition. Overall, patterns of means were similar for the two groups under investigation.

Discussion

The goal of this study was to investigate three aspects of morphological awareness of poor comprehenders: morphological structure awareness, morphological analysis, and morphological decoding. Poor comprehenders performed more poorly than average comprehenders on the derived items of word analogy task and performed similarly to average comprehenders on all other measures.

Confirming the findings of Tong et al. (2014, 2011), poor comprehenders performed worse than average comprehenders on the derived, but not inflected, items of a word analogy task. Groups did not differ on the sentence completion task, which focused solely on derived items. Confirming this pattern with larger groups in an adequately powered study suggests the need to take seriously the complex pattern uncovered here and elsewhere.

This is a challenging pattern for which to find a simple explanation. We suspect that poor comprehenders struggle in particular with derivational transformations, as these are generally later emerging than inflectional ones (e.g., Berko, 1958). Challenges with derived forms may be reinforced by reading comprehension difficulties; poor comprehenders read less and derive less meaning from what they read than average comprehenders (e.g., Clarke, Henderson, & Truelove, 2010), providing fewer opportunities to learn these less frequent derived words. These deficits might emerge in particular in the word analogy task because of the frequencies of the words in this task; a post-hoc evaluation shows that words in the analogy task have lower surface frequencies than those in the sentence completion task. Further, the sentence context of sentence completion may have indirectly aided the poor comprehenders in particular by augmenting their weak working memory (e.g., Cain, Oakhill, & Bryant, 2004). Evidence suggests that sentential information aids working memory because the sentence context allows participants to rebuild the information given to them (Cowan et al., 2003). Thus, the sentence context may have indirectly supported retention of the stimuli, improving poor comprehenders' performance on this task.

Turning to our morphological analysis task, we found that both poor and average comprehenders were more accurate on words with high than low frequency bases; this effect emerged to a similar extent in our two groups. Further, average comprehenders performed better than poor comprehenders on the morphological analysis task. In our view, the finding of similar sized base frequency effects suggests that poor and average comprehenders had similar morphological analysis skill. This base frequency effect suggests that participants were using the morphological structure to help them infer meaning of infrequent morphologically complex words, as reflected by the higher as compared to the lower frequency base morpheme. This effect is more convincing knowing that it emerges from a set of low surface frequency words, reducing the likelihood that children would already know the words. We remain open to the possibility that the overall poorer performance of the poor comprehenders in comparison to the average comprehenders reflects subtle morphological analysis deficits. We know the poor comprehenders' poor performance on this task is not attributable to their deficit in aspects of derivational morphology, as when we controlled for the derived items in the word analogy task, the group difference remained. Further, we suspect that the group difference is not attributable to differences in vocabulary, given matching between our two groups. It could, however, reflect higher-level language comprehension (e.g., Nation & Snowling, 1997), given that the task was aurally administered. Considering these potential differences in interpretation of our results, we think that morphological analysis is an area worthy of future investigation.

Finally, poor and average comprehenders performed similarly on our tasks of morphological and orthographic decoding. On derived word reading, we found a similar base frequency effect for poor and average comprehenders, suggesting that both groups were using morphemes to aid their word reading to the same extent. In the Nunes et al. task (Nunes et al., 2012), poor comprehenders decoded morphological and orthographic units as accurately as average comprehenders. Taken together, our results suggest that morphological and orthographic decoding skills, features of the consolidated alphabetic phase (Ehri, 2005), are likely to be intact in poor comprehenders. These findings suggest that poor comprehenders' average word reading extends to higher level word reading skills, at least as measured here.

The results of this study have educational implications. Considering our morphological structure awareness finding that poor comprehenders have specific difficulties with derived forms, it might be useful to target these in order to augment reading comprehension. Intervention studies with children with other word level reading disabilities found that targeting the structure and meaning of morphological affixes (i.e., morphological structure awareness and morphological analysis) improves reading comprehension more so than alternate treatments (e.g., Wolter & Dilworth, 2014). Such an intervention could be promising for poor comprehenders, specifically targeting derivational forms. Further, given that we did not find specific deficits of poor comprehenders on morphological analysis and decoding, it might not be effective to train poor comprehenders on these specific skills. We hope this new knowledge can inform interventions designed to develop reading comprehension skills in poor comprehenders.

Turning to theoretical interpretations, our results encourage a re-envisioning of Perfetti et al.'s (2005) model of reading comprehension when applied to poor comprehenders. Specifically, results of the morphological decoding tasks suggest that it is unlikely that morphology impacts reading comprehension indirectly through word reading within this specific population. Further, our morphological structure awareness and analysis results provide minimal evidence for morphology directly affecting the reading comprehension skills of poor comprehenders. However, morphological analysis and morphological decoding are significant predictors of reading comprehension in typical readers (e.g., Deacon et al., 2015). Thus, Perfetti et al.'s model might well capture the complex relationship between morphology and reading comprehension in typical readers, but might need refinement for application to poor comprehenders.

We need to interpret this study's findings within the context of participant selection. We used the linear regression method to identify poor comprehenders. The principal advantage of this method is that it takes into account several factors related to reading comprehension when selecting the poor comprehenders, instead of only considering the word reading and reading comprehension skills of this population. In our case, this meant that we controlled for phonological awareness, non-verbal ability, and vocabulary. This increases confidence that we selected children with deficits specific to reading comprehension. A second advantage of the regression technique lies in identifying an average comprehender group (see Tong et al., 2011), rather than the above average comprehenders identified as a comparison group in some other studies (e.g., Cain & Oakhill, 2006). Finally, we thank a reviewer for pointing to the possibility that our prevalence of poor comprehenders in our sample might be high. We noted, though, that our identification rate (14%) is in keeping with that in existing studies, across which there is a range of identification rates (see Rønberg & Petersen, 2015 for a review). Certainly, an important future step in this line of research lies in standardising selection of poor comprehenders.

We also need to interpret results in line with its methodology. Matching for vocabulary (see also Cain, Lemmon, & Oakhill, 2004) was important to us to ensure that uncovered differences were specific to morphology, but it might have rendered our groups similar and made differences more difficult to detect. Further, we did not measure other factors that could be relevant. Two would be working memory and listening comprehension tasks, both likely linked to performance on our morphological awareness tasks (Cain, Oakhill, & Bryant, 2004; Cain, Lemmon, & Oakhill, 2004), and to reading comprehension (Gough & Tunmer, 1986). Additionally, the items in our experimental tasks are not directly comparable and there was some evidence of low reliability. Given the similar performance of poor and average comprehenders on many of our measures of morphological awareness, future research should perhaps explore other potential areas of deficits, such as syntactic awareness (e.g., Tong et al., 2014).

In summary, this study supports the findings of previous research (e.g., Tong et al., 2014) by demonstrating that poor comprehenders have deficits in certain aspects of morphological awareness and extends this work to demonstrate relatively intact morphological analysis and decoding skills. This work provides insight into novel areas that could have been the source of poor comprehenders' reading comprehension deficits. In this spirit, our study provides evidence for one aspect of morphological awareness with which poor comprehenders struggle and begins to rule out two other potential areas of difficulty. Future research should continue to investigate other potential causes of reading comprehension deficits.

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Elizabeth MacKay is a student in the Clinical Psychology PhD Program at Dalhousie University. She has worked with Dr. Hélène Deacon in the Language and Literacy Lab for three years.

Kyle Levesque, BA (Hons), MSc in Experimental Psychology. PhD candidate in Experimental Psychology at Dalhousie University.

Dr. Hélène Deacon, BSc (Hons), PhD in Experimental Psychology. Professor at Dalhousie University.

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Address for correspondence: Elizabeth Jean MacKay, Department of Psychology and Neuroscience, Dalhousie University. Email: *e.mackay@dal.ca*