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How Word Reading Skill Impacts Text Memory: The Centrality Deficit and How Domain Knowledge Can Compensate

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Abstract

We examined text memory in children with word reading deficits to determine how these difficulties impact representations of text meaning. We show that even though children with poor word decoding recall more central than peripheral information, they show a significantly bigger deficit relative to controls on central than on peripheral information. We call this the *centrality deficit* and argue that it is the consequence of insufficient cognitive resources for connecting ideas together due to these children's resources being diverted from comprehension to word decoding. We investigated a possible compensatory mechanism for making these connections. Because a text representation is a synthesis of text information and a reader's prior knowledge, we hypothesized that having knowledge of the passage topic might reduce or eliminate the centrality deficit. Our results support this knowledge compensation hypothesis: the centrality deficit was evident when poor readers did not have prior knowledge, but was eliminated when they did. This presents an exciting avenue to pursue for possible remediation of reading comprehension in children with word identification difficulties.

Success in school, especially beyond the primary grades, depends heavily on reading and, most importantly, remembering what one has read. Children who have difficulty in the accuracy and speed with which they read words are thus at a disadvantage. It is well documented that word decoding problems lead to poor performance on reading comprehension tests (e.g., Berninger, Abbott, Vermeulen, & Fulton, 2006; Lyon, 1995; Shankweiler, D. 1989; Snowling, 2000; Torgesen, 2000), although the magnitude of the deficit is more evident on some comprehension test formats than on others (Keenan, Betjemann, & Olson, 2008). What is less clear is exactly what aspects of comprehension are affected. Research on the sources of comprehension difficulties has surged in recent years (e.g., Cain & Oakhill, 2007; Nation, 2005; Paris & Stahl, 2005), but that research typically excludes children with word decoding deficits and explores differences between poor and good comprehenders who do not have decoding problems. We contend that it is also important in comprehension research to understand the struggles that poor decoders have with comprehension so as to gain insights into avenues of remediation. Of course, one route to improve comprehension in children with decoding deficits would be to improve their word decoding skill. But other avenues might emerge from knowing how their understanding of a passage varies from that of typical readers. Do they remember less because they are only getting the main points, but missing details? Or are they remembering details but doing poorly on abstracting the main ideas? Or are they showing deficits across all types of information? The goal of this paper is to better understand poor decoders' struggles with comprehension by comparing the representations of meaning that are reflected in their retellings of passages to those of readers with adequate decoding skill, and then use that information to explore a possible compensatory mechanism that might serve to remediate

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comprehension deficits in children with word reading problems above and beyond improving their decoding skills.

Centrality Effect and Centrality Deficit

It is a well-known finding in the text memory literature that the more central an idea is to the gist of the text, the more likely it is to be recalled. This is manifested not just in skilled readers, but also in very young readers (Brown & Smiley, 1977; Keenan & Brown, 1984), and in readers with a learning disability (Curran, Kintsch, & Hedberg, 1996; Espin, Cevasco, van den Broek, Baker, & Gersten, 2007). It holds whether the text consists of a single sentence (Kintsch & Keenan, 1973) or a long passage (Britton, Meyer, Hodge, & Glynn, 1980; Cirilo & Foss, 1980; Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975; Kintsch & van Dijk, 1978; Meyer, 1974). Whether centrality is defined by ratings of the ideas or by more theoretical notions (e.g., Kintsch & van Dijk; van den Broek, Young, Tzeng, & Linderholm, 1999), recall always monotonically increases as the level of centrality of the idea increases – we refer to this as the *centrality effect*.

In reviewing this literature, we noted that there was an intriguing pattern evident in the handful of studies that examined how poor reading skills impacts recall of central and peripheral information. As noted above, even though poor readers tend to recall less than controls, they do show a centrality effect. What is intriguing is that even though they recall central information better than peripheral, they show a bigger deficit relative to the controls in their recall of central information; i.e., their biggest deficit is on the information that they recall the best. To illustrate, consider the data depicted in Figure 1, which is adapted from Curran et al. (1996), and shows the proportion of idea units recalled from long passages by poor readers and by controls. Both groups show the centrality effect with recall increasing as the centrality of the information increases. Note, however, that while the controls recalled more than the poor readers at each level, the difference between the groups is larger for the more central information than for the peripheral information. Curran et al. report a significant interaction between reading skill and centrality. We have coined the term *centrality deficit* to refer to this deficit in text recall of central information.

Evidence for the Centrality Deficit in Poor Readers

The first evidence for a centrality deficit in the text recall of poor readers dates back to the 1970s. Smiley, Oakley, Worthen, Campione, & Brown (1977) examined recall of stories in 7th graders, where the poor readers consisted of students who were enrolled in a remedial reading program. They examined four levels of centrality, where centrality of idea units was defined by ratings from undergraduates. Both groups showed the centrality effect in that the most central ideas were recalled the best. However, they also reported a significant Group x Centrality interaction; relative to controls, the poor readers showed a greater deficit in the recall of the central ideas than the peripheral ideas, thus providing evidence for the centrality deficit.

Hansen (1978) reported similar findings for story recall in fifth- and sixth-grade students, where the poor readers consisted of children significantly below grade level on a reading achievement test. Instead of using ratings to assess centrality like Smiley et al. (1977), Hansen performed a propositional analysis of the stories (Kintsch, 1974) to determine the centrality of each idea unit. Like Smiley et al., Hansen found what we are calling a centrality deficit because the poor readers recalled significantly fewer central ideas than controls, even though there was no difference between them on recall of peripheral ideas.

More recently, Curran et al. (1996) found evidence of a centrality deficit by defining centrality using macrostructure levels from summaries of expert readers. They tested 8th and 9th grade adolescents, where the poor readers consisted of students who scored at least two years below

grade level on a reading comprehension test. As can be seen in Figure 1, they found the centrality effect in both groups; but again there was evidence for a centrality deficit in that the difference between poor and skilled readers was greatest for the most central ideas.

Reduced sensitivity to the centrality of information in texts is evident not only in poor reader's recall but also in their ratings of which ideas in a text are most central. For example, Winograd (1984) found that eighth-grade good readers were better than eighth-grade poor readers at distinguishing central from peripheral sentences when asked to rate the importance of selected sentences from a passage. Interestingly, Winograd found that the poor readers were not just randomly guessing which sentences were central because correlations between an individual subject's centrality ratings and the centrality ratings of the rest of the children in the same group revealed a higher correlation between the sentences rated important by poor readers ($r = .62$) than by good readers ($r = .34$) or adults ($r = .37$); i.e., poor readers' ratings were not idiosyncratic. Poor readers selected sentences full of rich, visual detail, while good readers defined centrality in terms of textual importance.

In sum, the literature shows that poor readers develop a representation of the text during reading that does somewhat distinguish central from peripheral information because their recall shows a centrality effect. However, it appears that this representation does not differentiate central from peripheral ideas as clearly as the representation of more skilled readers because the slope of the function relating recall to level of centrality is flatter for poor readers than for good readers (see Figure 1). Although the centrality deficit has long been apparent in the literature, not much has been made of it. We propose, however, that the centrality deficit serves as a symptom of an underdeveloped text representation that does not allow the centrality of ideas to emerge as distinctively as in the representations of good readers. We turn now to consider the factors that likely contribute to poor readers' deficient representations and then lay the groundwork for a hypothesis regarding remediation.

Theoretical Explanation of the Centrality Deficit

Slow, labored word reading places demands on other cognitive processes, such as working memory, which in turn can make it difficult to comprehend connected text. Consequently, poor readers have fewer resources for comprehension than typical readers (Perfetti, 1985; Shankweiler, 1999). This can impact their processing of central text information in two ways. One is that poor readers will not have as many resources for recognizing or utilizing text structure cues that indirectly signal centrality. Centrality is rarely explicitly marked in a text; in other words, writers do not typically label ideas as being central or not, but rather use clause structure, order of mention of idea units, and other text factors to convey centrality. When a poor reader's attention is absorbed by decoding difficulties however, there are fewer resources to process these text cues.

The other way that poor readers' reduced resources can impact processing of central information is in connecting ideas. As we read we form connections among the text's ideas. Ideas having many connections are central; those having fewer connections are peripheral (Fletcher & Bloom, 1988; Graesser, Singer, & Trabasso, 1994; Kintsch, 1974; Trabasso & van den Broek, 1985; van den Broek, 1988). But when few interconnections can be made, because the reader does not have the resources available to make them, there will be less differentiation between central and peripheral ideas. Thus, we propose that poor readers show centrality deficits because the main ideas in their text representations have insufficient connections to allow centrality to emerge.

If our characterization of the centrality deficit is correct, then it ought to be possible to reduce the centrality deficit by making connections easier for poor readers to form so that more of

them can be made and centrality can emerge. We propose that a reader's prior knowledge can serve this function. We call this proposal the knowledge compensation hypothesis.

The Knowledge Compensation Hypothesis

A reader's mental representation of the text is a synthesis of information in the text and the reader's knowledge. Ideas become connected in the representation therefore either because of information in the text or because the reader's prior knowledge provides the connection. Our knowledge compensation hypothesis states that difficulties in using text information to establish connections can be offset by using prior knowledge to help form these connections.

There have been many demonstrations that prior knowledge facilitates comprehension; for example, an incomprehensible passage can be rendered easily comprehensible with a title that makes the relevant prior knowledge available (Alba, Alexander, Hasher, & Caniglia, 1981; Bransford & Johnson, 1972). Prior knowledge of baseball has been shown to increase recall of central more than peripheral ideas when experts' retellings are compared to those of baseball novices (Spilich, Vesonder, Chiesi, & Voss, 1979). It therefore seems reasonable that prior knowledge might serve as a compensatory mechanism in struggling readers by providing the basis for forming connections between text ideas.

If the knowledge compensation hypothesis is correct that prior knowledge can compensate for poor readers' reduced resources in forming connections based on information from the text, then it leads to a prediction about the occurrence of the centrality deficit. Namely, the centrality deficit should decline or be eliminated when a poor reader has prior knowledge of the topic. The basis for this prediction is that prior knowledge allows poor readers to make more connections between ideas and thus have a text representation that more clearly differentiates central and peripheral ideas than the representations they develop when they have no prior knowledge.

There have been a couple of demonstrations that prior knowledge can sometimes be more important than decoding skill in predicting reading comprehension (Samuelstuen & Braten, 2005; Shapiro, 2004). Knowledge has even been shown to compensate for reading disability. When poor readers had considerable expertise about baseball, Recht and Leslie (1988) found that prior knowledge of baseball allowed poor readers to recall more from a passage on baseball than good readers who had little prior knowledge of baseball. However, it is unclear from their results whether the effect of knowledge was a nonspecific facilitation of recall of all text ideas or a facilitation of central ideas. The elimination of the centrality deficit that is predicted by our knowledge compensation hypothesis requires that the effect be greater for central than for peripheral ideas. We turn now to our study to determine if that is the case.

Overview of Study

A serious problem with many earlier studies of text recall in poor readers is how they defined their group of poor readers. Most studies defined their poor readers using performance on reading comprehension tests. The problem with that method is that low scores on reading comprehension could result from either poor comprehension skill, poor word decoding skill, or both. If we are to understand the components underlying poor reading, it is important to be as specific as possible about defining the nature of the deficit. The present study defines poor reading based on poor word decoding skills. We assess word decoding on two measures of single word reading and then use a composite of those scores to define the poor decoders as the lowest 16 percent.

We recognize that when we select children who are poor decoders, it does not eliminate the possibility that many of them may also be poor comprehenders. Word decoding skill and

comprehension skill are correlated (e.g., Curtis, 1980; Perfetti, 1985; Shankweiler, 1989). Although recent studies have shown some independence (Cain & Oakhill, 2006; Nation, Clarke, & Snowling, 2002; Oakhill, 1994; Oakhill, Cain, & Bryant, 2003), even at a genetic level (Keenan, Betjemann, Wadsworth, DeFries, & Olson, 2006), because the two skills are correlated, we attempted to tease apart the effects of poor decoding and poor comprehension by controlling for listening comprehension skill in examining the effects of poor decoding on memory for text. By covarying out the children's performance on a composite of listening comprehension tests, we statistically eliminate comprehension deficits that are not specific to reading and thereby obtain a clearer picture of the impact poor word decoding has on developing a representation of the text.

With our group of poor readers thus well defined, one major goal of this study was to determine if children with poor word decoding show a centrality deficit in their text recalls by showing a greater difference from controls on central information than on peripheral information. The other goal was to test the knowledge compensation hypothesis. We hypothesized that when poor decoders have no prior knowledge of the topic, they would show a centrality deficit. However, we expected that when poor decoders had knowledge of the topic, that knowledge would compensate for their reduced resources for comprehension and reduce or eliminate the centrality deficit.

It is important to note that our study differs from most previous studies of prior knowledge effects on comprehension in the type of topic domain we examine. Others have used non-academic topics such as baseball or soccer (e.g., Chiesi, Spilich, & Voss, 1979; Recht & Leslie, 1988). We assess the effects of prior knowledge on a topic more like what children encounter in school so that we can relate our results to school performance. However, we recognize that one difference between having knowledge about baseball and having knowledge about more academic domains is that academic knowledge is more likely to be correlated with IQ. IQ is a construct so closely related to prior knowledge that subtests found in standardized measures of IQ (e.g., Vocabulary and Comprehension subtests on the Weschler Intelligence Scale for Children; Weschler, 1974) assess prior knowledge. Previous studies of prior knowledge effects did not control for IQ presumably because baseball knowledge is less likely to be related to IQ. Because our study involves academic topics, however, it is important to unconfound topic domain knowledge from general knowledge so that the group we refer to as having prior knowledge differs from the no prior knowledge group only in knowledge of the passage topic per se, not overall knowledge. To do this, our study covaries out IQ differences between the groups. Thus, in assessing the effects of prior knowledge, any group differences in recall can be attributed to domain knowledge rather than reflections of higher IQs facilitating comprehension.

The data for this study were collected as part of a larger, ongoing study of individual differences in language comprehension (cf. Keenan et al., 2006). One of the tests in the battery, the Qualitative Reading Inventory (QRI; Leslie & Caldwell, 2001), assesses children's retellings of stories; because it also includes an assessment of the children's knowledge of the passage topic before they read and recall, it provided an ideal opportunity for us to assess the centrality deficit in poor decoders and begin to explore the validity of the knowledge compensation hypothesis. It turned out, however, that most QRI passages were not suitable to testing our hypotheses because either all children knew about the topic (e.g., octopus) or none knew anything (e.g., Andrew Carnegie). In order to assess the effects of knowledge, we needed a passage where children varied in their knowledge. Thus, we were limited to examining retellings of a passage about Amelia Earhart, who some children knew and some children never heard of. Because this is an exploratory study, we simply classified children as to whether they were familiar with the topic or not, ignoring for this first pass the fact that some of the children in the knowledge group knew quite a bit about her whereas others knew only that she was

associated with airplanes. Because we did not manipulate the knowledge variable and assign children to groups, the difference between the prior knowledge group and the group with no prior knowledge is potentially subtle; this could leave us with limited power to detect the hypothesized interaction between reading ability, knowledge, and centrality predicted by the knowledge compensation hypothesis. However, the opportunity to examine the occurrence of the centrality deficit in a context of such a well-defined sample and the possibility of at least being able to initially explore the knowledge compensation hypothesis motivated our doing this exploratory study.

Method

Participants

Eighty-seven fourth- and fifth-grade children, whose average age was 9.8 years, participated in the study. They were tested as part of a larger study of comprehension skills affiliated with the Colorado Learning Disabilities Research Center (cf. Keenan et al., 2006; Olson, 2006).

Group Definitions

Decoding skill was measured by a composite *z*-score of word recognition ability using the Timed Oral Reading of Single Words (Olson, Forsberg, Wise, & Rack, 1994) and the Peabody Individual Achievement Test (Dunn & Markwardt, 1970) word recognition test. Children who had an age-adjusted composite decoding *z*-score of −1 or below composed the poor word decoding group; controls had a word decoding composite *z*-score of zero or greater. There was no difference between the word decoding groups in age (*M*(poor decoders) = 9.85, *M*(control) = 9.73; $F(1, 85) = 1.39$, $p > .05$). However, the difference between mean word decoding z-scores for the poor decoders ($M = -1.76$) and controls ($M = .96$) was highly significant ($F(1, 85) = 252.63$, $p < .001$).

The two knowledge groups were defined by the children's answer to the background knowledge question that preceded the text. Twenty-nine children (15 Poor Decoders, 14 Controls) had No Prior Knowledge (No PK) and 58 (25 Poor Decoders, 33 Controls) had PK. It is important to note that there was no difference between the knowledge groups in either age (*M*(PK) = 9.80 yrs., *M*(No PK) = 9.76 yrs.; $F(1, 85) < 1$) or average word decoding *z*-score (*M*(PK) = −.17, *M*(No PK) = −.54; $F(1, 85) = 1.08$). However, there was a significant difference between the knowledge groups in full scale IQ, as assessed by the Weschler Intelligence Scale for Children-Revised (WISC-R; Weschler, 1974; *M*(PK) = 113.76, *M*(No PK) = 106.34; $F(1, 85) = 7.17$, $p < .01$) and in listening comprehension ability (*M*(PK) = −.14, *M*(No PK) = −.46; $F(1, 85) = 3.86$, $p = .05$). Listening comprehension ability was based on the combined age-adjusted *z*-scores for the *Woodcock-Johnson Oral Comprehension* (Woodcock, McGrew, & Mather, 2001), and listening versions of the *Qualitative Reading Inventory – 3* (Leslie & Caldwell, 2001) and the *KNOW-IT Test* (Barnes, Dennis, & Haefele-Kalvaitis, 1996; Barnes & Dennis, 1996). The two reading ability groups also showed significant differences in IQ (*M*(poor decoders) = 104.50, *M*(controls) = 117.06; $F(1, 85) = 28.30$, $p < .001$) and listening comprehension ability (*M*(poor decoders) = −.60, *M*(controls) = .05; $F(1, 85) = 20.77$, $p < .001$). These group differences provided the rationale for using full scale IQ and listening comprehension as covariates in examining the effects of poor word decoding on text memory.

Materials

Reading passage—The passage that was used for this study was *Amelia Earhart* from the Qualitative Reading Inventory – III (QRI; Leslie & Caldwell, 2001). It was selected because it had sufficient variability among children in their responses to the assessment of their prior knowledge of the topic. The passage is 263 words long.

Defining prior knowledge—The concept question, "Who was Amelia Earhart?" was used to define two levels of prior knowledge: No Prior Knowledge (No PK) and Prior Knowledge (PK). A child who could not provide any accurate information in response to this question was classified as No PK, whereas those saying something that showed some familiarity with the passage topic were classified in the PK group. The reliability of the knowledge classification was assessed across a subset of concept questions that was scored by multiple testers; there were no discrepancies among the testers' ratings.

Defining centrality—A variety of techniques have been employed in previous studies to determine which ideas in a passage are central and which are peripheral. Some, such as propositional hierarchies (Kintsch & Keenan, 1973; Kintsch, 1974) and causal networks (van den Broek & Trabasso, 1986), can be extremely laborious to apply to long passages such as that used in the present study. A measure that correlates highly with more theoretical assessments of centrality is ratings of centrality (Albrecht & O'Brien, 1991; O'Brien & Myers, 1987). Because ratings are easier to obtain for long passages, we defined the centrality of the idea units in our passages using ratings obtained from undergraduates.

Each QRI passage is accompanied by a checklist of idea units found in the passage. The *Amelia Earhart* checklist consists of 47 idea units. This checklist was given to 17 undergraduates after they read the passage, and they were asked to rate the importance of each idea on the checklist to the overall meaning of the passage using a 0 – 7 Likert scale that ranged from the idea being "unimportant to the passage" to "very important to the passage". A mean rating was calculated for each idea unit. The ratings had high reliability estimates (Cronbach's $\alpha = .92$).

The mean ratings formed a normal distribution, and we used two different methods to break the distribution into categories of central and peripheral. One was to use a median-split, so that the idea units below the median were labeled peripheral, and those above were labeled central. The second way was to define the ideas in the highest quartile as central and those in the lowest quartile as peripheral. The analyses yielded identical results, so we confine the presentation of the results to just the median split method.

Procedure

Administering the QRI to assess reading comprehension involves having children read grade-appropriate passages and then recall them. Before reading each passage, the child was first asked the concept question that assesses knowledge of the passage topic. Then they read the passage and gave an immediate free recall. The child's retelling was audio-recorded, transcribed, and later scored according to the QRI idea unit checklist (described in the *Defining Centrality* section). Participants were credited for recalling a given idea unit if they stated the idea verbatim or represented the gist of the idea using synonymous language. The recalls were scored by research assistants who were blind to both the centrality of the idea units and the participants' reading ability and level of prior knowledge. Thirty-one recalls were scored by multiple raters, and inter-rater reliability of this subset was very high (Cronbach's $\alpha = .97$).

Results

A mixed design ANCOVA was used. Knowledge and decoding ability were between-subjects factors, centrality was a repeated measures factor, and full scale IQ and listening comprehension were covaried to ensure that knowledge and reading group effects were not due to the group differences in IQ or listening comprehension described earlier.

Centrality Effect

Our recall data showed the typical centrality effect, with participants recalling more central than peripheral information, ($F(1, 81) = 41.42$, $p < .001$; partial $\eta^2 = .34$). Tests of simple effects showed that this centrality effect was significant in both poor word decoders ($F(1, 37) = 9.99$, $p < .01$; partial $\eta^2 = .21$) and controls ($F(1, 44) = 23.86$, $p < .001$; partial $\eta^2 = .35$).

Centrality Deficit

We predicted that children with poor decoding would show a centrality deficit – more of a deficit compared to controls on the recall of central than peripheral information – when they had no prior knowledge of the passage topic, but that having prior knowledge would reduce the deficit. Statistically speaking, we predicted an interaction between centrality and reading skill for the No PK group but no such interaction for the PK group. This pattern was not supported by a significant 3-way interaction in the ANCOVA between decoding skill, centrality, and knowledge ($F(1, 81) = 1.20$, $p > .05$). However, as can be seen in Table 1, the data show the predicted pattern. When children have No PK of the topic, the difference between controls and poor decoders is larger (16%) on central than on peripheral ideas (10%) - a centrality deficit. In the children who have PK, however, the difference is the same (11%). Although the data in Table 1 are the percentage of ideas recalled, unadjusted for IQ and listening comprehension, the adjusted means also show the same pattern (as shown in Figures 1 and 2). Because the test of the three-way interaction was underpowered (observed power = .17), we proceeded to explore the significance of this pattern of knowledge and reading group differences by performing two post-hoc ANCOVAs, one on the children with No PK and one on the children with PK, each having centrality and word decoding ability as the factors, and covarying IQ and listening comprehension.

When children have no prior knowledge, there is a significant interaction between reading ability and centrality ($F(1, 25) = 4.20$, $p = .05$; partial $\eta^2 = .14$). Figure 2 displays the adjusted means when both groups have no prior knowledge of the topic. As in the unadjusted means there is a larger difference (15%) between groups in recall of central information (51% for controls vs. 36% for poor decoders), and a much smaller difference (6%) between the groups in recall of peripheral information (34% controls vs. 28% poor decoders).

Knowledge Compensation

Although our knowledge compensation hypothesis was not supported by the underpowered 3-way interaction between centrality, prior knowledge, and reading ability, the post-hoc ANCOVA on retellings from those who had prior knowledge showed that when children do have prior knowledge there is no longer an interaction between reading ability and centrality ($F(1, 54) < 1$); as shown in Figure 3, the poor decoders show no greater deficit on central ideas (5%) than on peripheral ideas (6%). Thus, having prior knowledge of the topic appears to provide a basis for interconnecting ideas so that the centrality deficit can be reduced or eliminated.

It is interesting to note that the compensatory effects of topic knowledge on processing central information are confined to the poor decoders. The control group shows no effect of topic knowledge on central information. As can be seen in Table 1, controls recall about the same amount of central information whether they have prior knowledge (52%) or not (51%), suggesting that they have an ability to focus on central points using text cues, whereas these cues may elude children with decoding difficulties unless they have scaffolding from prior knowledge of the topic.

Discussion

Studies of good and poor readers commonly find that poor readers do worse on comprehension (e.g., Shankweiler, 1989; Swanson & Alexander, 1997; Torgesen, 2000), but they typically do not give insight into the nature of the differences between good and poor readers' mental representations that underlie these quantitative differences. Studies on the nature of comprehension deficits (e.g., Cain & Oakhill, 1999, 2007; Cain, Oakhill, Barnes, & Bryant, 2001; Nation, 2005) typically exclude poor decoders in order to focus on factors beyond word identification related to comprehension; consequently, they too do not provide insight into how decoding difficulties might lead to differences in text representations. As a result, there is a gap in our understanding of how decoding problems alter the development of a text representation. The purpose of the current study was to begin to fill that gap by examining qualitative differences in text recall. By exploring ways in which topic knowledge might allow poor decoders to compensate, we hoped to open additional avenues to remediate their reading comprehension problems.

We examined the relative recall of central and peripheral ideas as a way to assess the quality of the text representation that a child constructs while reading. Centrality is a property that emerges from interconnecting ideas in an effort to establish a coherent representation of the text (Fletcher & Bloom, 1988; Graesser et al., 1994; Kintsch, 1974; Trabasso & Sperry, 1985; Trabasso & van den Broek, 1985; van den Broek, 1988). What makes central ideas central is that they have more connections to other ideas. This interconnectedness is what facilitates recall and leads to better recall of central than peripheral ideas, the *centrality effect*.

Our review of the literature found that while poor readers, like good readers, show a centrality effect, the slope of the function seemed flatter than that found for good readers; specifically, poor readers appeared to have a greater deficit relative to controls in their recall of central than peripheral ideas, what we labeled the *centrality deficit*. The present study not only replicated this finding of a centrality deficit in poor decoders, but also was able to help clarify whether it was due specifically to word decoding difficulties. Previous studies defined poor readers as low scores on reading comprehension tests; but such low scores could result from either poor comprehension skill, poor decoding skill, or both. Our study was able to ensure that the children indeed had a deficit in word decoding by defining our groups on independent measures of word decoding skill. Furthermore, because we had assessments of the children's listening comprehension ability and IQ, we were able to also determine whether the centrality deficit remained when individual differences associated with listening comprehension ability and IQ, which tend to correlate with word decoding, were covaried out. Thus, our finding that the centrality deficit remains evident when individuals have specific word decoding difficulties provides unique insight into how word decoding deficits impact comprehension processes.

We interpret the centrality deficit observed in poor word decoders as stemming from their need to allocate more resources to word identification than controls. As a result they have fewer resources to connect ideas; this results in an underdeveloped text representation where there are fewer interconnections between ideas, and in turn less differentiation between central and peripheral ideas. Thus, poor decoders show a centrality deficit because the main ideas in their text representations have insufficient connections to allow centrality to emerge. This also explains why poor word decoders recall less: when there are fewer interconnections in the representation, there are fewer paths to follow in retrieval.

These findings demonstrate the value of using text recall as a measure of comprehension. This was a popular measure in the early days of comprehension research (e.g., Britton et al., 1980; Cirilo & Foss, 1980; Kintsch & Keenan, 1973; Kintsch et al., 1975; Kintsch & van Dijk, 1978; Meyer, 1974), but the fact that recalls are arduous to score often motivates educators

and researchers to choose alternative assessment formats (e.g., multiple choice, cloze). The present study shows, however, that text recalls can provide important insights into the qualitative aspects of the representation constructed to represent the meaning of the text and can reveal important individual differences. They are thus an important tool in trying to comprehend comprehension.

The main contribution of this study was not just identifying and explaining the centrality deficit in poor decoders, but also providing preliminary evidence that prior knowledge of the passage topic can help compensate for this deficit. Based on the fact that a reader's mental representation of the text is a synthesis of text information and prior topic knowledge, we hypothesized that readers who have difficulties in using text information to establish connections could offset those difficulties by using their knowledge for the connections – the knowledge compensation hypothesis. Although our results cannot conclusively confirm this hypothesis, they do provide some support. We found that the centrality deficit occurs in poor decoders when they have no prior knowledge of the topic, but it is eliminated when they do have topic knowledge.

How might prior knowledge facilitate construction of a text representation so as to potentially eliminate the centrality deficit in poor decoders? One way in which it could help is that when a reader has prior knowledge about a topic, failures to attend to text clues that indirectly signal centrality are less fatal because what is central is already known to some extent (Goetz, Schallert, Reynolds, & Radin, 1983). In addition, when a reader has prior topic knowledge, fewer resources are required to form connections between text ideas because those connections are already available as part of the reader's knowledge. Thus, rather than having to make an effortful, text-based inference to connect ideas together, the reader who has prior knowledge can simply activate connections between ideas already connected in their knowledge base, i.e., make knowledge-based inferences (Hannon & Daneman, 1998; Long, Oppy, & Seely, 1994). In short, knowledge can facilitate the development of a representation that better identifies central ideas.

A question for future research would be to determine whether the centrality deficit is eliminated when poor decoders read passages that are easy for them to decode. If we are correct in our analysis of the cause of the centrality deficit, then when children with word reading deficits read a passage that is easy for them to decode, such as a passage that is well below grade level, they should be able to form the necessary connections and no longer show a centrality deficit, even when they have no prior knowledge of the topic.

Future research might also try to build on our preliminary findings by implementing an experimental design in which prior knowledge is manipulated by teaching half the participants a relevant knowledge base while withholding such knowledge from the other half. However, as Kamalski, Sanders, & Lentz (2008) noted, manipulating knowledge is not straightforward. Knowledge cannot be delivered similarly to everyone to the same extent because individual differences in prior knowledge will impact how the new knowledge is processed. So, the control one hopes to achieve by having an experimental design that assigns participants to knowledge groups cannot be fully achieved because of preexisting knowledge differences. In addition, when one attempts to control knowledge by teaching a knowledge base, it is difficult to give a knowledge base relevant to a passage without highlighting all the information in the passage that is central. As a result, rather than serving as the “knowledge” that allows readers to form connections among a text's ideas, the knowledge base might simply be serving as a prime, cueing the reader to which ideas should be attended to and recalled.

Although it will be important to replicate our study with more statistical power and additional passages, the current results nevertheless suggest an interesting direction for possible remediation of reading comprehension difficulties in children with word decoding problems.

They suggest that in addition to improving comprehension by improving word decoding skill, one might be able to improve reading comprehension by building up the child's knowledge base. This could be done by presenting information in a non-reading format, such as instructional videos (Kamalski, Sanders, & Lentz, 2008). Kamhi (2007) suggests that building conceptual knowledge is not only an effective method of improving comprehension, but it is also more responsive to instruction than traditional, domain-general methods of comprehension instruction. Developing a child's knowledge base thus represents an exciting avenue to pursue for possible remediation of comprehension problems, like the centrality deficit.

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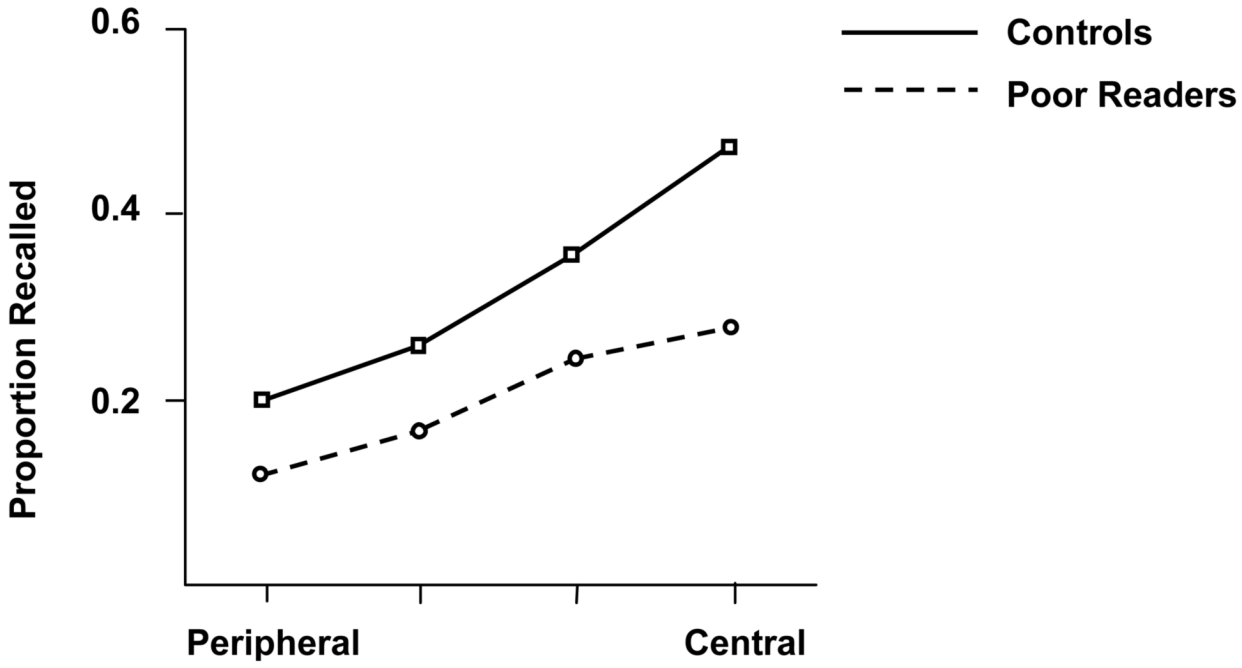

Figure 1.
Illustration of the centrality deficit. Adapted from Curran et al. (1996).

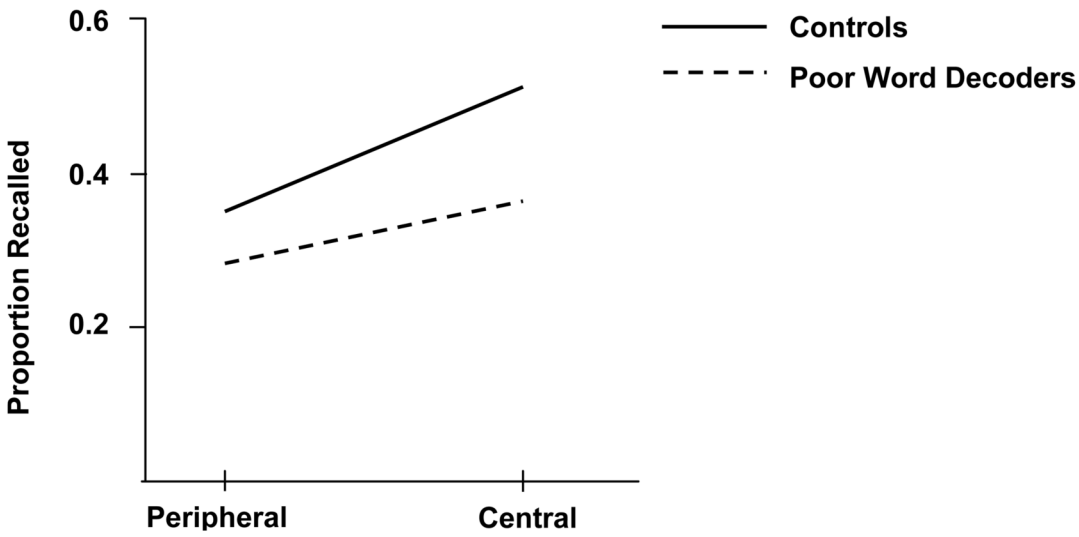

Figure 2.
Proportion of central and peripheral ideas recalled by children without prior topic knowledge as a function of word decoding ability. Means are adjusted for IQ and listening comprehension.

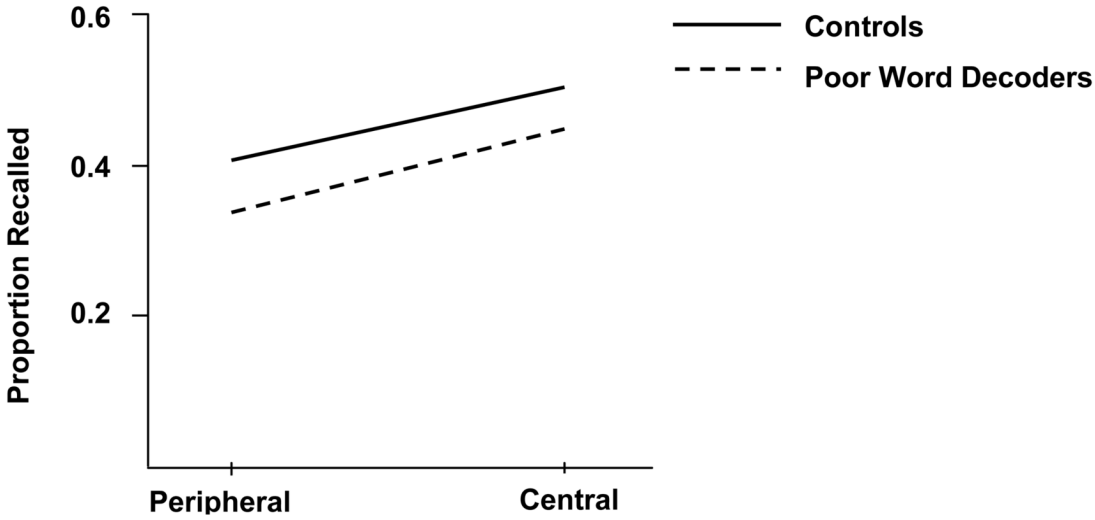

Figure 3.
Proportion of central and peripheral ideas recalled by children with prior topic knowledge as a function of word decoding ability. Means are adjusted for IQ and listening comprehension.

Table 1

Unadjusted means and standard deviations of the proportion of peripheral and central idea units recalled by Controls and Children with Poor Word Decoding.

	Peripheral	Central
No Prior Knowledge		
Controls	.36 (.08)	.51 (.11)
Poor Decoders	.26 (.14)	.35 (.15)
Difference	.10	.16
Prior Knowledge		
Controls	.43 (.15)	.52 (.15)
Poor Decoders	.32 (.15)	.41 (.13)
Difference	.11	.11