

How word decoding, vocabulary and prior topic knowledge predict reading comprehension. A study of language-minority students in Norwegian fifth grade classrooms

Veslemøy Rydland · Vibeke Grøver Aukrust · Helene Fulland

Published online: 3 November 2010

© The Author(s) 2010. This article is published with open access at Springerlink.com

Abstract This study examined the contribution of word decoding, first-language (L1) and second-language (L2) vocabulary and prior topic knowledge to L2 reading comprehension. For measuring reading comprehension we employed two different reading tasks: Woodcock Passage Comprehension and a researcher-developed content-area reading assignment (the Global Warming Test) consisting of multiple lengthy texts. The sample included 67 language-minority students (native Urdu or native Turkish speakers) from 21 different fifth grade classrooms in Norway. Multiple regression analyses revealed that word decoding and different facets of L2 vocabulary explained most of the variance in Woodcock Passage Comprehension, but a smaller proportion of variance in the Global Warming Test. For the Global Warming Test, prior topic knowledge was the most influential predictor. Furthermore, L2 vocabulary depth appeared to moderate the contribution of prior topic knowledge to the Global Warming Test in this sample of language minority students.

Keywords Language-minority students · Vocabulary · Prior topic knowledge · Reading comprehension

Introduction

Despite consistent findings of lower reading comprehension for language-minority students (Droop & Verhoeven, 1998; Lervåg & Aukrust, 2010; Nakamoto, Lindsey, & Manis, 2007), the specific challenges they face are not clear. The present study seeks to investigate components that predict reading comprehension by addressing relationships between word decoding, first-language (L1) and second-language (L2)

V. Rydland (✉) · V. G. Aukrust · H. Fulland

Institute of Educational Research, University of Oslo, P.O.Box 1092, Blindern, 0317 Oslo, Norway
e-mail: veslemoy.rydland@ped.uio.no

vocabulary and prior topic knowledge and their contribution to reading comprehension among L2 readers in Norwegian fifth grade classrooms. For this purpose, we used a standardized reading comprehension test as well as a researcher-developed reading comprehension test involving multiple texts and resembling a typical classroom reading assignment. The latter test was administered as a classroom session as part of the overall study “Classroom discourse and text comprehension” with a total of 410 students attending 21 different classes. For the purpose of the present study, the native Urdu and native Turkish students ($N = 67$) in these classrooms also participated in additional, individual test sessions.

The relative contributions of word decoding and vocabulary to reading comprehension may differ depending on how reading comprehension is assessed (Cutting & Scarborough, 2006; Keenan, Betjemann, & Olson, 2008, Lervåg & Aukrust, 2010). One of the tests of reading comprehension applied in this study, Woodcock Passage Comprehension, is a widely used standardized measure that involves reading sentences or passages with a cloze procedure as a response format. The other test, the Global Warming Test, is constructed by our research group to represent a more authentic fifth grade content-area reading task in which students have to make connections between multiple texts all addressing a science topic; global warming. For this latter test, we expected students’ prior topic knowledge of global warming to impact their reading comprehension. We argue that prior topic knowledge may be an essential part of many of the comprehension processes students engage in, and should be specifically included in research aiming at investigating factors that contribute to students’ reading comprehension.

The present study has a twofold purpose. First, we examine the relative impact of decoding and vocabulary on L2 reading comprehension across the two different reading tasks. Research on L2 reading has long acknowledged the strong relation between, respectively, decoding, L2 vocabulary and reading comprehension (August, Carlo, Dressler, & Snow, 2005; Carlisle, Beeman, Davis, & Spharim, 1999; Hoover & Gough, 1990; Kieffer & Lesaux 2007; Lesaux, Lipka, & Siegel, 2006; Nakamoto et al., 2007; Proctor, Carlo, August, & Snow, 2005).

Second, we examine more closely the impact of prior topic knowledge in the Global Warming Test. While various studies have investigated how linguistic component skills such as decoding and vocabulary influence L2 reading comprehension, we know much less about how students’ prior topic knowledge affects these relationships and how levels of L2 vocabulary may interact with prior topic knowledge to determine L2 reading comprehension. When reading for learning in the domain-areas, reading fluency and general vocabulary may be supportive, but not sufficient for comprehending the texts.

Studies conducted with monolingual samples indicate that the prior topic knowledge that students bring with them to the reading task may be an important factor explaining their comprehension of expository texts (Alexander & Jetton, 2000; Best, Floyd, & McNamara, 2008; Cunningham & Stanovich, 1997; Samuelstuen & Bråten, 2005). Alexander and Jetton (2000) identified topic knowledge as a specific type of background knowledge referring to the depth of one’s knowledge in relation to a particular selection of text. In this way, prior topic knowledge is a suitable construct for reading comprehension research, because it

links readers' background knowledge to the subject in a specific text and the topic related concepts included in that text.

Prior topic knowledge may be particularly important for the comprehension of multiple content-area texts by providing students with a top-down tool to bring together information in different texts and go beyond what is explicitly stated in the texts (Donin & Silva, 1993). In a sample of graduate students' reading in their first (L1) and second (L2) languages, Chen and Donin (1997) studied text processing as affected both by language proficiency and prior topic knowledge. They found that prior topic knowledge had a top-down influence on text comprehension whereas linguistic proficiency had a bottom-up influence. For the high knowledge readers with less L2 proficiency, their knowledge seemed to have compensated for their lack of language skills.

While the role of prior topic knowledge is continuously addressed in experimental and intervention studies investigating reading comprehension among monolingual samples (e.g. McNamara, Kintsch, Songer, & Kintsch, 1996; Spires & Donley, 1998), predictive studies concerning younger students' reading comprehension seldom attend to this issue (among neither L1 nor L2 readers). One reason for this may be that it has been difficult to disentangle the construct of prior topic knowledge from the construct of vocabulary, possibly leading to a situation where the construct of vocabulary has replaced the construct of prior topic knowledge. Although there are obvious links between vocabulary knowledge and prior topic knowledge, they are separate constructs and need to be investigated as such. On the one hand, students with a less well-developed vocabulary may face challenges in acquiring prior topic knowledge which is decontextualized and cognitively demanding. On the other hand, two students who have both a rich lexical repertoire and good word-processing skills may differ with respect to the experiences and knowledge they possess related to a specific topic. Vocabulary and prior topic knowledge may share variance in comprehension as well as offer distinct contributions to comprehension.

A second reason why prior topic knowledge is not included in predictive studies on young students' reading comprehension may be that most of the currently used standardized reading comprehension tests have been constructed to minimize the impact of prior topic knowledge on reading outcomes. This is mainly done by giving students relatively brief passages which deal with different topics to read. The diversity in text topics is expected to ensure that each child gets a similar spread of familiarity with the text, while the short passages limit the need for students to draw inferences based on their larger knowledge base. Although such tests do contribute valuable information about a student's level of reading comprehension, the attempt to remove the influence of prior topic knowledge on reading comprehension in the construction of tests is not without problems (for discussion see Johnston, 1984).

In a broad perspective, the profound emphasis on more limited testing formats is a challenge for predictive reading comprehension research (and the implications that are drawn from this research), because it may entail a situation in which the process of reading comprehension itself is conceptualized in a one-sided way. The process of reading comprehension may for instance be perceived as largely dependent on

bottom-up processes (such as decoding and vocabulary) at the expense of top-down processes (for instance related to the use of prior topic knowledge to bind text elements together). In light of this problem, Fletcher (2006) has argued for the need to expand the reading comprehension assessments to take into account comprehension as it actually occurs in the classroom.

In middle school, students are expected to read and learn from content-area texts in which abstract relationships and new concepts are introduced. Content-area reading involves reading for a purpose and requires students to build an understanding and make inferences across relatively extensive and sometimes multiple texts. Most previous studies of background knowledge in second-language readers have examined the impact of culturally relevant knowledge to reading comprehension. This research converges on a fairly consistent finding that L2 learners' reading comprehension improves when students read culturally familiar texts (Droop & Verhoeven, 2003; for review, see Goldenberg, Rueda, & August, 2006). Although some text comprehension difficulties may be attributable to cultural knowledge, many others are not. For example, the prior topic knowledge application to understand domain-area texts (such as science texts) is often not culturally specific.

We have identified two studies that have investigated the role of prior topic knowledge on language-minority students' reading comprehension. By comparing language-minority students to their monolingual peers, these studies emphasize that language-minority students may have more problems employing the prior knowledge they possess because of limited L2 proficiency. In one study Garcia (1991) examined the reading comprehension of English expository texts in fifth- and sixth grade native-Spanish speaking students and English monolinguals. The results showed that the reading comprehension of the native-Spanish speakers was considerably below that of their monolingual peers. According to Garcia, the low frequency words in the texts constituted a particular challenge for the native-Spanish speakers. Probably because of these difficulties, the native-Spanish speakers were uncertain about when to apply their knowledge base to answer the questions probing inferences based on the texts.

In another study, Hacquebord (1994) compared the reading comprehension performance among Dutch monolingual and native Turkish speaking students in secondary school. Although the groups did not differ in prior topic knowledge, the native Turkish speakers still scored significantly below the Dutch monolingual group. Analyses of the students' answers to the reading comprehension questions suggested that the groups were relatively equal in dealing with the questions probing macro-level information (such as the texts' main idea), but that the Dutch monolinguals performed significantly better on the questions related to micro-level information. This finding may indicate that the native Turkish speakers figured out the gist of the text, while at the same time lacking the specific L2 vocabulary needed to respond to the micro-level questions.

In total, these studies point to the interdependencies between L2 vocabulary and prior topic knowledge in language-minority students' reading comprehension. However, by comparing language-minority students to their monolingual peers,

these studies do not shed light on how bottom-up and top-down processes interact and influence reading comprehension within a group of language-minority students. In a study of monolingual high school students investigating the relative contribution of vocabulary and prior topic knowledge, Cromley and Azevedo (2007) suggested that prior topic knowledge in addition to vocabulary had the largest impact on reading comprehension. A better understanding of L2 reading comprehension therefore requires an examination of how prior topic knowledge is used in the L2 reading process.

Studies of vocabulary and comprehension in L2 learners have distinguished between vocabulary breadth (number of words known) and depth (richness of the semantic representation) (Lervåg & Aukrust, 2010; Ordóñez, Carlo, Snow, & McLaughlin, 2002). Moreover, the particular vocabulary type of text-cohesive words or connectives (such as ‘although’, ‘because’, ‘in spite of’) have received attention in L2 reading comprehension research (Crosson, Lesaux, & Martiniello, 2008; Degand & Sanders, 2002; Droop & Verhoeven, 2003). A recent study that is particularly relevant for the present study was conducted with monolingual sixth graders in Spain. Sanchez and Garcia (2009) examined the relationship between text cohesion vocabulary (one dimension of what they term “rhetorical competence”) and reading comprehension while accounting for students’ word decoding skills and prior topic knowledge. Their findings indicate that text cohesion vocabulary made a significant contribution to middle school students’ reading comprehension of expository texts.

As vocabulary measures are frequently reported globally, little is known about how different aspects of vocabulary play a role across different reading assignments (for discussion see Pearson, Hiebert, & Kamil, 2007). In this present study we analyzed separately three different facets of L2 vocabulary (breadth, depth, text cohesion) in two different measures of L2 reading comprehension. The evidence regarding L1 vocabulary impact on L2 reading comprehension is mixed. While some studies have found no significant impact of L1 vocabulary on L2 reading comprehension beyond the impact of corresponding L2 predictors (for review see Lindsey, Manis, & Bailey, 2003), others have found that at least a small part of the variance in L2 reading comprehension can be accounted for by L1 vocabulary (Carlisle et al., 1999; Proctor, August, Carlo, & Snow, 2006). For this reason L1 vocabulary is considered in the analysis of relations between L2 vocabulary and reading comprehension.

Summing up, we seek to understand more fully how word decoding, vocabulary, and prior topic knowledge play independent roles as well as interact in L2 reading comprehension by addressing the following two research questions:

1. To what extent can word decoding and vocabulary explain variance in the two different measures of L2 reading comprehension (reading short passages versus reading multiple texts on one topic)?
2. When reading multiple texts on one topic, what is the relative role of prior topic knowledge vis-à-vis word decoding and vocabulary in explaining L2 reading comprehension?

Methods

Participants

The participants were 67 bilingual fifth graders from 21 different classrooms in two larger cities in Norway. The students had Turkish ($N = 37$) or Urdu ($N = 30$) as their first language and Norwegian as their second. Girls accounted for 44% of the sample group. Parental occupation was reported by the children. Almost 45% of the mothers and 14% of the fathers were unemployed, while the employed parents had jobs with low educational and/or vocational demands. None of the parents had a job that required more than 3 years of higher education.

Because the Global Warming Test was conducted with all the students in the participating classes, we were able to compare the reading comprehension performance of the sampled students to their classmates, who were native speakers of Norwegian ($N = 135$). While the mean score on the Global Warming Test was nearly 9.5 ($SD = 4.3$) for the sampled students, their native speaking classmates had a mean score of 15.8 ($SD = 5.6$). Thus, the students in the present study appeared to be struggling readers in terms of comprehending content-area texts in the L2 (Norwegian).

The Turkish and Pakistani populations in Norway share a common history of immigration to seek work since the late 1960s, and marriage and family reunification have later been the main reasons for immigration. Students with at least one parent born in Turkey or Pakistan, and who spoke either Turkish or Urdu in addition to Norwegian at home, were sampled. Only two mothers and four fathers were born in Norway. All but three students were either born in Norway or came to Norway during the first year of life.¹ The student arriving latest moved to Norway in second grade and he was the only student in this sample who had not attended Norwegian preschool. When the children in this study entered school (age 6), the educational policy in Norway was to postpone explicit reading instruction until the second grade (age 7) (although most preschool and first grade classrooms focused on building phonological awareness and letter knowledge informally through games etc.). Thus, all the students sampled for this study had received their formal reading instruction within the Norwegian school system. The mean length of preschool attendance was approximately 3 years (12% of the students had only 1 year of preschool attendance before entering first grade).

The policy of instruction of language-minority students in Norway is to provide support for development of the Norwegian language (Norwegian Ministry of Education and Research, 2007). A large variation and a local character of the L1 support offered by schools to language-minority students in Norway has been documented (Aasen & Mønnes, 1999). All students in this sample attended classes where Norwegian was the language of instruction (and the language in the text books) in all subjects. While some schools offered L1 instruction and/or bilingual

¹ The two students that moved to Norway during the preschool period and the one student that moved to Norway in second grade do not represent outliers in the language or reading outcomes reported on in this study.

instruction a few hours a week early in the school years, other schools provided no L1 support (Norwegian Directorate for Education and Training, 2010).

Procedure

To measure prior topic knowledge and content-area reading comprehension, the sampled students and their classmates participated in a classroom session where researcher-developed tests were administered. In addition, the sample students participated in individual sessions where standardized tests were used to measure L1 vocabulary, L2 component skills and L2 reading comprehension. Because the students in this study did not receive domain-area L1 instruction in fifth grade and were generally not encouraged to use their L1 within the classroom context (see description above), it was decided to conduct the measure of prior topic knowledge in Norwegian. All tasks and tests were administered and scored by the authors. Raw scores were used in the analysis.

Table 1 provides information on students' scores (means and standard deviations) for each measure presented below.

Measures

L1 and L2 vocabulary breadth

To measure L1 vocabulary breadth, we used a translated version of the British Picture Vocabulary Scale 2nd edition (Dunn, Dunn, Whetton, & Burley, 1997). Moreover, a translated version of the Peabody Picture Vocabulary Test, third edition (Dunn & Dunn, 1997) was used to measure L2 vocabulary breadth. In the test situation the student had to recognize an orally presented word and point to one of four pictures corresponding to the word. The British Picture Vocabulary Scale was

Table 1 Means, standard deviations, Cronbach's alpha and correlations between variables

	1.	2.	3.	4.	5.	6.	7.	8.
<i>M</i>	87.35	96.34	18.57	13.25	66.91	23.64	5.41	9.45
<i>SD</i>	25.40	18.08	5.12	3.98	10.82	5.93	2.99	4.25
Cronbach's alpha	.90	.95	.81	.80	–	.87	.74	.84
1. L1 vocabulary breadth								
2. L2 vocabulary breadth	–.08							
3. L2 vocabulary depth	–.08	.55***						
4. L2 Text cohesion vocabulary	–.02	.48***	.51***					
5. Word decoding	–.04	.14	.33**	.25*				
6. Woodcock PC	–.01	.60***	.65***	.73***	.47***			
7. Prior topic knowledge	.04	.39**	.51***	.38**	.21	.49***		
8. The global warming test	.07	.37**	.51***	.43***	.42***	.47***	.64***	

N = 67, * $p < .05$, ** $p < .01$, *** $p < .001$

administered using a computerized voice to read the words out loud. The maximum possible score on both tests was 144.

L2 vocabulary depth

The vocabulary subtest from the Wechsler Intelligence Scale for Children, Third edition (WISC-III) was used to measure L2 vocabulary depth. This vocabulary subtask requires the child to explain the meaning of words read out loud by the examiner, thus providing information on productive vocabulary and semantic richness. The task contained 30 words ranked in order of increasing difficulty. All items were scored 0, 1 or 2; a score of 0 points was given for obviously wrong answers or local answers, 1 point was given for vague responses, less pertinent answers or synonyms, while 2 points were given for good synonyms and general classifications. The maximum possible score was 60.

L2 text cohesion vocabulary

A measurement of knowledge of text cohesion vocabulary, (conjunctions such as because, while, despite etc.), was adapted from the Text Cohesion Task (TCT) developed by Crosson et al. (2008) and translated into Norwegian. Text cohesion vocabulary is linguistic devices that carry a high level of meaning in a text because they construct the semantic relationship between sentences or clauses in a text (Crosson et al., 2008). The task was a cloze measure that assesses text cohesion at the sentence level. Each of the 22 items contained two sentences presented in a written format. The connective that linked the ideas between the two sentences was missing. Four choices of connectives were presented to the student. In order to make the task less vulnerable to decoding skills, the examiner read aloud the sentences and the four words of choice, while the student could read along and also re-read the text and the connectives. Each correct word was given 1 point. The maximum possible score was 22.

Word decoding

To measure the students' L2 word reading skills, we used the Test of Oral Word Reading Efficiency- Form A (TOWRE-A) (Torgersen, Wagner, & Rachotte, 1999). A very high correlation (.97) between TOWRE-A and TOWRE-B was recently reported within another sample of native Urdu speaking students in Norway (Lervåg & Aukrust, 2010). The TOWRE requires the child to read aloud as quickly and accurately as possible a list of real words ranked according to difficulty. The score was the number of words read correctly in 45 s and is a combined measure of fluency and accuracy of decontextualized word reading. The maximum possible score was 104.

Passage comprehension

The students' reading comprehension was measured using a Norwegian translation of Woodcock Reading Mastery Test-R, Passage Comprehension (Woodcock, 1989).

This is a cloze-type test format, where the student silently reads unfinished sentences or passages in order of increasing difficulty and suggests an appropriate word to fill in the blank to give the sentence meaning. The ceiling criterion of six wrong answers in a row was used. The maximum possible score was 68.

Prior topic knowledge

The topic of global warming is not systematically covered in the curriculum in Norway until sixth grade. Still, due to the general societal interest of the topic, the children were expected to have some degree of exposure to the subject, both in educational and more informal settings. To measure prior topic knowledge, a questionnaire with 19 items related to global warming was developed by the researchers. The students were given 15 min to complete the task. In line with Valencia, Stallman, Commeyras, Pearson, and Hartman's (1991) discussion of construct validity when assessing prior topic knowledge, the measure of prior topic knowledge included different test formats. Fourteen items were in a conventional multiple choice format (with three distracters) while five items were open-ended questions. In the open-ended questions, the students were asked to write down the meaning of five concepts appearing in the texts (carbon dioxide, atmosphere, energy, climate and produce). While some of these constructs can be characterized as topic-specific (e.g., carbon dioxide), other constructs were more general low frequency academic words (e.g., produce). The students' responses in the open-ended tasks were ranked on a scale from 0–2. For each item, criteria for what qualified as 0, 1 or 2 points were developed by the researchers based on a subsample of the children's answers. Level of abstraction, generality and preciseness were considered when categorizing the answers. Cohen's Kappa for the scoring of open-ended questions was .84 (inter-rater agreement). The maximum achieved score was 14 out of 24 possible. The low score in prior topic knowledge demonstrates that although the students had some degree of knowledge of the topic of global warming, none of the students in this sample could be characterized as experts on the topic.

The texts

Three texts on global warming were constructed by the researchers and consisted of one narrative-based text (665 words), one peer letter to an editor (435 words), and one textbook extract gathered from two different science textbooks for sixth graders (376 words). Because we expected that many of the students would have relatively little knowledge of the topic of global warming, the first two texts were of a more personal nature in the sense that they attempted to evoke interest and engagement in the students. The students read the texts for 20 min. Though this was sufficient time for most of the students taking part in the study to complete the reading task, a few (9 out of 76 students in the original sample) failed to complete it in the allotted time. As the reading comprehension test presupposed that the children had read all three texts, only the 67 students who completed the reading task were included in the final sample.

Content-area reading comprehension

Content-area reading comprehension was measured through a researcher-made test—the Global Warming Test—with questions related either directly to the texts or to questions requiring inferences from information presented in the texts. The scale consisted of 21 items; 14 multiple choice tasks and 7 open-ended questions (‘What is global warming?’ ‘Why is the desert expanding?’). Responses to topic questions were scored on a scale of 0–2 points. From a maximum possible score of 28, the highest score attained was 22. Cohen’s Kappa for the scoring of open-ended questions was .86 (inter-rater agreement).

Reliability

Because the tests utilized in the present study were translated into Norwegian (and one test into Turkish), Chronbach’s Alpha coefficients were calculated for the different measures. As seen in Table 1, the reliability was acceptable for all the measures we employed.

Analysis

We investigated both research questions by using multiple regression analyses. To answer the first research question, we looked at how the predictor variables word decoding, vocabulary breadth, vocabulary depth and text cohesion vocabulary could explain variance in the two different measures of reading comprehension. When addressing the second research question, we used only the Global Warming Test as the outcome variable and included prior topic knowledge as well as an interaction term (between vocabulary depth and prior topic knowledge) among the predictor variables.² Because of the relatively small sample size, we decided to present only one interaction term in the regression analysis. This analysis included the respective first order terms as well as the other predictor variables (e.g., word decoding). Preliminary analyses revealed that potential interaction effects were not significantly altered by including or excluding control variables.

Results

Students’ L1 and L2 vocabulary breadth

The native Turkish speaking children appeared to have a higher mean score on L1 vocabulary breadth ($M = 99.56$, $SD = 19.67$) compared to the native Urdu speaking students ($M = 72.21$, $SD = 23.70$), and this difference was significant ($t = -5.086$, $p < .000$). The native Urdu speaking students had a higher mean score

² The variables vocabulary depth and prior topic knowledge were centered before the interaction term was created to prevent multicollinearity among the first-order terms and the interaction term. The outcome variable content-area reading comprehension was left in its original metric.

on L2 vocabulary breadth ($M = 100.17$, $SD = 16.95$) compared to the native Turkish speaking students ($M = 93.24$, $SD = 18.59$), but this difference was not significant. The standard deviations for L1 and L2 vocabulary breadth showed large variations among the students.

As seen in Table 1, the whole sample of students had higher scores on the measure of L2 vocabulary breadth compared to the measure of L1 vocabulary breadth, indicating that the students as a group were slightly more skilled in L2 Norwegian than they were in L1 Urdu or Turkish. However, as L1 vocabulary breadth was measured with BPVS translated into Urdu or Turkish and L2 vocabulary breadth was measured with PPVT translated into Norwegian, these measures are not directly comparable. It should be mentioned that no significant intergroup differences in L2 language skills were found. Moreover, there were no differences between the native Turkish and Urdu speaking groups in how L1 skills related to L2 skills.

Correlations among the predictor and outcome variables

Correlations among variables (Table 1) revealed that the students' L1 vocabulary breadth did not relate in any significant way to word decoding, L2 vocabulary, prior topic knowledge, or reading comprehension. The different measures of L2 vocabulary; vocabulary breadth, vocabulary depth and text cohesion vocabulary were strongly interrelated. Word decoding was weakly correlated with vocabulary depth and text cohesion vocabulary. Furthermore, students' word decoding skills and L2 vocabulary skills were strongly related to their performance on the Woodcock Passage Comprehension and the Global Warming Test.

Prior topic knowledge was not correlated with word decoding, but with L2 vocabulary and the two measures of reading comprehension. There was a particularly strong relationship between prior topic knowledge on the one hand and vocabulary depth and the Global Warming Test on the other. L2 vocabulary may account for the apparent relationship between prior topic knowledge and the Woodcock Passage Comprehension. When L2 vocabulary was controlled, there was no relationship between prior topic knowledge and the Woodcock Passage Comprehension.

To what extent can word decoding and vocabulary explain variance in the two different measures of L2 reading comprehension (reading short passages versus reading multiple texts on one topic)?

To answer the first research question, we started out by investigating the degree to which word decoding and L2 vocabulary predicted reading comprehension, leaving out L1 vocabulary breadth since this measure was not related to reading comprehension in this group of students. Table 2 presents regression analyses with the Woodcock Passage Comprehension and the Global Warming Test as the outcome variables. Both word decoding, vocabulary breadth and depth and text cohesion vocabulary explained unique variance in the Woodcock Passage Comprehension. As much as 71% of the variance in Woodcock Passage Comprehension was explained by these predictors ($R^2 = .73$). The beta-values reveal that word decoding and text

Table 2 Regression model investigating the role of word decoding and L2 vocabulary on two different measures of reading comprehension

Predictor variables	Outcome variables					
	Woodcock PC			The global warming test		
	<i>B</i>	SE	β	<i>B</i>	SE	β
Word decoding	.14	.04	.26**	.12	.04	.27*
L2 vocabulary breadth	.08	.03	.24**	.02	.03	.10
L2 vocabulary depth	.24	.10	.20*	.23	.11	.27*
L2 text cohesion vocabulary	.67	.12	.45***	.19	.13	.18
R^2	.73			.36		

$N = 67$, * $p < .05$, ** $p < .01$, *** $p < .001$

cohesion vocabulary made relatively large contributions to this model. Less of the variance in the Global Warming Test was explained by the model of word decoding, vocabulary breadth, vocabulary depth, and text cohesion vocabulary ($R^2 = .36$). Only word decoding and vocabulary depth explained unique variance in the Global Warming Test. Interestingly, word decoding explained a similar degree of variance across the two measures of reading comprehension. Word decoding alone explained 26% ($R^2 = .26$) of the variance in Woodcock Passage Comprehension, and 27% ($R^2 = .27$) of the variance in the Global Warming Test.

Beyond word decoding, the L2 vocabulary did not add much variance in the Global Warming Test. Thus, the two measures of reading comprehension seemed to draw upon vocabulary breadth, vocabulary depth and text cohesion vocabulary to very different degrees. For example, as much as 54% ($R^2 = .54$) of the variance in Woodcock Passage Comprehension could be explained by text cohesion vocabulary alone, while 19% ($R^2 = .19$) of the variance in the Global Warming Test was explained by text cohesion vocabulary alone. Although both Woodcock Passage Comprehension and text cohesion vocabulary are based on a cloze task which may account for the high relationship between the two measures, this association between a very specific aspect of L2 vocabulary and L2 reading comprehension is noteworthy. The Woodcock Passage Comprehension measures comprehension at the sentence and passage level and may be particularly sensitive to variations in students' text cohesion vocabulary. When reading multiple texts within the content areas (such as in the Global Warming Test) the students' comprehension at the sentence level may be less critical for grasping the main ideas. Instead students' conceptual knowledge may guide comprehension to a larger extent. This issue was further explored in the second research question.

When reading multiple texts on one topic, what is the relative role of prior topic knowledge, word decoding and vocabulary in explaining L2 reading comprehension?

While the Woodcock Passage Comprehension measure of reading comprehension is designed to diminish the effects of students' prior topic knowledge, students' prior

Table 3 Regression model investigating the role of word decoding, L2 vocabulary, prior topic knowledge and the interaction term vocabulary depth x prior topic knowledge on the Global Warming Test

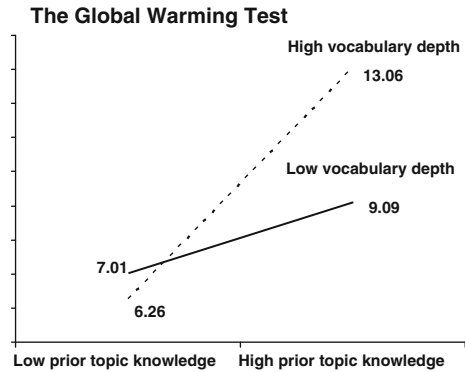
Predictor variables	Outcome variable		
	The global warming test		
	<i>B</i>	SE	β
Word decoding	.10	.04	.24**
L2 vocabulary breadth	.02	.03	.09
L2 vocabulary depth	-.01	.10	-.01
L2 text cohesion vocabulary	.19	.11	.18
Prior topic knowledge	.67	.14	.47***
L2 vocabulary depth x prior topic knowledge	.09	.03	.26**
R^2		.58	

$N = 67$, ** $p < .01$, *** $p < .001$

topic knowledge is likely to play an essential role in their comprehension of content-area texts. In a separate regression analysis (Table 3), we examined the students' performance on the Global Warming Test by including prior topic knowledge among the predictors.

The predictors comprised word decoding, the three measures of L2 vocabulary and prior topic knowledge, in addition to the cross-product multiplicative term between vocabulary depth and prior topic knowledge. This model now explained a significant degree of variance in the Global Warming Test ($R^2 = .58$). As seen in the Beta values, prior topic knowledge explained most of the variance in the Global Warming Test ($\beta = .47$, $p < .001$), suggesting that the students with more prior topic knowledge scored higher on the Global Warming Test. As demonstrated earlier (Table 2), vocabulary depth was the strongest predictor of the Global Warming Test among the different measures of L2 vocabulary. Thus, we investigated the interaction effect between vocabulary depth and prior topic knowledge on the Global Warming Test. Even after including word decoding, L2 vocabulary and prior topic knowledge, the vocabulary depth and prior topic knowledge cross-product contributed significantly to the Global Warming Test, explaining as much as 6% of the variance. The interaction between vocabulary depth and prior topic knowledge is displayed graphically in Fig. 1 (not including the control variables). The steeper curve for the students who were high on both vocabulary depth and prior topic knowledge, suggests that the reading comprehension performance of this group of students surpassed the reading comprehension performance of the students who were low on vocabulary depth and high on prior topic knowledge (or vice versa). This interaction predicts that students with rich semantic representations of words (measured by vocabulary depth) were more likely to benefit from increased prior topic knowledge. At the opposite end, students with limited vocabulary depth were not fully able to utilize their prior topic knowledge to support comprehension of the texts (as seen in the slighter incline in the curve).

Fig. 1 Interaction between vocabulary depth and prior topic knowledge on the Global Warming Test



Discussion

The present study investigated the role of word decoding, vocabulary and prior topic knowledge in fifth graders' L2 reading comprehension. Reading comprehension was measured with the Woodcock Passage Comprehension, a standardized test constructed to minimize the effect of students' prior topic knowledge on their reading scores, and the Global Warming Test, constructed by the authors to represent a more authentic reading task (multiple texts about Global Warming). This latter test included response forms that are more challenging than the cloze procedure employed in the Woodcock Passage Comprehension. A comparison of students' reading comprehension outcomes across these two tests, revealed a large gap in the amount of variance that could be accounted for by the different component skills. This difference was mainly due to a substantially higher contribution of L2 vocabulary in Woodcock Passage Comprehension, while prior topic knowledge seemed to play the most important role in the Global Warming Test.

The following three issues will be discussed in relation to L2 reading comprehension as was measured in the present study (reading short passages versus multiple texts on one topic); (1) the role of word decoding, (2) the role of vocabulary and prior topic knowledge, and (3) the role of L1 competencies in L2 reading comprehension.

First, an interesting finding in this study was that word decoding made a similarly strong contribution to both Woodcock Passage Comprehension and the Global Warming Test. While other studies have reported relatively large disparities in the predictive power of word decoding across different measures of reading comprehension (e.g., Cutting & Scarborough, 2006; Keenan et al., 2008), we found that word decoding skills appeared to be equally imperative for reading comprehension outcomes independent of whether students read short passages or multiple lengthy texts. The fact that students' word decoding skills was a prime predictor of their reading comprehension performance even in fifth grade can probably be explained by the fact that these students were struggling readers compared to their native speaker classmates.

A second finding of the present study was that the role of student's L2 vocabulary skills in their L2 reading comprehension depended upon how reading comprehension was assessed. All three facets of L2 vocabulary measured in this study contributed unique variance to the Woodcock Passage Comprehension, with text cohesion vocabulary playing the most important role. When predicting students' outcome on the Global Warming Test only the vocabulary measure of depth explained unique variance, suggesting that this reading task was most sensitive to the depth and richness of students' semantic representations.

The finding that so much of the variance in Woodcock Passage Comprehension could be accounted for by L2 vocabulary is not surprising in light of the fact that the Woodcock reading comprehension test batteries have high vocabulary load and high syntactic complexity (Francis, Snow, August, Carlson, Miller, & Iglesias, 2006). It is worth noting, however, that students' L2 vocabulary skills were not better predictors of their content-area reading comprehension, since the three texts about global warming also carried a heavy vocabulary load.

One plausible explanation for this finding is that the more general measures of L2 vocabulary do not fully capture the type of vocabulary skills (or vocabulary processes) students need to draw upon in order to comprehend content-area texts more fully. The measure of prior topic knowledge that we developed specifically targeted the low frequency academic words included in the content-area texts the students read. In order to attain high scores on prior topic knowledge, the students needed to draw upon their knowledge base related to the key concepts. Including prior topic knowledge among the predictors significantly improved the amount of variance accounted for in the Global Warming Test. In fact, prior topic knowledge appeared to be the strongest single factor impacting on the students' comprehension of these texts.

Furthermore, our study supports and extends the findings in previous studies (Droop & Verhoeven, 1998; Garcia, 1991) suggesting that middle-grade language-minority students' use of prior topic knowledge in the comprehension process may be constrained because of limited knowledge of the second language. By looking specifically at different aspects of vocabulary, we were able to detect an interesting interaction between vocabulary depth and prior topic knowledge in the Global Warming Test. This interaction suggests that students with limited semantic representations of words in their second language were less able to use their prior topic knowledge for comprehending the texts.

Although the direction of these interactions cannot be determined based on our analysis, it seems plausible to assume that the level of vocabulary skills influenced how students employed their prior topic knowledge in the reading comprehension process. In fact, the interaction between vocabulary depth and prior topic knowledge was evident, even when word decoding and the other facets of vocabulary were controlled. Overall, these findings highlight the specific challenges faced by language-minority students who are acquiring a second language while simultaneously learning from texts in that language. A limited vocabulary in the second language may in itself hamper reading comprehension, but the problem increases because a limited vocabulary additionally affects the process of applying one's prior topic knowledge when reading. This finding suggests that broadening students'

semantic representation of words in the second language may enable them to make use of their prior topic knowledge in the reading comprehension process.

Our study furthermore points to the importance of developing language-minority students' knowledge of the function and meaning of various text cohesion words that appear in the texts. For the skilled reader text cohesion vocabulary may guide the text integration process by linking clauses or sentences together into meaningful units. In this way text cohesion vocabulary is highly supportive of comprehension, but children typically have to learn these words by being exposed to them in written communicative contexts, and they are rarely taught explicitly. An L2 reader who struggles to identify the meaning of words used in written communication may receive little text support in acquiring the meaning of connectives (Degand & Sanders, 2002).

It should be mentioned that there was a higher proportion of unexplained variance in the Global Warming Test compared to the Woodcock Passage Comprehension. When reading lengthy multiple texts, other reader characteristics (such as reading strategies and topic interest) than the component skills we measured in this study are likely to play a role in the student's reading comprehension. In spite of this limitation, our study has demonstrated that prior topic knowledge explains content area reading comprehension, both alone and in interaction with L2 vocabulary. Taken together, these findings imply that students need to be capable of applying both bottom-up and top-down processes for optimal content-area reading comprehension.

Finally, in line with previous research suggesting that vocabulary impacts reading comprehension in a language-specific way, we found that L1 vocabulary breadth was not related to L2 vocabulary breadth or L2 reading comprehension (for review, see Lindsey et al., 2003). Since some studies have pointed to a possible cross-language relationship between higher order L1 and L2 vocabulary (Ordonez et al., 2002), it is a limitation of the present study that we did not attain additional information about the students' L1 vocabulary depth and L1 reading comprehension. In light of the strong influence of prior topic knowledge on L2 reading comprehension that was demonstrated in this study, developing students' prior topic knowledge in both their L1 and L2 may be a fruitful path for enabling language minority students to comprehend content-area texts. Interestingly, Ulanoff and Pucci (1999) found that attempts to build prior topic knowledge in children's first language before reading in their second language seemed to aid vocabulary development. Whereas we made a decision in this study to measure prior topic knowledge in L2 based on L2 being the language of instruction in the schools, future research should address how prior topic knowledge acquired and measured in L1—and thereby not dependent upon L2 skills—may support L2 reading comprehension for young readers with limited L2 vocabulary skills.

Acknowledgments We would like to thank the students and teachers who contributed their time and interest to this study. We would also like to thank Gunnar Bjørnebekk for his help in making the figure demonstrating the interaction effect reported in this study. Parts of the findings presented in this article have been presented at the 2009 biennial meeting of the European Association for Research on Learning and Instruction, Amsterdam, The Netherlands, and at the 2009 annual meeting of the Society for Scientific Studies of Reading, Boston USA.

Open Access This article is distributed under the terms of the Creative Commons Attribution Non-commercial License which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author(s) and source are credited.

References

- Aasen, J., & Mønnes, E. N. (1999). *Minoritetselever i grunnskolen. Analyse av ressursbehovet til særskilt norsk- og morsmålsopplæring* [Minority students in primary and lower secondary school. Analysis of the need for resources in Norwegian as a second language- and mother tongue education]. Høgskolen i Hedmark.
- Alexander, P. A., & Jetton, T. L. (2000). Learning from text: A multidimensional and developmental perspective. In M. L. Kamil, P. B. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research* (Vol. III, pp. 285–310). New York: Routledge.
- August, D., Carlo, M., Dressler, C., & Snow, C. (2005). The critical role of vocabulary development for English language learners. *Learning Disabilities Research & Practice, 20*, 50–57.
- Best, R. M., Floyd, R. G., & McNamara, D. S. (2008). Differential competencies contributing to children's comprehension of narrative and expository texts. *Reading Psychology, 29*, 137–164.
- Carlisle, J. F., Beeman, M. M., Davis, L.-H., & Spharim, G. (1999). Relationship of metalinguistic capabilities and reading achievement for children who are becoming bilingual. *Applied Psycholinguistics, 20*, 459–478.
- Chen, Q., & Donin, J. (1997). Discourse processing of first and second language biology texts: Effects of language proficiency and domain-specific knowledge. *The Modern Language Journal, 81*, 209–227.
- Cromley, J. G., & Azevedo, R. (2007). Testing and refining the direct and inferential mediation model of reading comprehension. *Journal of Educational Psychology, 99*, 311–325.
- Crosson, A. C., Lesaux, N. K., & Martiniello, M. (2008). Factors that influence comprehension of connectives among language minority children from Spanish-speaking backgrounds. *Applied Psycholinguistics, 29*, 603–625.
- Cunningham, A. E., & Stanovich, K. (1997). Early reading acquisition and its relation to reading experience and ability 10 years later. *Developmental psychology, 83*, 264–274.
- Cutting, L. E., & Scarborough, H. S. (2006). Prediction of reading comprehension: Relative contributions of word recognition, language proficiency, and other cognitive skills can depend on how comprehension is measured. *Scientific Studies of Reading, 10*, 277–299.
- Degand, L., & Sanders, T. (2002). The impact of relational markers on expository text comprehension in L1 and L2. *Reading and Writing: An Interdisciplinary Journal, 15*, 739–757.
- Donin, J., & Silva, M. (1993). The relationship between first- and second-language reading comprehension of occupation-specific texts. *Language Learning, 43*, 373–401.
- Droop, M., & Verhoeven, L. (1998). Background knowledge, linguistic complexity, and second-language reading comprehension. *Journal of Literacy Research, 30*, 253–271.
- Droop, M., & Verhoeven, L. (2003). Language proficiency and reading ability in first- and second-language learners. *Reading Research Quarterly, 38*, 78–103.
- Dunn, L., & Dunn, L. (1997). *Peabody picture vocabulary test (PPVT-III)* (3rd ed.). Circle Pines, MN: American Guidance Service.
- Dunn, L., Dunn, L., Whetton, C., & Burley, J. (1997). *British picture vocabulary scale II*. Windsor: NFER-Nelson.
- Fletcher, J. M. (2006). Measuring reading comprehension. *Scientific Studies of Reading, 10*(3), 323–330.
- Francis, D. J., Snow, C. E., August, D., Carlson, C., Miller, J., & Iglesias, A. (2006). Measures of reading comprehension: A latent variable analysis of the diagnostic assessment of reading comprehension. *Scientific Studies of Reading, 10*, 301–322.
- García, G. E. (1991). Factors influencing the English reading test performance of Spanish speaking Hispanic children. *Reading Research Quarterly, 26*, 453–465.
- Goldenberg, C., Rueda, R. S., & August, D. (2006). Sociocultural influences on the literacy attainment of language-minority children and youth. In D. August & T. Shanahan (Eds.), *Developing literacy in second-language learners: Report of the National Literacy Panel on language-minority children and youth* (pp. 269–318). Mahwah, NJ: Lawrence Erlbaum.

- Hacquebord, H. (1994). L2-reading in the content areas: Text comprehension in secondary education in the Netherlands. *Journal of Research in Reading, 17*, 83–98.
- Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing, 2*, 127–169.
- Johnston, P. (1984). Prior knowledge and reading comprehension test bias. *Reading Research Quarterly, 19*, 219–239.
- Keenan, J. M., Betjemann, R. S., & Olson, R. K. (2008). Reading comprehension tests vary in the skills they assess: Differential dependence on decoding and oral comprehension. *Scientific Studies of Reading, 12*, 281–300.
- Kieffer, M. J., & Lesaux, N. K. (2007). The role of derivational morphology in the reading comprehension of Spanish-speaking English language learners. *Reading and Writing: An Interdisciplinary Journal, 21*, 783–804.
- Lervåg, A., & Aukrust, V. G. (2010). Vocabulary knowledge is a critical determinant of the difference in reading comprehension growth between first and second language learners. *Journal of Child Psychology and Psychiatry, 51*, 612–620.
- Lesaux, N. K., Lipka, O., & Siegel, L. S. (2006). Investigating cognitive and linguistic abilities that influence the reading comprehension skills of children from diverse linguistic backgrounds. *Reading and Writing: An Interdisciplinary Journal, 19*, 99–131.
- Lindsey, K. A., Manis, F. R., & Bailey, C. E. (2003). Prediction of first-grade reading in Spanish-speaking English-language learners. *Journal of Educational Psychology, 95*, 482–494.
- McNamara, D. S., Kintsch, E., Songer, N. B., & Kintsch, W. (1996). Are good texts always better? Interactions of text coherence, background knowledge, and levels of understanding in learning from text. *Cognition and Instruction, 14*, 1–43.
- Nakamoto, J., Lindsey, K. A., & Manis, F. R. (2007). A longitudinal analysis of English language learners' word decoding and reading comprehension. *Reading and Writing: An Interdisciplinary Journal, 20*, 691–719.
- Norwegian Directorate for Education and Training. (2010). Grunnskolen Informasjonssystem (GSI). Retrieved from <http://www.wis.no/stat09/application/main.jsp?languageId=1>.
- Norwegian Ministry of Education and Research. (2007). *Equal Education in Practice! Strategy for better teaching and greater participation of linguistic minorities in kindergartens, schools and education 2007–2009*.
- Ordonez, C. L., Carlo, M. S., Snow, C. E., & McLaughlin, B. (2002). Depth and breadth of vocabulary in two languages: which vocabulary skills transfer? *Journal of Educational Psychology, 94*, 719–728.
- Pearson, P. D., Hiebert, E. H., & Kamil, M. L. (2007). Source theory and research into practice: Vocabulary assessment: What we know and what we need to learn. *Reading Research Quarterly, 42*, 282–296.
- Proctor, C. P., August, D., Carlo, M., & Snow, C. (2006). The intriguing role of Spanish vocabulary knowledge in predicting English reading comprehension. *Journal of Educational Psychology, 98*, 159–169.
- Proctor, C. P., Carlo, M., August, D., & Snow, C. (2005). Native Spanish-speaking children reading in English: Toward a model of comprehension. *Journal of Educational Psychology, 97*, 246–256.
- Samuelstuen, M., & Bråten, I. (2005). Decoding, knowledge, and strategies in comprehension of expository texts. *Scandinavian Journal of Psychology, 46*, 107–117.
- Sanchez, E., & Garcia, J. R. (2009). The relation of knowledge of textual integration devices to expository text comprehension under different assessment conditions. *Reading and Writing: An Interdisciplinary Journal, 22*, 1081–1108.
- Spires, H. A., & Donley, J. (1998). Prior knowledge activation: Inducing engagement with informational texts. *Journal of Educational Psychology, 90*, 249–260.
- Torgersen, J., Wagner, R., & Rachotte, C. (1999). *Test of word-reading efficiency*. Austin, TX: PRO-ED.
- Ulanoff, S. H., & Pucci, S. L. (1999). Learning words from books: The effects of read aloud on second-language vocabulary acquisition. *Bilingual Research Journal, 23*, 319–332.
- Valencia, S. W., Stallman, A. C., Commeyras, M., Pearson, P. D., & Hartman, D. K. (1991). Four measures of topical knowledge: A study of construct validity. *Reading Research Quarterly, 26*, 204–233.
- Woodcock, R. W. (1989). *Woodcock reading mastery tests revised*. Circle Pines, MN: American Guidance Service.