COMPUTER-BASED ASSESSMENT OF READING IN 7- TO 10 Y-O CHILDREN: THE ROLE OF VOCABULARY IN WORD READING AND COMPREHENSION

N. Bailloud¹, P. Auphan¹, A. Magnan¹², J. Ecalle¹

¹ Laboratoire d’Etude des Mécanismes Cognitifs (EMC) ; LabEx CORTEX ANR-11-LABX-0042 (FRANCE)  
² Institut Universitaire de France (IUF) (FRANCE)

Abstract

This study aims at assessing reading ability in primary school children. One hundred ninety-eight French-speaking children in grade 2 (N=48), grade 3 (N=50), grade 4 (N=50), and grade 5 (N=50) were assessed using a computer-based program. Efficiency and accuracy were recorded. Word Reading was assessed with a phonological decoding task, an orthographic discrimination task and a semantic categorization task. Reading and listening comprehension were assessed using texts with three types of questions to examine literal and two inferential processes (text-connecting inferences and knowledge-based inferences). Vocabulary depth was assessed with questions about properties and categories of target words in the latter texts. Results from analyses of variance showed an effect of the grade level on the four components. Supplementary regression analyses highlight the emerging role of vocabulary knowledge as word reading processes become more and more automated. This study provided a complete and accurate assessment of reading skill. An analysis of performance according to grade should provide important information about reading processes and difficulties which children may encounter during primary school.

Keywords: Reading, Comprehension, Vocabulary, Computer-based assessment.

1 INTRODUCTION

The aim of this study is to present a computer-based assessment (CBA) of reading skills and vocabulary. Using CBA has two major advantages: standardization of items and automatic data collection, especially the speed of processing which is a good indicator of reading ability in all components. According to the "Simple View of Reading" (SVR) [1], reading ability is the product of word identification and listening comprehension processes. Word identification is described as a process that activates phonological, orthographic and semantic representations. But, this first process might not be sufficient. Reading also requires listening comprehension processes to extract meaning from words, sentences and discourses. In this context, vocabulary belongs to comprehension processes. However, according to other authors [3]-[5], vocabulary could also be an external component that would directly affect reading comprehension and word identification [2]. Many studies reported that vocabulary measures account for a unique source of variance in reading comprehension. As a matter of fact, vocabulary knowledge affected reading comprehension over and above the contributions made by word identification processes and listening comprehension processes [3]-[5].

Two theories of reading detail the explicit role of vocabulary. 1/ According to the lexical restructuration theory, vocabulary is strongly related to the development of phonological awareness [6]. Indeed, phonological representations supporting word identification processes are becoming increasingly segmented as vocabulary develops. In this context, phonological awareness is limited by the nature of phonological representation. Many studies have highlighted the indirect role of vocabulary both in the development of phonological awareness [7], [8] and in word identification processes [9], [10]. 2/ In the lexical quality theory, vocabulary depth (i.e., semantic representations of word) is critical to reading comprehension [2], [11]. This theory suggests that variations in quality of lexical representation have implications for comprehension skills. A lexical representation is of high quality when it includes fully specified phonological, orthographic and semantic representations leading to a rapid retrieval of lexical representations. In contrast, a low-quality representation leads to specific problems in comprehension processes [11]. Many studies provide evidence of correlations between depth vocabulary, reading comprehension [12]-[14], and vocabulary instruction [15], [16]. To summarize, numerous authors suggested the need for extending the SVR model and implement vocabulary to explain reading comprehension.
As for the exact role of vocabulary in reading skill and reading comprehension, there are unanswered questions. The present research explored the relations between vocabulary, listening comprehension and reading comprehension from grade 2 to grade 5 using a computer-based assessment. Since each component of the SVR is evaluated, it is possible to examine precisely the weight of vocabulary in reading and comprehension abilities.

We expect that 1/ scores taking into account accuracy and speed should increase with grade levels and 2/ that the weight of vocabulary should also increase with age and reading expertise. With respect to the lexical quality (Perfetti & Hart, 2002), vocabulary knowledge should be more critical for reading comprehension across grade.

2 METHODOLOGY

2.1 Participants

Initially, results were collected from a sample of 371 students attending primary school and middle school. When collecting middle school student’s data, we had to face technical problems preventing us from using their results. Therefore, in this study, we present only data from 198 primary school students (from grade 2 to grade 5). The students were recruited from two primary schools in Rhône-Alpes Auvergne areas. No schools were considered as area for special help in education (ZEP). All participants spoke French as their first language. Table 1 shows the number of male and females and the mean age for each grade.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Male</th>
<th>Female</th>
<th>Age (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>23</td>
<td>25</td>
<td>90.77 (7.5)</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>32</td>
<td>99.40 (14.4)</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>26</td>
<td>114.18 (4.14)</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>30</td>
<td>121.08 (14.02)</td>
</tr>
</tbody>
</table>

2.2 Assessments

The software program (DiCoLec; Diagnostic de la Compréhension en Lecture; Diagnosis of Reading Comprehension) included tasks for each component of reading ability. Four components of reading ability were assessed: Word reading, listening comprehension, reading comprehension and vocabulary.

2.2.1 Word Reading

The participants performed two trials before each Word Reading task. For all word reading tasks, two measures were recorded: the number of correct responses and the response times. To eliminate outlier’s response times, two operations were conducted for each participant: 1/ response times that were over two standard deviations from the mean were replaced by the mean response time; 2/ after replacement, a mean response time was recalculated. Finally, the ratio between mean response times and correct responses, which we refer to as the speed-accuracy indicator (SAI)\(^1\) was selected as the final score.

Three levels of lexical representations were examined in three different tasks. In the Phonological decoding, the children had to decide whether two pseudo-words could be pronounced in the same way: 10 yes (e.g., baccal/bacqua) and 10 no (e.g: rozan/rossan). In the Orthographic discrimination, the children had to decide whether two pairs of items were identical or not: 16 yes (e.g. tente-tente) and 16 no (e.g. rubis/rudis). Finally, in the Semantic categorization the children had to decide whether two words were semantically related: 18 pairs were related (“yes” responses: pomme – poire; apple – pear) and 18 pairs were not (“no” responses: pomme-salon; apple – living room). A global score SAI (mean of the scores in the three tasks) has been calculated for each participant.
2.2.2 Reading and Listening comprehension

In reading comprehension task, the children had to read silently two texts presented on the computer screen (see Fig. 1), a short and simple one (text A, 110 words) and a longer and complex one (text B, 233 words). In listening comprehension task, the children had to listen to a text read aloud by the software (a man’s voice): a short and simple one (text C, 115 words) and a longer and complex one (text D, 233 words). Reading and listening texts were then followed by 12 questions (read by the participant for reading comprehension, read by the software for oral comprehension): four related to explicit textual information, four requiring the construction of a text-connecting inference via the resolution of an anaphora, and four requiring the production of a knowledge-based inference. Questions were forced-choice and comprised two distractors and only one correct answer. To respond, children had to click on the response they thought correct. After reading (or hearing) the questions, children could also look back at the text. In the listening condition, they could also listen to the question and possible answers again. The order of the questions was randomized.

Two measures were recorded: the weighted scores for correct responses (2 points if correct answer without return to the text, 1 point if correct answer with return to the text, 0 point if wrong answer) and the time taken to respond.

![Figure 1. Example of the reading comprehension task presenting an explicit textual information question.](image)

\[
\text{SAI} = \left( \frac{\text{Correct Answers}}{\text{Total Answers}} \times \frac{1}{\text{MeanResponseTime}} \right) \times 1000
\]

2.2.3 Vocabulary

Here, we examined vocabulary depth through categories and properties of each word selected in the texts. Children had to decide whether propositions about a target word were right or wrong. Eight words were selected from comprehension texts with three questions for each word, resulting in 24 questions in total: 12 “yes” responses (e.g. “un ballon est-il rond?” – Is a ball round?) and 12 “no” responses (e.g. “un chat aboie-t-il?” – Does a cat bark?). Two measures were recorded: the number of correct responses and the response time. The dependent variable used was the SAI.

2.3 Procedure

All participants were administered the computer-based assessment individually but sessions were collectives. Sessions lasted from 45 to 60 min. Tasks were proposed in a pseudo-random fashion. Vocabulary-related tasks were administered at the final step of assessment because these tasks were based on words from the comprehension texts.
### 3 RESULTS

#### 3.1 Grade-Level Differences Effect

Analyses of Variance (ANOVAs) were conducted with Grade as a between-subject factor on the SAIs for the four tasks. We observed a significant effect of Grade for each task (see Fig. 2).

In the **Word reading task**, a significant effect of the grade was found ($F(3, 194) = 23.317, p < .0001$) with better results as a function of grade. Tuckey Post-hoc test revealed significant differences between G2 ($M = .20; SD = .01$) and G3 ($M = .26; SD = .01; p < .05$), but not between G3 and G4 ($M = .31; SD = .01; p = .07$) and, between G4 and G5 ($M = .35; SD = .01; p = .14$).

In the **Listening Comprehension task**, a significant effect of the grade was found ($F(3, 194) = 7.4221, p < .0001$) with better results as a function of grade. Tuckey Post-hoc test revealed no significant differences between G2 ($M = .1.01; SD = .09$) and G3 ($M = 1.03; SD = .09; p = .99$), between G3 and G4 ($M = 1.34; SD = .09; p = .053$) and, between G4 and G5 ($M = 1.50; SD = .09; p = .58$).

In the **Reading Comprehension task**, a significant effect of the grade was found ($F(3, 194) = 15.795, p < .0001$) with better results as a function of grade. Tuckey Post-hoc test revealed significant differences between G2 ($M = .18; SD = .02$) and G3 ($M = .30; SD = .02; p < .05$), between G4 ($M = .29; SD = .02$) and G5 ($M = .39; SD = .02$) but not between G3 and G4 ($p = .96$).

In the **Vocabulary task**, a significant effect of the grade was found ($F(3, 194) = 12.155, p < .0001$) with better results as a function of grade. Tuckey Post-hoc test revealed significant differences between G3 ($M = .81; SD = .06$) and G4 ($M = 1.05; SD = .06; p < .05$) but not between G2 ($M = .76; SD = .06$) and G3 ($M = .81; SD = .06, p = .94$), and between G4 and G5 ($M = 1.23; SD = .06; p = .17$).

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**Figures 2. Scores (SAI) in function of Grade.**
3.2 Weight of vocabulary in primary school

Two multiple regressions analyses were used to test the hypothesis of vocabulary contribution to reading comprehension, one on the students in Grade 2 and 3 (i.e., participants with non-automated reading abilities) and one on the students in Grade 4 and 5 (i.e., participants with more automated reading abilities). The models are presented in Table 2.

<table>
<thead>
<tr>
<th>Table 2. Multiple regression analyses for reading comprehension</th>
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<tbody>
<tr>
<td>Grade 2-3 (N=98)</td>
</tr>
<tr>
<td>1. Word reading</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2. Listening compren.</td>
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<tr>
<td>3. Vocabulary</td>
</tr>
<tr>
<td>Grade 4-5 (N=100)</td>
</tr>
<tr>
<td>1. Word reading</td>
</tr>
<tr>
<td>2. Listening compren.</td>
</tr>
<tr>
<td>3. Vocabulary</td>
</tr>
</tbody>
</table>

In the group of younger children (G2-G3), word reading accounted for 45% of the variance in reading comprehension. Listening comprehension explained 25% of variance in reading comprehension. Vocabulary did not contribute to reading comprehension. These data highlighted the critical role of word reading in reading comprehension at the beginning of the instruction of reading.

In the group of older children (G4-G5), word reading explained 40% of the variance in reading comprehension. Vocabulary accounted for 31% of the variance in reading comprehension. Listening comprehension did not seem to contribute. These results are consistent with the idea that vocabulary knowledge becomes important as word reading processes are more and more automated.

4 CONCLUSIONS

The present research examines the weight of vocabulary knowledge in reading comprehension. The present results reported the specific role of vocabulary depth in reading comprehension. Results show that, when reading abilities are not fully automated, vocabulary did not seem to significantly contribute to reading comprehension. On the contrary, when reading abilities seem more automated, vocabulary now significantly account for a source of variance in reading comprehension. When less resources are allocated to word reading processing, vocabulary knowledge could start contributing to reading comprehension.

Beyond the effects shown in this study, we will briefly review the highlights of using a computer-based assessment to examine the different components of reading. Most noticeably, standardization of tests on a large sample of children are made possible and could allow to measure precisely accuracy and speed of access to lexical representations. The computer software, called DiCoLec, offers to evaluate the three levels of lexical representations, comprehension processes in the oral and written modality as well as vocabulary depth. An entire assessment of reading ability should enable reader profiles to be established to propose remediation in reading skills.

REFERENCES


