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The High Potential of Computer-Based Reading Assessment

Le potentiel élevé de l'évaluation informatisée de la lecture

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Abstract

The aim of this study is to propose advantages provided by computerized tools when assessing reading ability. A new computer-based reading assessment evaluating both word reading and reading comprehension processes was administered to 687 children in primary (N=400) and secondary (N=287) schools. Accuracy (weighted scores) and speed of access (response times) automatically recorded by the software were analyzed based on developmental issues (ANOVAS), correlation matrices, structural equation modeling, and clinical interpretation. Results underlined the validity and reliability of the tool. The discussion addresses the limitations of the present computer-based assessment and presents perspectives for taking fuller advantage of computerized technologies.

Keywords: computer-based assessment, word reading, reading comprehension, primary and secondary children, validity, reliability

Résumé

L'objectif de cette étude est de présenter les avantages qu'apportent les outils numériques pour l'évaluation de l'habileté en lecture. Un nouvel outil informatisé évaluant les processus d'identification de mots écrits et la compréhension en lecture a été proposé à 687 élèves d'école primaire (N=400) et de collège (N=287). Des analyses statistiques (ANOVAS, matrices de corrélation, modélisation d'équation structurelle) et une interprétation clinique ont été réalisées à partir de deux types de données enregistrées automatiquement par le logiciel : la précision (scores pondérés) et la vitesse (temps de réponses). Les résultats soulignent la validité et la fiabilité de l'outil. La discussion porte sur les limites du présent outil informatisé et présente les perspectives pour tirer un meilleur profit des technologies numériques.

Introduction

Two criteria are essential for the quality of a reading assessment. Firstly, the reading assessment must be constructed based on psychological theories (Carlson, Seipel, & McMaster, 2014). Secondly, the validity and the reliability of the measures must be verified (Kimberlin & Winterstein, 2008). Validity refers to the ability of the test to measure the cognitive skills for which it was designed (Smith, 2005). Satisfying this criterion is largely based on the choice of the underlying theoretical model to answer the question: how should we assess reading ability? Reliability indicates the extent to which the task reflects the real level of the cognitive skill assessed, based, for example, on the stability of the results from one test to the next for one and the same patient (Mowbray, Holter, Teague, & Bybee, 2003). This criterion is also demanding in terms of the construction of the material (selection of items, inter-item homogeneity) and the definition of, and respect for, the test conditions (time of item presentation, recorded measures). This second aspect seems to benefit considerably from the advantages of computerized tools (Protopapas & Skaloumbakas, 2007; Richter, Isberner, Naumann, & Neeb, 2013).

The aim of this study is to present the benefits of using computer-based assessment (CBA) to evaluate reading ability (i.e., the ability to read a text and understand its meaning) in a large sample of French students from grade two to grade nine. Indeed, reading is an essential skill for both daily life (reading signs) and social life (keeping informed by reading the newspaper), as well as for academic success (reading and understanding instructions) and, therefore, also professional success (OCDE, 2016). Since the tool was designed for screening for reading difficulties and for use by professionals who are not necessarily experts in the field of reading, a simple reading framework has been chosen: the Simple View of Reading, which describes two main reading components (i.e., word reading and comprehension; Hoover & Gough, 1990; Protopapas, Simos, Sideridis, & Mouzaki, 2012). Moreover, the tool was created with the objective of screening a large range of students: from grade two, in which the focus of learning is based more on word reading, to grade nine, in which the learning focus is placed more on comprehension and, more specifically, inferences (Ebert & Scott, 2016; Ouellette & Beers, 2009; Tilstra, McMaster, Van den Broek, Kendeou, & Rapp, 2009; Vellutino, Tunmer, Jaccard, & Chen, 2007). We will present a number of arguments indicating the benefits of computerized technologies in enhancing the validity and reliability of assessment tools. This study supports the idea that CBA could be a promising tool permitting the rapid, accurate examination of students' performance and allowing professionals to undertake suitable interventions for poor readers.

Why and How to Assess Reading Ability?

There are many theoretical approaches to assessing reading ability and these can be either competing or complementary. The right approach will depend on the objectives of the evaluation. Several of these approaches are worth looking at, including two major approaches: first, evaluations undertaken to detect difficulties and, second, evaluations undertaken to test theoretical models (Cain & Oakhill, 2006). The way the assessment is constructed may vary depending on the objective. When undertaken to examine the relevance of a theoretical framework, evaluations are intended for interpretation by experts in the field of reading research. Therefore, it makes sense to administer a wide variety of tasks designed to examine the complexity of reading (Kim, 2017; Massonnié, Bianco, Lima, & Bressoux, 2018; Perfetti & Stafura, 2014; Vellutino, Tunmer, Jaccard, & Chen, 2007). In the context of the detection of difficulties, the evaluation is intended to be interpreted by professionals who are not necessarily experts in reading. Thus, the underlying theoretical framework should be simple. Moreover, as it is designed for use by non-experts, the results should be quickly available and easily understood. The present study will deal only with evaluations aimed at screening for reading difficulties.

Which Theoretical Framework Should be Used to Assess Reading Ability?

Classically, the complexity of reading ability has been paradoxically simplified through reference to two distinct and independent components: the decoding component, based on print-dependent processes, and the linguistic component, based on print-independent processes (Protopapas et al., 2012). Indeed, according to the *Simple View of Reading* (SVR; Gough & Tunmer, 1986; Hoover & Gough, 1990), reading ability can be summarized using the classic formula: R = D*C, where R is the reading ability represented by reading comprehension performance, D corresponds to decoding processes and more generally to word reading[1], and C to linguistic comprehension. Numerous studies have criticized the simplicity of the SVR approach, including with reference to the independence of the decoding and comprehension components (Tunmer & Chapman, 2012). However, recent studies have argued in favour of the SVR approach and provide support for the independence of these two components. Using structural equation modelling, studies involving English-speaking children (Cain & Chiu, 2018; Kim, 2017) or French-speaking children (Massonnié, Bianco, Lima, & Bressoux, 2018) have shown that the models that best fit the data are those for which the D and C components fully mediate the influence of language and cognitive abilities on reading comprehension. Authors explain their objections to the SVR in terms of developmental issues alone. Before children learn to read, decoding and linguistic comprehension are thought to be linked through phonological awareness. Indeed, phonological awareness is thought to depend on oral language abilities (C) but should also predict decoding performance. However, this link should disappear when children learn to read and phonological awareness would then be solely related to D (Catts et al., 2015). In sum, despite its seeming simplicity, the well-known formula presented above should not cover over the complexity of the different sub-processes involved in the decoding and comprehension components of reading (Kim, 2017).

The Lexical Quality Hypothesis (LQH; Perfetti & Hart, 2002) can be used to specify the sub-processes of decoding. In this approach, word reading processes are characterized by three levels of word representation stored in the mental lexicon which establish a link with reading comprehension processes: the orthographic (i.e., the spelling of the word) and phonological (i.e., the sound of the word) inputs that contribute to breadth of vocabulary; and the semantic input (i.e., the meaning of the word) that contributes to depth of vocabulary (Ouellette, 2006). A high lexical quality requires the synchronous and rapid retrieval of these word-reading representation levels and is necessary for successful reading comprehension (Richter et al., 2013). This lexical quality hypothesis has been integrated in a complete Reading System Framework (Perfetti & Stafura, 2014) that sees the mental lexicon as intermediate between decoding and comprehension-related processes (Swart et al., 2016) mediated by lexical quality (Cartwright, 2007). In addition, with regard to comprehension, we can consider literal processes relating to information explicitly presented in the text, on the one hand, and inferential processes related to implicit information, on the other. Moreover, within the inferential processes, there is a further distinction between text-connecting inferences, in which the reader has to link together several items of textual information, and

[1] "*But we firmly believe that word recognition skill (in an alphabetic orthography) is fundamentally dependent upon knowledge of letter-sound correspondence rules*" (Gough & Tunmer, 1986, p. 7).

gap-filling inferences, in which readers have to relate textual information to their own general knowledge (Oakhill & Cain, 2006).

To summarize, if the two components of reading in the SVR model seem too simple or imprecise to assess reading, then by combining this approach with LQH and integrating the literal and inferential processes in comprehension, it might be possible to provide a more precise framework for assessing the two components of reading ability.

Why Use Computers to Assess Reading?

Over the last 10 years, an increasing number of new technologies have been used to assess reading ability and the related skills, such as phonological awareness or vocabulary (for examples, see Richter et al., 2013; Schaefer, Bowyer-Crane, Herrmann, & Fricke, 2015).

The advantages of CBA relate to three aspects. First, with respect to task characteristics, computers provide more precise measurements and identify a level of reading expertise based on two measurable variables (Protopapas & Skaloumbas, 2007): the number of correct answers, referred to as accuracy, and the response time, referred to as speed of processing (speed of access to the lexical representations; processing speed of the explicit and implicit information). It is very important to record response times because a high processing speed is a characteristic of automated processes. Therefore, computerized assessment is a good way of obtaining precisely these two measures (Richter, et al., 2013). The fact that the tests are administered in a standardized manner for all children enhances the reliability of the measurement (Terzis & Economides, 2011). For example, timings and presentation speeds can be controlled precisely. These benefits are supported by the greater interest that test-takers express in computer-based reading tests compared to conventional tests (Singleton, 2001) as well as by the possibility of using multimodal (and hence more attractive) items (i.e., visual/audio items; Wang, Jiao, Young, Brooks, & Olson, 2008).

Second, computerized assessments of reading ability are easy to implement. Indeed, the benefits of controlled task presentation and the automatic recording of measures make the tool easy-to-use for professionals in both individual and collective test conditions (Singleton, 2001). Moreover, they also make it possible to obtain immediate and specific scores, either in the form of composite scores (e.g., combining accuracy and speed of access) or of standardized scores. However, this immediate scoring does not eliminate the need to synthesize and interpret the results (Protopapas & Skaloumbakas, 2007). Nevertheless, it makes it possible for practitioners to concentrate on the observation and collection of clinical data during the test session. In addition, the raw scores must continue to be accessible to the practitioner as an aid to interpretation.

Third, CBA offers advantages for the subject being evaluated. Indeed, the attractive aspect of computerized tools encourages motivation and engagement in the task (Chua & Don, 2013). Attentional resources are therefore recruited in an optimal way that provides a better indication of performance and reduces the attentional variation bias of the subjects evaluated (Terzis & Economides, 2011). In addition, interaction with the computerized tool rather than with the professional can reduce the stress of the evaluation situation. Finally, the software environment provides sufficient guidance to ensure that subjects can act independently to some extent (Protopapas & Skaloumbakas, 2007). As a result, the use of computerized tools seems to be beneficial for populations with specific needs including populations with attention disorders or social and communication difficulties (Lin, Chang, Liou, & Tsai, 2013).

Conversely, the use of new technologies for reading has raised some issues such as the harmful impact of screens on reading comprehension and long-term memory encoding (Mangen, Walgermo, & Brønnick, 2013) due to (a) increased cognitive demand linked to digital exploration on the assessment tool (Salmerón & Delgado, 2019) or (b) the more rapid reading which occurs on digital media, due to the so-called *scrolling-effect* (Dyson & Haselgrove, 2001). However, Margolin et al., (2013) found that there was no significative difference in reading comprehension depending on the reading medium (paper, computer, or e-book). In another study, Wang et al. (2008) found that the validity of a computer-based test was similar to that of a paper-based test, with some variability depending on subjects' familiarity with the digital tool. Finally, due to the importance of new technologies in everyday life as well as in school and professional environments, current research should no longer focus on the impact of new technologies on reading but more on how to improve reading using digital media (Singer & Alexander, 2017). For example, the harmful impact of new technologies (such as the diversion of cognitive resources away from understanding and toward digital navigation) can be partially reduced by paying particular attention to the ergonomic qualities of the software (Bastien & Scapin, 1995; Dambreville & Bétrancourt, 1998; Ros & Rouet, 2006; Tricot et al., 2003).

Research Questions

The aim of this study was to explore the contribution of computer-based tools to assess reading. In this purpose, children from grade two to grade nine were evaluated on word reading and reading comprehension using a computer-based reading assessment. For each task, two measures were recorded: accuracy and speed. Four research questions were investigated:

(1) How do response times and correct responses change in the four tasks according to grade?
(2) What are the links between intra- and inter-task measures in primary students and secondary students?
(3) Are the data in accordance with the model of reading ability tested through the two components, namely word reading and reading comprehension?
(4) How could professionals benefit from CBA in order to obtain results quickly?

Method

Participants

The reading ability of 687 children from urban primary and secondary schools in the East of France was evaluated from grade 2 to grade 9. The grade samples consisted of 65 to 124 students each (see Table 1). All of them were normally developing children and none had repeated a school year. They were all French-speaking and had no specific learning problems. Children with deviant scores in any of the tasks (i.e., differences of two standard deviations above or below the group mean for the same grade) were excluded. The present study was conducted in accordance with the Declaration of Helsinki (Association Médicale Mondiale, 1964). All the participants' parents were informed.

Table 1
Distribution of Children from Grade 2 to Grade 9 and Their Mean Age

Grades	*N*	Boys/Girls	Mean age
G2	82	40 / 42	7;7
G3	98	38 / 60	8;5
G4	124	62 / 62	9;7
G5	96	48 / 48	10;5
G6	65	35 / 30	11;8
G7	70	36 / 34	12;8
G8	68	38 / 30	13;8
G9	84	34 / 50	14;9

Material and Procedure

The software program consisted of several tasks addressing two components of reading ability, namely word reading and reading comprehension[2]. The same tasks were administered to all the children. In word reading, three silent reading tasks evaluated the precision and speed of access to different features of the lexical representations: an orthographic discrimination task, a phonological decoding task, and a semantic categorization task (see Figure 1; see Table 2 for their characteristics). The participants performed two trials before each task.

Table 2
Characteristics of the three word reading tasks

Tasks	Orthographic Discrimination	Phonological Decoding	Semantic Categorization
Instructions	Deciding whether two pairs of items were identical or not	Deciding whether two pseudo-words could be pronounced in the same way	Deciding whether two words were semantically related or not

[2] The psychometric properties and materials of those tasks are detailed in another paper (Auphan, Ecalle & Magnan, 2018) dealing with readers' subtypes.

Material	16 pairs of identical words 16 words paired with 16 visually similar pseudo-words Variation on: length: short (5 letters) or long (9-10 letters), frequency: frequent (mean U[a] = 82.37) or rare (mean U = 4.04)	16 pairs of pseudo-words Variation on: one or two syllables	36 pairs of words of two syllables Variation on: lexical frequency: two frequent words, one frequent word and one rare word or two rare words strength of association based on semantic relationships[b] (high, low or non-associated)
Responses	16 yes (e.g., *tente-tente*) 16 no (e.g., *rubis/ rudis*	10 yes (e.g., *baccai/ baquai*), - 10 no (*rozan/rossan*)	18 yes (*pomme – poire)* 18 no (*pomme-salon*)
Reliability	.88	.77	.83
Scores	weighted score (see paragraph below titled word reading scoring) response time speed-accuracy indicator (SAI[c]; see paragraph below titled Word reading scoring)		

Note .[a] U index from the French Manulex database (*Lété, Sprenger-Charolles, & Colé*, 2004). [b] categorized as high or low on the basis of a Latent Semantic Analysis.

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

In the reading comprehension task, the children read silently to themselves two texts presented on the computer screen (see Figure 2): a short and simple text (text A, 110 words) and a longer more complex text (text B, 233 words). Each of the texts was followed by 12 questions read by the participant: four related to explicit textual information, four required the construction of a text-connecting inference via the resolution of an anaphora, and four required the production of a knowledge-based inference. The questions were forced-choice and comprised two distractors and only one correct answer. To respond, the children clicked on the response they thought correct. After reading the questions, the children could also look back at the text. The order of the questions was randomized.

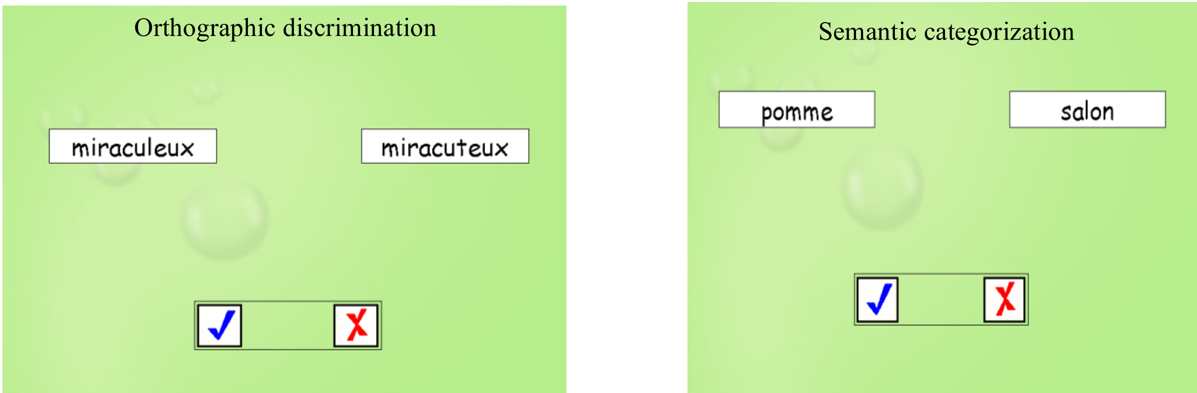


Figure 1. Screenshots of two tasks in word reading.

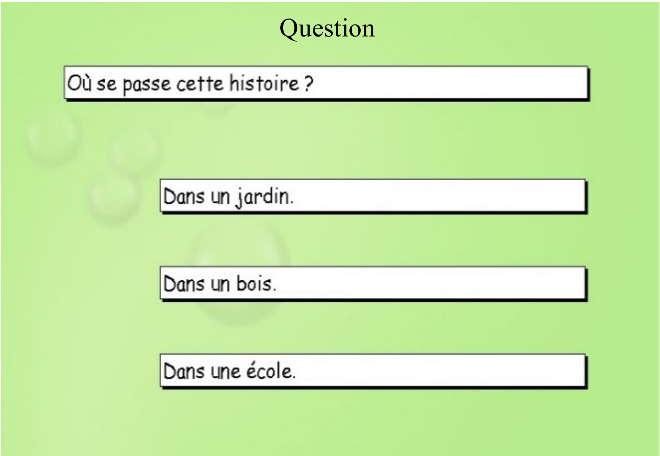


Figure 2. Screenshot of a question in reading comprehension.

Word reading scoring.

Two measures were recorded: the weighted score (the number of correct responses minus the number of errors), and the response time. In order to eliminate aberrant response times (outliers), a two-step operation was 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. Another score was also calculated to consider both accuracy and response time simultaneously. This was the ratio between mean response times and correct responses, which we refer to as the speed-accuracy indicator (SAI).

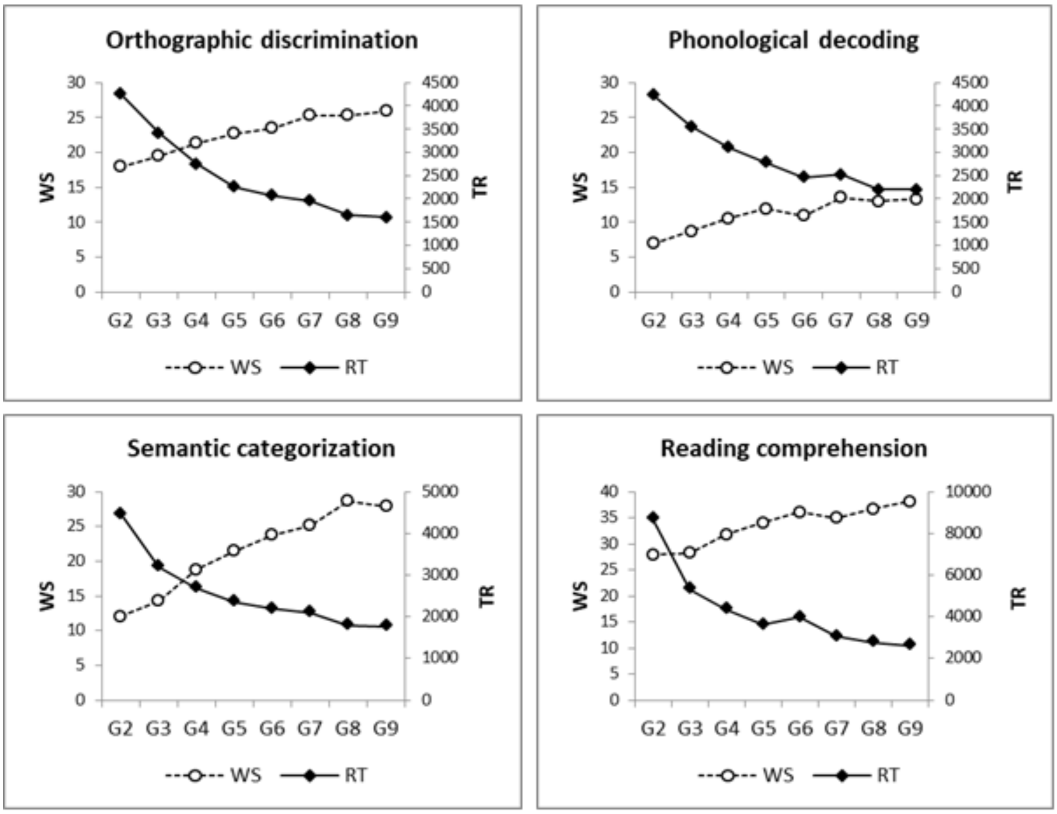
Reading comprehension scoring.

Two measures were recorded: the weighted scores for correct responses (two points if correct answer without return to the text, one point if correct answer with return to the text, zero points if wrong answer) and the time taken to respond (recording started after the children had clicked to display all the possible answers). The reliability for text A was .72 and for text B it was .75. Weighted scores and SAI were calculated for the two texts.

Results

The results will be presented in four phases to respond to the four research questions.

Evolution of performance from Grade 2 to Grade 9.



Figures 3. Evolution of the weighted scores (WS) and response times (TR in minutes) in the four reading tasks depending on grade level (G).

We observed a significant change in performance on the two measures, with weighted scores increasing and reaction times decreasing as expected from grade 2 to grade 9 (Figure 3). In line with developmental trajectories of reading acquisition (Ebert & Scott, 2016; Tilstra et al., 2009), the slope of the performance change (weighted scores and response times) was less marked during secondary than during primary school. Indeed, the differences between all measures were greater from grade 2 to grade 5 than from grade 6 to grade 9 (see Table 3).

Table 3

Results of ANOVAS and Differences of Weighted Scores and Response Times Between Grade 5 and Grade 2 and Between Grade 9 and Grade 6

Tasks	Scores	$F(7,679)$	$p <$	η^2	G5-G2	G9-G6
OD	WS	10.7	.0001	.10	4.7	2.3
	TR	69.97	.0001	.42	-2002	-472
PD	WS	10.56	.0001	.10	5	2.4
	TR	26.79	.0001	.22	-1453	-265
SC	WS	33.82	.0001	.26	9.5	4

	TR	41.88	.0001	.30	-2109	-409
RC	WS	18.38	.0001	.16	6.2	2
	TR	47.61	.0001	.33	-5081	-1363

Note. OD: orthographic discrimination; PD: phonological decoding; SC: semantic categorization; RC: reading comprehension; WS: weighted scores; TR: response times (in minutes).

Links between performance in the four tasks.

Table 4

Correlation Matrix Between Weighted Scores and Reaction Times in the Four Tasks for Primary Students (Lower Left) and Secondary Students (Upper Right)

	OD WS	OD TR	PD WS	PD TR	SC WS	SC TR	RC WS	RC TR
OD WS		.06	.39*	-.01	.23*	-.06	.21*	-.26
OD TR	.16*		-.03	.53*	-.18*	.61*	-.11	.38*
PD WS	.36*	-.02		.02	.34*	.01	.25*	-.24*
PD TR	.03	.52*	.06		.06	.53*	.01	.47*
SC WS	.37*	-.07	.46*	.02		-.02	.36*	-.14*
SC TR	.06	.60*	-.03	.56*	.04		-.01	.40*
RC WS	.25*	-.17*	.44*	-.05	.56*	-.18*		-.29*
RC TR	-.18*	.39*	-.26	.30*	-.29*	.43*	-.36*	

Note. OD: orthographic discrimination; PD: phonological decoding; SC: semantic categorization; RC: reading comprehension; WS: weighted scores; TR: response times (in minutes); *: significant

It is of particular interest to examine two types of link in greater detail (see Table 4): the intra-task links (white cells with borders) and the inter-task links with the weighted scores (light gray cells) and the response times (dark gray cells). For the former, in both groups, we observed very weak correlations between word reading scores (only one was significant in the orthographic discrimination task but still very low at .16). However, in reading comprehension, the links were greater and negative (-.36; -.29). The inter-task links between weighted scores were higher, in particular in the case of the links between semantic categorization and reading comprehension (.56 in primary students; .36 in secondary students). Finally, the same observation can be made at the level of the response times in the four tasks. To summarize, we found no obvious relationship between weighted scores and response times in word reading. On the other hand, in reading comprehension globally, when response times increased, the weighted scores were better, both in the primary and secondary students.

Structure of reading ability.

We specified a structural model in which reading comprehension is explained by word reading (Figure 4). We used the outcomes that took account of accuracy and speed (SAI) across the entire sample (*N*=687). The data were analyzed using Stata 14. To examine the model fit multiple indices were used, including chi-square (χ^2), comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residuals (SRMR). All the fit indexes were as expected from SEM analyses (Schreiber, Nora, Stage, Barlow, & King, 2006): $\chi^2(8) = 35.17$, $p < .0001$; CFI = .99; TLI = .98; SRMR = .03; RMSEA = .07. Moreover, we observed a high correlation between word reading and reading comprehension (.73).

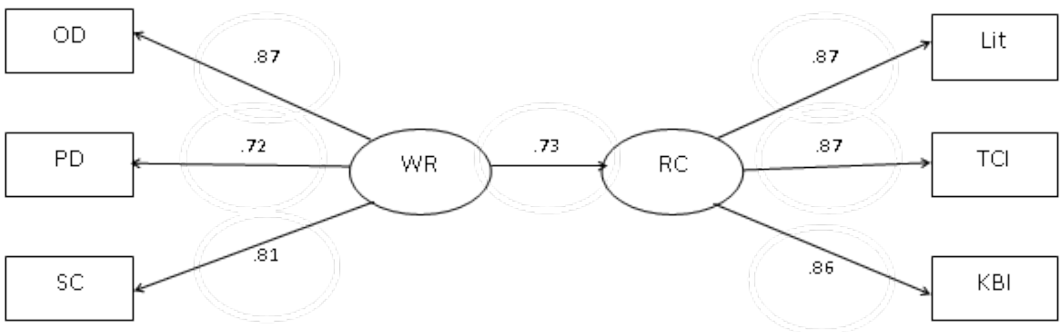


Figure 4. Structural model depicting reading ability through its two components: word reading (WR) with questions relating to orthographic discrimination (OD), phonological decoding (PD), semantic categorization (SC); and questions investigating reading comprehension (RC) with literal (Lit), text-connecting (TCI), knowledge-based (KBI) inferences.

Summary presentation of the results for a student.

Figure 5 presents the performance of a student obtained just after the administration of the tasks. The reading performance is defined by the two variables accuracy (weighted scores) and speed (response times). On the horizontal axis with the *z* scores, 0 corresponds to the mean for a grade level. Performances above the mean are indicated on the right (positive *z* score; +1 sd and so on) and performances below the mean are indicated on the left (negative *z* score; -1 sd and so on). By comparing the results of a student with his or her reference group (age and grade), professionals can quickly estimate whether the student's performance in each task is ahead of or behind the norm, and can also do so separately for accuracy and speed. Indeed, a student may perform well on accuracy even though reading slowly (high response times) and the opposite may also be true. For example, in Figure 5, we can observe a discrepancy in the orthographic discrimination and phonological decoding tasks between accuracy (negative *z* score) and low response times (positive *z* score), meaning that this student seemed to have responded quickly but somewhat inaccurately. This kind of discrepancy could help professionals identify how students perform such reading tasks.

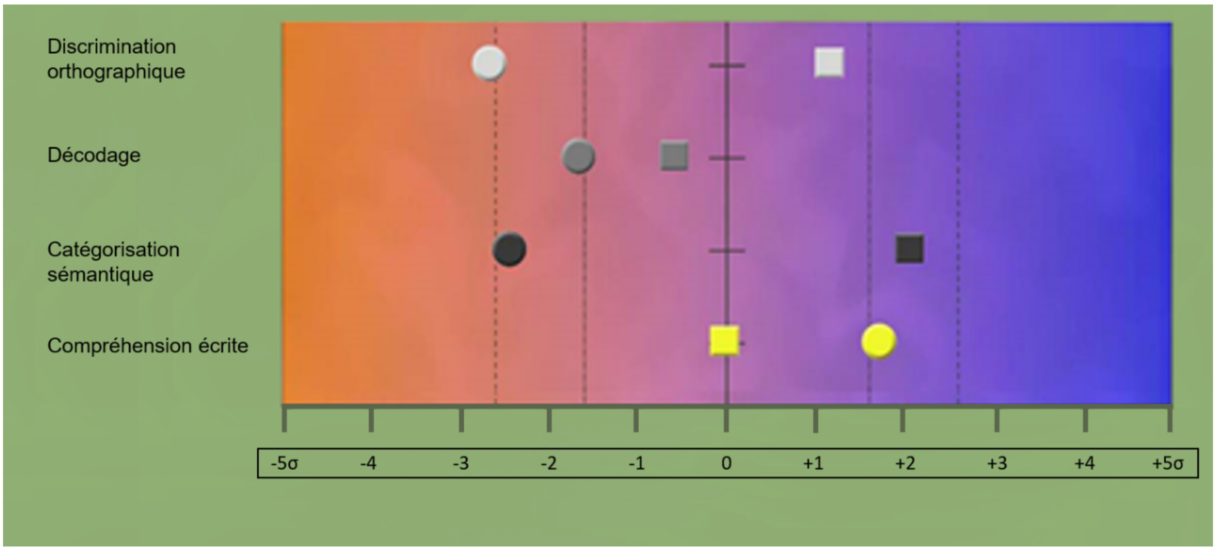


Figure 5. Screenshot of the presentation of the performance (square for speed and circle for accuracy) of a student in the four tasks.

Discussion

Summary and Interpretation of the Results

The main objective of this study was to emphasize the advantages of using a computerized tool to assess reading ability. Four research questions were addressed in order to examine the criteria of sensitivity, reliability, theoretical validity as well as practical aspects of CBA.

How do TR and WS change in the four tasks according to grades?

Performance measured in terms of both weighted score (accuracy) and response time (speed of access) changed from grade 2 to grade 9: weighted scores increased, whereas response times decreased, both indicating an improvement in performance with grade. It is worth noting that these changes were particularly pronounced in primary school but were smaller in secondary school. The results for these two indicators revealed grade-related task sensitivity, thus attesting in part to the reliability of the assessment.

What are the links between intra- and inter-task measures in primary students and secondary students?

The quality of the recorded measures attesting to task reliability was assessed by means of intra- and inter-task correlations. The intra-task correlation revealed a non-significant correlation between weighted scores and response times for all word reading tasks (except for orthographic discrimination, for which there was a low correlation coefficient). These results differ from those presented by Richter et al. (2013). Indeed, in their study, significant negative correlations were found between response times and weighted scores for each of the three word reading tasks that examined word representation level. The differences between our results and those of Richter et al. (2013) could be due to task differences between the two studies (oral versus written presentation, item length and frequency), as suggested by Balota and Chumbley (1984). For the reading comprehension task, weighted scores and response times were negatively correlated. This result is consistent since response times for this task include reading the three forced-choice options and then picking the one that best answers the question. In other words, response times for this task include word reading performances and this affected performance in reading comprehension as suggested by the SVR (Hoover & Gough, 1990): the slower word reading is, the lower the accuracy during reading comprehension.

Correlations between all tasks were good, both for weighted scores and response times, and this was particularly true of the correlation between semantic categorization and reading comprehension. This result is consistent with the idea that semantic processes might act as an intermediate between phonological and orthographical word representation levels and reading comprehension, as described in the more recent Reading System Framework (Perfetti & Stafura, 2014) and also suggested by research on vocabulary (Braze et al., 2016; Colenbrander, Kohnen, Smith-Lock, & Nickels, 2016; Ouellette & Beers, 2009). Moreover, this result is consistent with the results of Richter et al. (2013): using structural equation modelling on three word reading tasks and one reading comprehension task, they found that orthographic and phonological performances were indirectly related to reading comprehension through semantic performances that mediate their influence. It should be noted that correlations between word reading tasks and reading comprehension were lower for secondary than for primary school students. In line with several developmental studies (Cain & Chiu, 2018; Chen & Vellutino, 1997; Tilstra et al., 2009), word reading seems to explain more variance in reading comprehension at the beginning of reading acquisition, whereas linguistic comprehension processes seem to explain more variance in higher grades as the word reading processes become more automated.

Are the data consistent with the model of reading ability tested through the two components, WR and RC?

Structural equations modelling (SEM) was used to test the theoretical validity of the tool. SEM computations were performed using SAI, a measure that combines response times and weighted scores. Each lexical quality task correlated well with the word reading component, and each comprehension processing task correlated well with the reading comprehension component. What is more, the two components, word reading and reading comprehension, were highly correlated. However, to be fully compatible with the SVR (Ebert & Scott, 2016; Hoover & Gough, 1990), this battery still needs a task that evaluates comprehension isolated from word reading (i.e., listening comprehension). This constitutes one major limitation of this study.

How can professionals benefit from CBA to obtain results quickly?

The main objective of this study was to argue that the use of a computer-based tool could enhance the reliability and validity of assessments. Moreover, a further advantage lies in the practical nature of the tool. Indeed, automatic recording of precise off-line and on-line data (Schatz & Browndyke, 2002) coupled with the automatic scoring facilitates implementation by professionals. Beyond the automatic recording of the measures, the possibility of recording several type of measures easily and precisely makes it possible to track students, behaviour (Jeong, 2014) in the form of motivation (Wise & DeMars, 2006;

Wise & Kong, 2005) or reading strategies (Gil, Martinez, & Vidal-Abarca, 2015). For example, based only on an examination of the response times and correct response scores taken separately, it is possible to reveal different kinds of behaviour in test-takers (Table 5). If accuracy is good (score higher than random level) and speed of access is rapid (low response time score), it can be inferred that the test-taker uses the reading processes efficiently. If accuracy is good but speed of access is slow (high response time score), it can be inferred that the test-taker is able to use the reading processes but does not do so efficiently (processes not automated) or that the test-taker has a globally slow cognitive functioning (i.e., population with cognitive disabilities, as is the case of some subjects with autism for example, Mayes & Calhoun, 2008; Oliveras-Rentas, Kenworthy, Roberson, Martin, & Wallace, 2012). If accuracy is low (correct response score not different from random level) and speed of access is rapid, it can be inferred that the test-taker uses rapid guessing behaviour (Lee & Jia, 2014) that could be due to low motivation or a high level of difficulty (Kong, Wise, & Bhola, 2007). Finally, if accuracy is low and speed of access is slow, it can be inferred that the test-taker presents impaired processes.

Table 5

Tracking Test-Takers' Behaviour Through an Examination of Response Times and Correct Responses

		Response Time	
		Low	High
Correct response	Random	Rapid guessing behaviour (impulsivity due to high item difficulty or low motivation)	Impaired processes
	> random	Efficient processes	Global slowness of functioning or Non-automated processes

The present CBA can therefore extend the solutions available in French and complement existing tools, such as, for example, Evalec (Evaluation de la Lecture [*Reading Assessment*]; Pourcin, Sprenger-Charolles, El Ahmadi, & Colé, 2016; Sprenger-Charolles, Colé, Béchennec, & Kipffer-Piquard, 2005) and TInfoLec (Test Informatisé de la Lecture [*Computerized Reading Test*]; Beauvais et al., in press), both of which test only word reading and associated skills such as phonological skills and letter knowledge.

Limitations

Three principal limitations of this study need to be pointed out. First, the same tasks were administered for all the children, from grade two to grade nine, thereby reducing sensitivity of the test. However, task normalization for each grade level makes it possible to screen for reading difficulties. Second, it lacks a task evaluating comprehension processes isolated from reading processes, in essence, listening comprehension. This second limitation is directly related to the third one, namely that evaluating comprehension processes is complex. Three aspects make it difficult: (a) question format, (b) the assessment of reading strategies (e.g., using number of returns to the text), and (c) the recording of the response times.

In this battery, the choice was made to use a forced-choice question format in order to allow easy automatic scoring. On the one hand, the forced-choice question format facilitates comprehension processes, in particular in terms of inference processing (Cain & Oakhill, 2006; Ozuru, Best, Bell, Witherspoon, & McNamara, 2007). On the other, open-ended questions are difficult to implement in CBA because they would limit automatic scoring and would require the recording of oral responses.

In order to increase the sensitivity and reliability of the comprehension task, recent research has focused on the second aspect: how to assess test-takers' reading strategies (see, for example, the Read & Answer technology presented in Vidal-Abarca et al., 2011, or the analysis of behavioural data recorded on computer in Greiff, Niepel, Scherer, & Martin, 2016). To this end, it would be interesting to propose different reading contexts (e.g., reading stories for entertainment or reading informative texts to search for information) and use different measures (e.g., reading times, number of returns to the text) to test whether readers change their strategies depending on the reading objectives. For example, readers can use several strategies: first read the text and then answer the questions or go directly to the questions and return to the text to find specific information in order to provide the answer (Cerdán, Vidal-Abarca, Martinez, Gilabert, & Gil, 2009; Gil, Martinez, & Vidal-Abarca, 2015). This would make it possible to evaluate the functional aspect of reading (Ros & Rouet, 2006), in essence, the adaptation of reading strategies depending on the reading objective.

The third aspect that impacts evaluation of reading processes is the difficulty of recording response times. For example, in the present reading comprehension task, response time recording started when the children clicked to display all possible choices. Furthermore, response time did not only measure the time to process comprehension but also the time to read the choices. Further research on response time recording should be undertaken to improve measurements in the test (Wise & DeMars, 2006), for example by displaying the optimum item response time to test-takers in order to avoid rapid guessing behaviours (Delen, 2015).

Conclusion

Computer-based assessment is a good way to obtain a simple, low-cost, and easy-to-use assessment tools for professionals without affecting validity or reliability, and indeed even improving these criteria (Delen, 2015) compared to paper-based tests. This results from the fact that computerized tools (1) provide ways of controlling standardized item presentation as well as precisely recording off-line and, particularly, on-line measures that contribute to the evaluation of reading processes (Gil, Martinez, & Vidal-Abarca, 2015; Richter et al., 2013) and (2) increase students’ motivation (Terzis & Economides, 2011), especially when care is paid to ergonomic criteria such as utility and usability (Maqableh, Moh’d Taisir Masa, & Mohammed, 2015, for details on the ergonomic evaluation of a tool, see Bastien & Scapin, 1995). Nevertheless, and in order to go further, recent research on computer-based tests emphasizes the need to go beyond simply matching paper-based and computer-based assessments and take advantage of all the characteristics of computerized technologies that offer additional benefits compared to paper-based tools. Furthermore, using a CBA should make it possible to (1) directly evaluate the quality of the specific processes that are being assessed (e.g., accuracy with number of correct response) and the strategies used (e.g., reading time, number of returns to the text) in the light of (2) the quality of task engagement and the level of motivation (response time, total amount of time spent on evaluation compared to accuracy). Despite this, further research is necessary to explore in detail the links between reading performances, reading strategies, and test-takers' behaviour and indicate how to interpret these.

Authors' Note:

Statement of human rights. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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References

Association Médicale Mondiale. (1964). Déclaration d'Helsinki: Principes éthiques applicables à la recherche médicale impliquant des êtres humains.

Auphan, P., Ecalle, J., & Magnan, A. (2018). Computer-based assessment of reading ability and subtypes of readers with reading comprehension difficulties: a study in French children from G2 to G9. *European Journal of Psychology of Education,* 1-23.

Balota, D. A., & Chumbley, J. I. (1984). Are lexical decisions a good measure of lexical access? The role of word frequency in the neglected decision stage. *Journal of Experimental Psychology: Human Perception and Performance, 10*(3), 340. doi:10.1037/0096-1523.10.3.340

Bastien, J. C., & Scapin, D. L. (1995). Evaluating a user interface with ergonomic criteria. *International Journal of Human-Computer Interaction, 7*(2), 105–121.

Beauvais, L., Bouchafa, H., Beauvais, C., Kleinsz, N., Ecalle, J., & Magnan, A. (in press). Tinfolec: A new French web-based test for reading assessment in primary school. *Canadian Journal of School Psychology.*

Braze, D., Katz, L., Magnuson, J. S., Mencl, W. E., Tabor, W., Van Dyke, J. A., & Shankweiler, D. P. (2016). Vocabulary does not complicate the simple view of reading. *Reading and Writing, 29*(3), 435–451. doi:10.1007/s11145-015-9608-6

Cain, K., & Chiu, Y.-D. (2018). The simple view of reading across development: The prediction of grade 3 reading comprehension by prekindergarten skills. *Remedial and Special Education.* doi:10.1177.0741932518762055

Cain, K., & Oakhill, J. (2006). Assessment matters: Issues in the measurement of reading comprehension. *British Journal of Educational Psychology, 76*(4), 697–708. doi:10.1348/000709905X69807

Carlson, S. E., Seipel, B., & McMaster, K. (2014). Development of a new reading comprehension assessment: Identifying comprehension differences among readers. *Learning and Individual Differences, 32,* 40–53. doi:10.1016/j.lindif.2014.03.003

Cartwright, K. B. (2007). The contribution of graphophonological-semantic flexibility to reading comprehension in college students: Implications for a less simple view of reading. *Journal of Literacy Research, 39*(2), 173–193. doi:10.1080/10862960701331902

Catts, H. W., Herrera, S., Nielsen, D. C., & Bridges, M. S. (2015). Early prediction of reading comprehension within the simple view framework. *Reading and Writing, 28*(9), 1407-1425.

Cerdán, R., Vidal-Abarca, E., Martinez, T., Gilabert, R., & Gil, L. (2009). Impact of question-answering tasks on search processes and reading comprehension. *Learning and Instruction, 19*(1), 13–27. doi:10.1016/j.learninstruc.2007.12.003

Chen, S, R., & Vellutino, F. R. (1997). Prediction of reading ability: A cross-validation study of the simple view of reading. *Journal of Literacy Research, 29*(1), 1–24. doi: 10.1080/10862969709547947

Chua, Y. P., & Don, Z. M. (2013). Effects of computer-based educational achievement test on test performance and test takers' motivation. *Computers in Human Behavior, 29*(5), 1889–1895. doi:10.1016/j.chb.2013.03.008

Colenbrander, D., Kohnen, S., Smith-Lock, K., & Nickels, L. (2016). Individual differences in the vocabulary skills of children with poor reading comprehension. *Learning and Individual Differences, 50,* 210–220. doi:10.1016/j.lindif.2016.07.021

Dambreville, S. C., & Bétrancourt, M. (1998). Ergonomie des documents techniques informatisés: Expériences et recommandations sur l'utilisation des organisateurs para-linguistiques. *Les Hypermédias: Approches Cognitives et Ergonomiques,* 123–138.

Delen, E. (2015). Enhancing a computer-based testing environment with optimum item response time. *Eurasia Journal of Mathematics, Science & Technology Education, 11*(6). doi:10.12973/eurasia.2015.1404a

Dyson, M. C., & Haselgrove, M. (2001). The influence of reading speed and line length on the effectiveness of reading from screen. *International Journal of Human-Computer Studies, 54*(4), 585–612. doi:10.1006/ijhc.2001.0458

Ebert, K. D., & Scott, C. M. (2016). Bringing the simple view of reading to the clinic: Relationships between oral and written language skills in a clinical sample. *Journal of Communication Disorders, 62,* 147–160. doi:10.1016/j.jcomdis.2016.07.002

Gil, L., Martinez, T., & Vidal-Abarca, E. (2015). Online assessment of strategic reading literacy skills. *Computers & Education, 82,* 50–59. doi:10.1016/j.compedu.2014.10.026

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education, 7*(1), 6–10. doi:10.1177/074193258600700104

Greiff, S., Niepel, C., Scherer, R., & Martin, R. (2016). Understanding students' performance in a computer-based assessment of complex problem solving: An analysis of behavioral data from computer-generated log files. *Computers in Human Behavior, 61,* 36–46. doi:10.1016/j.chb.2016.02.095

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing, 2*(2), 127–160. doi:10.1007/BF00401799

Jeong, H. (2014). A comparative study of scores on computer-based tests and paper-based tests. *Behaviour & Information Technology, 33*(4), 410–422. doi:10.1080/0144929X.2012.710647

Kim, Y. S. G. (2017). Why the simple view of reading is not simplistic: Unpacking component skills of reading using a direct and indirect effect model of reading (DIER). *Scientific Studies of Reading, 21*(4), 310-333.

Kimberlin, C. L., & Winterstein, A. G. (2008). Validity and reliability of measurement instruments used in research. *American Journal of Health-System Pharmacy, 65*(23), 2276–2284. doi:10.2146/ajhp070364

Kong, X. J., Wise, S. L., & Bhola, D. S. (2007). Setting the response time threshold parameter to differentiate solution behavior from rapid-guessing behavior. *Educational and Psychological Measurement, 67*(4), 606–619. doi:10.1177/0013164406294779

Lee, Y.-H., & Jia, Y. (2014). Using response time to investigate students' test-taking behaviors in a NAEP computer-based study. *Large-Scale Assessments in Education, 2*(1), 8. doi:10.1186/s40536-014-0008-1

Lété, B., Sprenger-Charolles, L., & Colé, P. (2004). MANULEX: A grade-level lexical database from French elementary school readers. *Behavior Research Methods, Instruments, & Computers, 36*(1), 156–166. doi:10.3758/BF03195560

Lin, C.-S., Chang, S.-H., Liou, W.-Y., & Tsai, Y.-S. (2013). The development of a multimedia online language assessment tool for young children with autism. *Research in Developmental Disabilities, 34*(10), 3553–3565. doi:10.1016/j.ridd.2013.06.042

Mangen, A., Walgermo, B. R., & Brønnick, K. (2013). Reading linear texts on paper versus computer screen: Effects on reading comprehension. *International Journal of Educational Research, 58,* 61–68. doi:10.1016/j.ijer.2012.12.002

Margolin, S. J., Driscoll, C., Toland, M. J., & Kegler, J. L. (2013). E-readers, Computer Screens, or Paper: Does Reading Comprehension Change Across Media Platforms? *Applied Cognitive Psychology, 27*(4), 512–519. doi:10.1002/acp.2930

Maqableh, M., Moh'd Taisir Masa, R., & Mohammed, A. B. (2015). The acceptance and use of computer based assessment in higher education. *Journal of Software Engineering and Applications, 8*(10), 557. doi:10.4236/jsea.2015.810053

Massonnié, J., Bianco, M., Lima, L., & Bressoux, P. (2018). Longitudinal predictors of reading comprehension in French at first grade: Unpacking the oral comprehension component of the simple view. *Learning and Instruction, 60,* 166-179. Retrieved from https://eprints.bbk.ac.uk/26172/

Mayes, S. D., & Calhoun, S. L. (2008). WISC-IV and WIAT-II Profiles in Children With High-Functioning Autism. *Journal of Autism and Developmental Disorders, 38*(3), 428–439. doi:10.1007/s10803-007-0410-4

Mowbray, C. T., Holter, M. C., Teague, G. B., & Bybee, D. (2003). Fidelity Criteria: Development, Measurement, and Validation. *American Journal of Evaluation, 24*(3), 315–340. doi:10.1177/109821400302400303

OCDE. (2016). Les élèves en difficulté pourquoi décrochent-ils et comment les aider à réussir?

Oliveras-Rentas, R. E., Kenworthy, L., Roberson, R. B., Martin, A., & Wallace, G. L. (2012). WISC-IV Profile in High-Functioning Autism Spectrum Disorders: Impaired Processing Speed is Associated with Increased Autism Communication Symptoms and Decreased Adaptive Communication Abilities. *Journal of Autism and Developmental Disorders, 42*(5), 655–664. doi:10.1007/s10803-011-1289-7

Ouellette, G., & Beers, A. (2009). A not-so-simple view of reading: how oral vocabulary and visual-word recognition complicate the story. *Reading and Writing, 23*(2), 189–208. doi:10.1007/s11145-008-9159-1

Ouellette, G. P. (2006). What's meaning got to do with it: The role of vocabulary in word reading and reading comprehension. *Journal of Educational Psychology, 98*(3), 554–566. doi:10.1037/0022-0663.98.3.554

Ozuru, Y., Best, R., Bell, C., Witherspoon, A., & McNamara, D. S. (2007). Influence of question format and text availability on the assessment of expository text comprehension. *Cognition and Instruction, 25*(4), 399–438. doi:10.1080/07370000701632371

Perfetti, C. A., & Hart, L. (2002). The lexical quality hypothesis. *Precursors of Functional Literacy, 11,* 67–86.

Perfetti, C., & Stafura, J. (2014). Word knowledge in a theory of reading comprehension. *Scientific Studies of Reading, 18*(1), 22–37. doi:10.1080/10888438.2013.827687

Pourcin, L., Sprenger-Charolles, L., El Ahmadi, A., & Colé, P. (2016). Reading and related skills in Grades 6, 7, 8, and 9: French normative data from EVALEC. *Revue Européenne de Psychologie Appliquée/European Review of Applied Psychology, 66*(1), 23–37. doi:10.1016/j.erap.2015.11.002

Protopapas, A., Simos, P. G., Sideridis, G. D., & Mouzaki, A. (2012). The components of the simple view of reading: A confirmatory factor analysis. *Reading Psychology, 33*(3), 217–240. doi:10.1080/02702711.2010.507626

Protopapas, A., & Skaloumbakas, C. (2007). Traditional and computer-based screening and diagnosis of reading disabilities in Greek. *Journal of Learning Disabilities, 40*(1), 15–36. doi:10.1177/00222194070400010201

Richter, T., Isberner, M.-B., Naumann, J., & Neeb, Y. (2013). Lexical quality and reading comprehension in primary school children. *Scientific Studies of Reading, 17*(6), 415–434. doi:10.1080/10888438.2013.764879

Ros, C., & Rouet, J. F. (2006). L'Ergonomie des Logiciels de Lecture: un Savoir-Faire en Emergence. *Lecture et Technologie Numériques: Enjeux et Défis Des Technologies Numériques Pour l'enseignement et Les Pratiques de Lecture,* 181–206.

Salmerón, L., & Delgado, P. (2019). Critical analysis of the effects of the digital technologies on reading and learning / Análisis crítico sobre los efectos de las tecnologías digitales en la lectura y el aprendizaje. *Culture and Education, 31*(3), 465–480. doi:10.1080/11356405.2019.1630958

Schaefer, B., Bowyer-Crane, C., Herrmann, F., & Fricke, S. (2015). Development of a tablet application for the screening of receptive vocabulary skills in multilingual children: A pilot study. *Child Language Teaching and Therapy,* 1–13. doi:10.1177/0265659015591634

Schatz, P., & Browndyke, J. (2002). Applications of computer-based neuropsychological assessment. *The Journal of Head Trauma Rehabilitation, 17*(5), 395–410. doi:10.1207/S15324826AN1001_6

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of Educational Research, 99*(6), 323–338. doi:10.3200/JOER.99.6.323-338

Singleton, C. (2001). Computer-based assessment in education. *Educational and Child Psychology, 18*(3), 58–74.

Smith, G. T. (2005). On Construct Validity: Issues of Method and Measurement. *Psychological Assessment, 17*(4), 396–408. doi:10.1037/1040-3590.17.4.396

Sprenger-Charolles, L., Colé, P., Béchennec, D., & Kipffer-Piquard, A. (2005). French normative data on reading and related skills from EVALEC, a new computerized battery of tests (end Grade 1, Grade 2, Grade 3, and Grade 4). *Revue Européenne de Psychologie Appliquée/European Review of Applied Psychology, 55*(3), 157–186. doi:10.1016/j.erap.2004.11.002

Swart, N. M., Muijselaar, M. M., Steenbeek-Planting, E. G., Droop, M., de Jong, P. F., & Verhoeven, L. (2016). Differential lexical predictors of reading comprehension in fourth graders. *Reading and Writing,* 1–19. doi:10.1007/s11145-016-9686-0

Terzis, V., & Economides, A. A. (2011). The acceptance and use of computer based assessment. *Computers & Education, 56*(4), 1032–1044. doi:10.1016/j.compedu.2010.11.017

Tilstra, J., McMaster, K., Van den Broek, P., Kendeou, P., & Rapp, D. (2009). Simple but complex: Components of the simple view of reading across grade levels. *Journal of Research in Reading, 32*(4), 383–401. doi:10.1111/j.1467-9817.2009.01401.x

Tricot, A., Plégat-Soutjis, F., Camps, J.-F., Amiel, A., Lutz, G., & Morcillo, A. (2003). Utilité, Utilisabilité, Acceptabilité: Interpréter les Relations Entre Trois Dimensions de l'Evaluation des EIAH. In *Environnements Informatiques pour l'Apprentissage Humain 2003* (pp. 391–402). ATIEF; INRP. Retrieved from https://edutice.archives-ouvertes.fr/edutice-00000154/

Tunmer, W. E., & Chapman, J. W. (2012). The simple view of reading redux vocabulary knowledge and the independent components hypothesis. *Journal of Learning Disabilities, 45*(5), 453–466. doi:10.1177/0022219411432685

Vellutino, F. R., Tunmer, W. E., Jaccard, J. J., & Chen, R. (2007). Components of reading ability: Multivariate evidence for a convergent skills model of reading development. *Scientific Studies of Reading, 11*(1), 3–32.

Vidal-Abarca, E., Martinez, T., Salmerón, L., Cerdán, R., Gilabert, R., Gil, L., Ferris, R. (2011). Recording online processes in task-oriented reading with Read&Answer. *Behavior Research Methods, 43*(1), 179–192. doi:10.3758/s13428-010-0032-1

Wang, S., Jiao, H., Young, M. J., Brooks, T., & Olson, J. (2008). Comparability of computer-based and paper-and-pencil testing in K–12 reading assessments a meta-analysis of testing mode effects. *Educational and Psychological Measurement, 68*(1), 5–24. doi:10.1177/0013164407305592

Wise, S. L., & DeMars, C. E. (2006). An application of item response time: The effort-moderated IRT model. *Journal of Educational Measurement, 43*(1), 19–38. doi:10.1111/j.1745-3984.2006.00002.x

Wise, S. L., & Kong, X. (2005). Response time effort: A new measure of examinee motivation in computer-based tests. *Applied Measurement in Education, 18*(2), 163–183. doi:10.1207/s15324818ame1802_2

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