

An Analysis of Individual Differences for a Computer Self-Regulated Reading Comprehension Task

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Abstract

Recent developments in brain imagery have made it possible to explore links between brain functions and psychological phenomena, opening a window between mind, brain and behavior. However, behavior cannot be understood solely by looking at the brain alone; the roles of the context, task, and practice are potent forces in shaping behavior. According to these ideas, we present a work experience to reflect on: 1) the variations of how people learn, 2) the learning potential of students with learning disabilities, and 3) computers as a tool to learn and to analyze student's reading comprehension processes. In this vein, we present and discuss an example of how different types of readers (average, dyslexia, and hemispherectomy) undertake a computer self-regulated reading comprehension task. This is not an experimental research study and results cannot be generalized. Theoretical and educational implications are discussed in line with the proposed aims.

Key words: brain, mind, behavior, context, reading comprehension, computers.

Introduction

Currently, educators and public opinion, in general, tend to prioritize neurological assessments over any other type of observation or context influence: we tend to think that a diagnosed brain lesion or dysfunction will result necessarily on a *limitation* of the student's abilities. We also tend to think that the performance of students with brain injury or learning disability, on any cognitive task, is going to be always lower than the performance of average students in the same task. However, Reitan & Wolfson (2008) stated that:

“A substantial degree of variability is found regardless of whether the sample has normal brain functions or brain functions impaired by disease or damage. Even though one group may score significantly lower statistically than another group, a substantial degree of overlap occur. This overlap basically guarantees the production of false negatives and false positives” (p. 34)

In addition, other studies have found no differences between skilled and less skilled adult readers: a) to predict their performance in a test (Maki, Shields, Wheeler, & Zachilli, 2005); b) to perform in test of verbal memory and orientation (Reis, Guerreiro, & Peterson, 2003).

Educators and researchers are coming to realize that students learn in different ways and different models are needed to capture the variations in how people learn. We should stop talking about disabilities and, instead, talk about differences in patterns of ability including strengths, as well as, weaknesses. Students take many different pathways to learn and we need tools that help us to capture and understand these variations (Battro, Dehaene, & Singer, 2011; Fischer, Dawson, & Schnepps, 2010).

In this regard, computers open new possibilities for the assessment of reading literacy skills. We can record rigorously the reader's behavior. Computers allow the analysis of student's reading processes that cannot be studied by paper and pencil alone. In addition we can then use the recorded sequences of actions to help students move more efficiently through their learning process.

With respect to learning to read, children move through different learning sequences as they master comprehension. Most of the research on reading comprehension has focused on the relationship between comprehension and other related reading variables (i.e. vocabulary, reading fluency, listening comprehension,

working memory, etc.). These studies usually investigate reading comprehension performance between groups of skilled and less skilled students and present conclusions for each of these two groups (Cain & Oakhill, 2011; Carretti, Borella, Cornoldi, & De Beni, 2009; Kim & Pallante, 2012). This kind of research does not capture individual differences, but reports normative patterns that result from average over many children.

Besides the importance of knowing and understanding the different skills that contribute to reading comprehension, it would be interesting to know how each reader adapts his/her own strategies to the reading condition to meet a goal, because, as we have pointed out above, a great degree of variability exists between samples of skilled and less skilled students. In fact, it is not realistic to classify students in groups of skilled and less skilled learners because each individual is unique and has his/her own learning style and strategies, strengths, and weaknesses.

Reading comprehension is a complex construct and a goal-directed activity in which a person intends to understand a text. The process of making sense of printed text is purpose-driven, as the reader has to make decisions about what and how to read (in) the text. We call “strategies” techniques employed by a reader in order to successfully read. Examples of such strategies can be skimming and scanning certain text sections. Presumably, as Graesser, Singer, and Trabasso (1994) stated, strategies play an important role in comprehension because readers use them to construct coherent mental representations of the text. The self-regulation of reading requires comprehension not only of the text but also of the task. Understanding how students engage in the processes of search and selection of information to learn and to answer questions is becoming an increasingly important area of research in discourse processing and reading comprehension (Wiley et al., 2009).

In the present study, in order to realize that readers use a wide variety of strategies to achieve the goal of a reading comprehension task, no matter their reading condition, we analyze in detail self-regulation processes in seven cases of different types of readers (four average readers, two readers with dyslexia and one reader with hemispherectomy). For this purpose we have used a software called Read&Answer (see Vidal-Abarca et al., 2011, for a detailed explanation of this technology). We selected this software because it keeps track of the readers’ actions when they interact with the text. As indicated in the previous paragraphs, computers open new possibilities for the

assessment of reading comprehension. Read&Answer (R&A) is a variation of the moving window technique: it presents masked text and questions. The reader unmask a piece of text or a question by clicking on them once at a time. R&A software mimics paper and pencil in task-oriented reading situation (reading a text or answering questions) and it allows the recording of online readers' self-regulatory actions or decisions. This provides a sequence of actions (i.e. re-read a piece of text, picture or question, search the text to answer a question, etc.) and the time spent on each action.

The present study is a detailed description of a work experience; consequently results cannot be generalized in any way. Through the cases presented, our aims are to consider: 1) the wide range of strategies displayed by different types of readers, 2) the potential of students with a learning disability diagnostic, and 3) how computers could be used to assess reading comprehension. To reach these aims we investigated: a) how different types of readers (average, dyslexia and hemispherectomy) differ in reading comprehension performance in a particular task; b) in which extent they can self-regulate their behaviors while they engage in a self-regulated reading comprehension activity, having the text available; c) if there are any differences, among participants, in spelling (analyzing their answers to the open-ended questions of the task).

We focused on seven different variables of the task:

1. The process of reading the text.
2. The process of reading and understanding the questions.
3. The decision to either search into the text to answer a question or to rely on the representation obtained from previously reading the text.
4. The access to relevant or irrelevant information, in the case the student makes the decision of referring back to the text. We defined relevant information as a segment of text that contains information needed to answer a question.
5. The time spent on all of the above processes.
6. The analysis of the spelling errors in the proposed open-ended questions (a non-strategic task).

In the given computer task, readers can control and monitor their reading process, with no time limit and having the text available.

Our goals are not only to develop profiles of response for participants, but also to link our qualitative case studies results to the empirical quantitative findings coming

from the reading comprehension assessment literature on strategy selection and test method effects. Theoretical and educational implications are discussed.

Method

Participants

Seven young adults took part in this study (mean age=22.9 years old). The sample included 5 males and 2 female students. Six of them were graduate students (recruited from educational psychology courses at a large Spanish University) and one of them had completed college preparatory studies. Intelligence quotient (IQ) was average or above average for all of them. Seven were born in Spain and one in Argentina, Spanish being their native language. Two of them were diagnosed with dyslexia and had curriculum adaptations provided by the “University Office of Access and Services for Individuals with Disabilities”. One of them had undergone a neurosurgical treatment: a hemispherectomy of the right hemisphere. This case has been described before: for a detailed explanation see Battro (2000), Immordino-Yang (2007) and López-Escribano & Moreno (2014). Four of them were average readers. The sample selection reflected disparate situations in which the process of interest is “transparently observable”. Therefore, conclusions will be drawn in different types of readers.

Materials

Text and questions. The text used in the experiment, entitled “*Monet’s biographical notes*”, consisted in 8 paragraphs and 510 words. It was an expository text selected from Claude Monet’s web page. Before the text, three Monet’s paintings were presented: “*Impression, Sunrise*”, “*The Studio Boat*” and “*Water Lilies*”.

We developed a total of sixteen questions. Questions were of two types: multiple choice and open-ended questions. There were eleven multiple choice questions (four retrieving, four inferential and three interpreting) and five open-ended questions. Retrieving questions tapped information that was explicitly stated in the text (memory-based questions), for example: “*In 1906 and nearly blind, Monet began a series of paintings of ... a) aquatic flowering plants; b) colorful flowers; c) lilies; d) different types of flowers.* Inferential questions focused on information that could be inferred from the text, for example: “*Before the second half of the XIX century painting outdoors was*

complicated, because... a) there were not enough industrial advances; b) the technique of impressionism was unknown; c) no painters were able to reflect the light in his works; d) paints dry out and oxidized immediately". Interpreting questions required the reader to identify the main idea of the text or to disambiguate vocabulary in context, for example: *"The title of this text could be... a) the gardens in the Monet's painting; b) the importance of color in the impressionism; c) Monet and the vibration of light; d) Monet and the painting outdoors"*.

The open-ended questions were based on the personal opinion of the participants about the three Monet's paintings presented at the beginning of the text. The questions were: *"Which one of the three presented Monet's paintings do you like most? Which one do you like least? And, what feelings do "Impression, Sunrise", "The Studio Boat" and "Water Lilies" convey to you?"*. As we stated above, the goal of these questions was to analyze the orthographic representations of the text written by each one of the participants.

Read&Answer Software. Participants performed the experiment using R&A software (see Vidal-Abarca et al., 2011) which allows the recording of online readers' actions (i.e., read and reread a piece of text, answer questions) and of the time spent on each action. Participants read the text knowing in advance that they had to perform a task for which the document was an available source of information. Three Monet's paintings and a text were initially presented in a masked format (see Figure 1). When they clicked on one of the fuzzy pictures or on a segment of blurry text, the picture or the paragraph appeared. When participants clicked on a new segment, it was unmasked, and the previous was remasked. Thus, only one segment was visible at a time (see Figure 2). Participants controlled the time of paragraph presentation by pressing the space bar to move to the next paragraph. In order to answer the questions, participants clicked on a screen button to go to the questions page. Participants could go back-and-forth between the text and the questions screen.

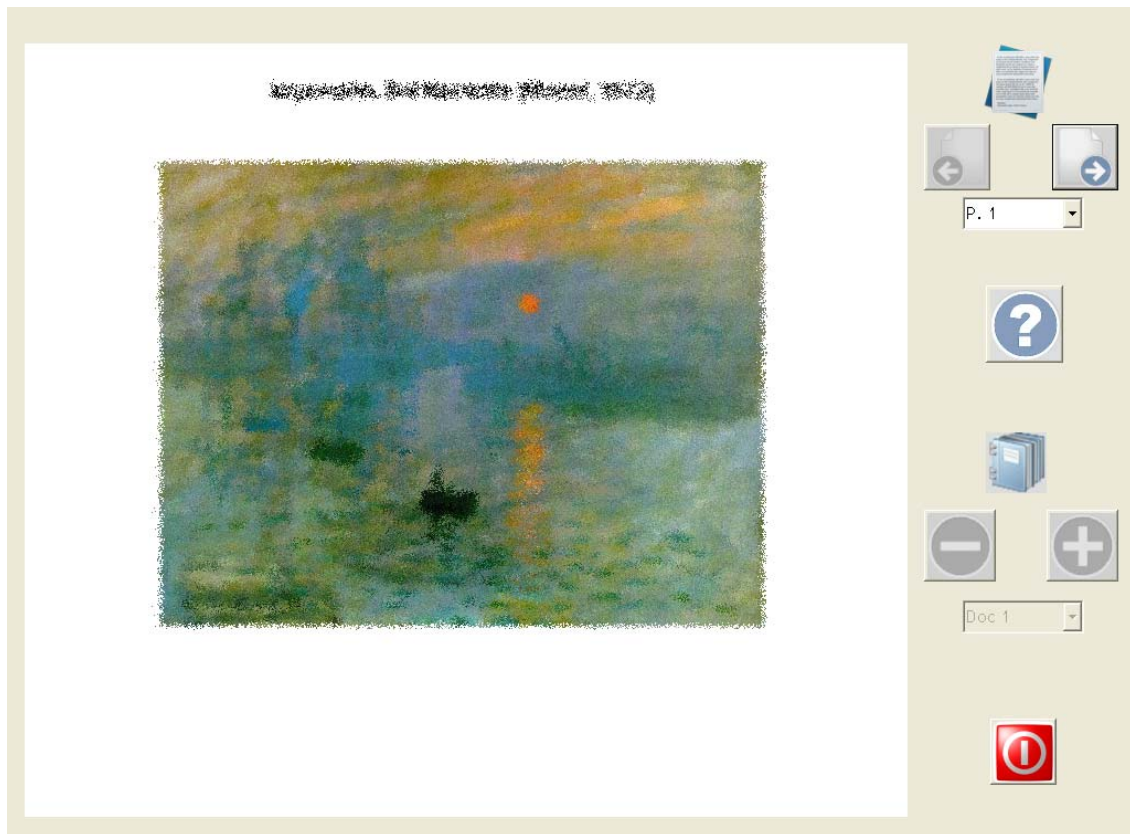


Figure 1. Screenshot of Read&Answer software: one of the paintings masked.



Figure 2. Screenshot of Read&Answer software: only one paragraph is visible at a time.

Procedure. Participants were tested individually during one session. Although R&A is an easy and intuitive software, readers were trained with it for 5 minutes in order to become familiar with the software and the experimental task.

Measures. The measures used in this study are the raw data automatically obtained with R&A technology and can be divided into three categories: *performance*, *reading time* and the *metacognitive self-regulation variables*.

- Performance variables correspond to the total score obtained in the multiple choice questions. They range from 0 to 11. Results are presented in percentage of correct answers (see Table 1).
- Reading time is the total time a participant spent looking at the pictures and reading the text or in the searching process answering questions. Results are presented in minutes (Table 1).
- Self-regulation indices include the following: (a) *number of search decisions* indicates the number of times the participant decides to refer back to the text to look for relevant or non-relevant information when answering a question, and (b) the time they spent searching back for information (see Tables 2 and 3). Here, we call relevant information a segment of text or picture that contains information needed to answer a question. Every question was related to at least one relevant piece of text or picture. In the output file provided by R&A, every segment was classified as relevant or irrelevant for a specific question.

In the open-ended questions we counted the total number of words written by each participant and three types of spelling mistakes: phonographic (*tranmitir* for *transmitir* [transmit]), stress (*musica* for *música* [music]) and lexical (*varco* for *barco* [boat]) (see Table 3).

We calculated the mean score of all the measures in order to compare the performance of the participants more easily.

Results

Concerning the overall measure of performance (total score), we found that the two participants with dyslexia obtained the highest scores (100% and 91% of correct answers). The score of the participant with hemispherectomy was 82%, similar to the score of almost all of the average readers. The lowest score, 64% of correct answers, corresponds to one of the average readers (see Table 1).

Table 1. Sample Characteristics and Total Scores in the Multiple Choice Questions.

SAMPLE CHARACTERISTICS				MULTIPLE CHOICE QUESTIONS (TOTALS)				
Participant	Sex	Reading Condition	Age	Total Task Time	Total Score (%)	Time in Text	Time in Questions	Total Searches
1. FJ	M	DIX	23	27.54	100	12.24	5.76	49
2. I	F	DIX	23	20.90	91	8.08	1.38	11
3. N	M	HEM	22	23.32	82	5.90	0.00*	0
4. M	F	AV	22	34.48	82	6.51	1.39	3
5. P	M	AV	25	21.31	82	10.97	3.57	20
6. ST	M	AV	22	24.52	82	7.97	2.02	14
7. S	M	AV	23	23.88	64	7.02	1.46	10
M			22.90	25.14	83.29	8.38	2.23	15.29
SD			1.07	4.67	10.93	2.36	1.88	16.29

Note: *Total time values equal to 0.0 mean that the participant did not do any search.

Regarding the total time spent on the whole task, there was variability, from 20.9 to 34.48 minutes (the first one corresponding to a reader with dyslexia and the second one to an average reader). However, most of the participants' times were around the mean value, i.e. 25.14 minutes (see Table 1).

For the three different types of multiple choice questions, we found that the mean score of correct answers was the highest in retrieving questions, 96.43%, followed by the mean in interpreting questions, 90.57%, and then by the mean in inferential questions, 64.29% (see Table 2).

Table 2. Multiple choice questions by category.

Participant	RETRIEVING QUESTIONS				INFERENTIAL QUESTIONS				INTERPRETING QUESTIONS			
	Total Score (%)	Total Time	Relevant Searches	Irrelevant Searches	Total Score (%)	Total Time	Relevant Searches	Irrelevant Searches	Total Score (%)	Total Time	Relevant Searches	Irrelevant Searches
1. FJ (D)	100	2.73	7	19	100	1.46	6	6	100	1.57	4	7
2. I (D)	100	1.38	3	8	75	0.00*	0	0	100	0.00*	0	0
3. N (H)	100	0.00*	0	0	50	0.00*	0	0	100	0.00*	0	0
4. M (A)	100	1.02	2	6	75	0.19	2	0	67	0.18	0	1
5. P (A)	100	1.30	3	7	50	1.35	5	3	100	0.92	3	4
6. ST (A)	100	1.29	5	3	50	0.18	1	1	100	0.55	1	3
7. S (A)	75	0.82	3	2	50	0.22	1	2	67	0.42	0	2
M	96.43	1.22	3.29	6.43	64.29	0.49	2.14	1.71	90.57	0.52	1.14	2.43
SD	9.45	0.82	2.21	6.24	19.67	0.64	2.41	2.21	16.10	0.57	1.68	2.51

Note: *Total time values equal to 0.00 mean that the participant did not do any search.

In the metacognitive skill of self-regulation, the results showed that there was great variability in the number of total searches ranging from 0 to 49 (see Table 1). We did not find significant differences in self-regulation between the different types of readers. One of the participants with dyslexia performed by far the largest number of searches; he is also the participant with the highest score. Participants searched more in retrieving questions than in inferential or interpreting questions (see Table 2). The correlation between correct answers and total number of searches is 0.62.

Finally, in the open-ended questions we found a great variability in the time spent on this specific task, ranging from 6.76 to 26.57 minutes. The number of written words also varies a lot, ranging from 141 to 447 (both scores of average readers). The number of relevant searches in open-ended questions was higher than in multiple choice questions. As the open-ended questions asked the participants to give their opinion about Monet's paintings, they wanted to see them again and it is understandable that it is easier to localize a picture than a specific paragraph of the text (see Table 3).

The percentage of spelling errors varies from 0.45 to 12.44%. The highest score on spelling errors corresponds to the participant with hemispherectomy (12.44%), followed by the participants with dyslexia (6.28% and 3.20%) (see Table 3).

Table 3. Open-Ended Questions.

Participant	Total Time	Relevant Searches	Irrelevant Searches	Words	Phonographic Errors	Stress Errors	Lexical Errors	Total Errors	% spelling errors p/w
1. FJ (D)	9.53	9	1	219	1	4	2	7	3.20
2. I (D)	11.44	8	3	223	0	14	0	14	6.28
3. N (H)	17.43	0	0	209	6	11	9	26	12.44
4. M (A)	26.57	10	1	447	0	2	0	2	0.45
5. P (A)	6.76	13	1	141	0	2	0	2	1.42
6. ST (A)	14.52	6	1	389	1	1	1	3	0.77
7. S (A)	15.39	9	2	255	1	2	0	2	0.78
M	14.52	7.86	1.29	269.00	1.29	5.14	1.71	8.00	3.62
SD	6.44	4.06	0.95	108.69	2.14	5.18	3.30	9.07	4.40

Discussion

The data of this experiment come from qualitative and quantitative analyses of the records of participants' self-regulatory actions in the context of answering questions about an available text, during a task of reading comprehension. This task was performed with the computer program R&A and conducted with a variety of readers (average, dyslexia and hemispherectomy).

We studied seven cases to provide description of their performance and strategy use. The selection of three types of readers allowed us to control strategy use variations and to clarify the findings for different types of readers, although the results shown here are for these specific participants, because as we said above, each individual is unique, consequently we cannot generalize the findings from this small sample. The cases were chosen to provide examples of disparate situations and, thus, extend the emergent theory on the importance of the variations on how people learn regardless of any particular neuropsychological condition.

The results reveal that, in this particular experiment, the reading comprehension task favor participants with dyslexia. In the present study we have shown that the participants with dyslexia searched more in the text and obtained the highest scores. The hemispherectomy participant's score did not differ from the scores of average readers in the multiple choice questions. The lowest score in reading comprehension was obtained by one of the average readers.

These results might contrast with the assumption that students with any type of learning disability might have always poorer comprehension accuracy than average readers.

Obviously we cannot generalize the results from this small sample of participants and as we pointed out, these results correspond to these specific readers. However, this can be a counter-example showing that the relationship between brain, mind and behavior is not always predictable and unidirectional, and that other variables might play an important role. Several reasons could explain this output.

When studying these seven cases, our interest was focused on developing a connection between behavior and the role that experience and the context play in the organization of the mind and the brain.

From an educational perspective one conclusion of the present study is that the brain is capable of continuously recycle itself, as the practice of any skill can cause that skill to become permanent (Robertson, Pascual-Leone, & Miall, 2004). In this respect, and as an example, we can refer to how the two participants with dyslexia and the one with hemispherectomy acquired strategies and skills to successfully undertake a reading comprehension task. The plasticity of the brain throughout the entire life cycle, context opportunities, and practice made it become possible. Environment can influence the brain's development to the point that the data from one neuroscience experiment cannot determine if the differences produced between the experimental and control conditions are due to neurological/genetic or instructional/environmental causes.

In the present study the type of computer self-regulated reading comprehension task should also be considered. In this task there was no time limit and the text was available for rereading. It may be possible that rereading does not elicit working memory effects and this allows readers to compensate for smaller working memory spans.

At the same time, students with learning disabilities might feel more comfortable working with computers, because computers bypass issues of attitude, affect and stereotypes that are characteristics of human interaction (Conty, Gimmig, Belletier, George, & Huguet, 2010). Participants work with computers without feeling judged and therefore this could avoid having a negative reaction to it.

In conclusion, educators should be aware that some apparent learning disability effects could be unnoticed if more ecologically appropriate tasks or procedures are used.

The cases analyzed in this study clearly reveal a substantial degree of variability in the metacognitive skill of self-regulation, regardless of any particular type of reader.

Each one of the participants has a unique way to adjust their strategies for the comprehension process and these strategies suit their purpose to fulfil specific reading goals. Thus, we can hypothesize that the participant with dyslexia with the highest number of searches, decided to search into the text because he was not convinced that he did know the correct answer, because he was motivated in the task or because he is a perfectionist.

On the contrary, other participants would decide not to search into the text when they were convinced that they knew the correct answer or if they were not motivated enough.

As shown by the correlation between the number of searches and the scores (0.62), participants who performed better tended to refer back to the text more times than participants with lower scores. In this sense the number of visits to relevant information could explain variance in the scores beyond general comprehension skills.

The contrast among participants (brain dysfunction/damage and average) was most notable in spelling. The performance (see Table 3) of the participants with dyslexia and the participant with hemispherectomy were the poorest. This result suggests that a significant proportion of people with dyslexia or brain damage might show deficits in spelling that exceed the poorest performances of most average readers. This type of task, such as spelling, which consists in automatic recovery of the lexicon, could be a better indicator of dyslexia or brain damage than a self-regulated reading comprehension task.

In summary, we found that learners adapt their strategies in a great variety of ways, to reach a goal no matter their reading condition. They try to self-regulate and to compensate their weakness to get the best possible performance. Not only the brain or the cognitive skills will influence the output: other variables such as motivation, self-regulation, type of task, learning style, and the context will add to the final result.

We need education to consider the differences between students instead of stigmatizing students as disabled. Today tests are used mostly for sorting students, not for knowing about their learning styles and improving their performance in the learning context.

The learning processes can be studied by considering different levels of analysis: biological, cognitive and behavioral. The influence of motivation, context, tasks and practice in all of them should be considered.

This study provides a brief view of the processes in which seven participants engage when they read a text and respond to questions. Here, the purpose was to give an in depth view of individual variability in self-regulatory reading comprehension processes in a computer task. The results of this study, with a small sample, are complementary to other studies' results on reading comprehension with larger samples, in the sense that both are important to gather information and to better understand reading comprehension processes and strategies in a variety of readers.

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