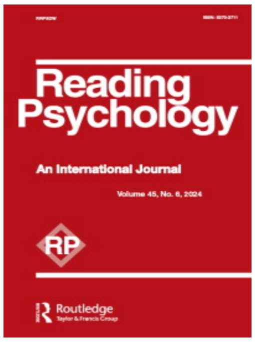

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Readers' Behavior during a Monitoring Task in English as a Foreign Language: Connecting Outcomes and Mental Processing

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ABSTRACT
Metacognitive skills are important for text comprehension, especially at university where most learning processes are unsupervised, and students rely on self-control and regulation when reading for comprehension. In today's universities, English as L2 has become the vehicle language for teaching and learning. However, some studies have concluded that university students who read English as L2 have inadequate metacognitive monitoring skills. Higher level processing skills, such as comprehension monitoring, are difficult to study and then improve. The main goal of the present study was to analyze the mental processing of readers when they monitored expository texts in English as L2 considering their English proficiency. Mental processing was related to readers' behavior when performing a reading task by using a set of variables guided by a psychological mechanism proposed for inconsistency detection. A total of 169 university students participated. The task was modeled on the error detection paradigm, which involved assessing the comprehensibility of scientific texts in English and reporting comprehension difficulties encountered. A special software was used to collect detailed data online about the readers' text processing and written reports. The results confirmed the set of processing variables and the theory-based predictions.

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Introduction

Metacognitive skills are important for text comprehension, especially at university, where most learning is unsupervised and students rely on self-control and regulation, i.e., on their comprehension monitoring skills (Nelson & Narens, 1990; Vilppu et al., 2023). Comprehension monitoring involves being aware that one does not understand and has been shown to be a good predictor of academic success in general (Veenman, Wilhelm, & Beishuizen, 2004; Krasiejko, 2010). Although university students have a high level of competence in their L1, their comprehension monitoring becomes difficult when they have to read in L2 or in a foreign language (Gómez, Solaz, & Sanjosé, 2014; Kay & Page, 2014). Nowadays, English (as a foreign or second language, FL/L2) is the vehicle language for teaching and learning in many universities. This situation has motivated teachers to improve students' monitoring skills when reading in L2/FL (Bimmel, van den Bergh, & Oostdam, 2001; Shih & Huang, 2018), a need that was not so evident in L1. The process of comprehension monitoring itself is usually not observable, only the results of a particular task, and this makes it difficult for teachers to meet their students' needs. In recent years, eye-trackers have enabled researchers to analyze readers' processing behavior when developing comprehension monitoring tasks. However, eye-trackers are still expensive and difficult for teachers to use.

The main objective of the present study was to analyze in detail Spanish university students' process of comprehension monitoring when reading in English as a FL, by collecting online data of the subjects' behavior while performing a specific metacognitive task. Instead of using eye-trackers, the present study used the "Read & Answer" software (Vidal-Abarca et al., 2011) to record online the subjects' behavior while reading an expository text in English in order to assess its comprehensibility. The Read & Answer software is inexpensive, easy to use and can be used and shared between classrooms. Teachers could develop and use similar tools using the modern applications available.

Students' Difficulties When Reading in FL/L2

Reading in English as a FL/L2 is frequently a hard task for students. Some difficulties include: (a) insufficient vocabulary knowledge, and therefore, inability to access the lexical and semantic meaning of the text or syntactic construction (Zhang & Zhang, 2022); (b) lack of attention to the superstructure of the text (Ghorbani-Shemshadsara, Ahour, & Hadidi-Tamjid, 2019); (c) poor ability to make inferences about the textual information (Horiba, 1996); (d) failure to monitor one's own comprehension and difficulty in linking micro/macro ideas to build local/global coherence (Currie et al., 2021; Gómez, Devís, & Sanjosé, 2013).

Years ago, L2/FL linguistic knowledge was found to be a strong predictor of reading comprehension in the L2 (Koda, 1989). More recently, other studies have found the same. In the meta-analysis conducted by Jeon and Yamashita (2014), the strongest positive correlates of L2 reading comprehension were L2 grammar knowledge, L2 vocabulary knowledge and L2 decoding. Similar results were found by Mancilla-Martinez and Lesaux (2010, 2017) with non-proficient children and adolescent Spanish speakers immersed in an Anglophone school context, and also in a meta-analysis by Kuperman et al. (2022) with university students, speakers of 11 different L1s, and proficient readers in English (L2).

Perfetti (1985) explained that readers with a low linguistic knowledge lack the automation of the low-level processes involved in language decoding (associated with vocabulary knowledge and grammar rules). Therefore, their cognitive resources are loaded by decoding, making it difficult to perform higher-level operations such as establishing relationships between sentences, constructing macro-ideas, making inferences or monitoring coherence (Perfetti & Stafura, 2014). Thus, some reading comprehension difficulties may be due to the inability to apply higher-order reading skills caused by poor vocabulary knowledge and decoding, among other reasons (Cain, Oakhill, & Bryant, 2004).

The ability to monitor comprehension is one of these higher-order reading skills, and, therefore, it is expected that difficulties will occur when the reader has a low linguistic domain of the target language, which is the case for most readers in FL/L2.

In this vein, some studies have been aimed at assessing students' comprehension monitoring behavior when reading in L2/FL. Lesaux and Harris (2017) conducted a study with sixth and seventh grade Latin American Spanish speakers immersed in Anglo-Saxon schools. The participants were selected because of their poor word reading and vocabulary knowledge in L2. The study found that the students' poor performance was not due to their lack of engagement in the reading tasks. The authors suggested that these students had poor comprehension monitoring skills and were, therefore, unaware of comprehension barriers and unable to overcome them.

Gómez and Sanjosé (2012) analyzed and compared Spanish pre-service teachers' comprehension monitoring during reading in Spanish (L1) and in English (FL). The texts contained embedded inconsistencies that affected micro (word level) and macro (sentence level) ideas. The participants had a low or intermediate level of English. They were able to detect only 33.3% of the embedded inconsistencies in the English texts, compared to 78.3% in the Spanish ones. They had particular difficulties with sentence-level inconsistencies. As the level of English proficiency increased, comprehension monitoring also improved, but more at the word level than at the sentence level. Mahmoudi (2014) obtained similar results with Iranian university students, EFL learners. However, the influence of poor L2 vocabulary knowledge was not as strong in the study developed by Nergis (2013). Turkish university students read different texts in English for academic purposes. Multiple regression analysis showed that syntactic awareness and control monitoring were stronger predictors than vocabulary knowledge.

Readers' Processing Behavior When Monitoring Comprehension

Eye-tracking has been the most widely used technique in recent years to study the process of comprehension monitoring in error detection tasks. In L1, an increase in gaze duration was observed for inconsistent information when participants detected an anomaly, and more rereading time was reported when participants had stronger regulatory skills (Connor et al., 2015; Zargar, Adams, & McDonald-Connor, 2020).

In L2, similar processing variables have been found to describe readers' behavior in comprehension monitoring. Currie et al. (2021) conducted a study with sixth grade monolingual English speakers and Spanish-English dual language learners (DLL) who had been in the program since kindergarten. Participants read several texts that contained embedded inconsistencies (incoherent texts) or others which did not contain any (coherent texts). They were asked to report whether each text made sense or not (the "product" variable). Word reading was also assessed (control) and monolinguals were stronger word readers than DLLs. Readers' processing behavior variables were defined from self-paced reading times. On average, monolinguals read faster than DLLs. Results showed that superior word readers performed better coherence monitoring. There were also differences in reading patterns (time distribution) when comparing students who reported the inconsistency correctly (longer times) with non-reporters. The authors' analyses concluded that coherence failure was due to the students' inability to detect the inconsistencies during reading, rather than a failure to encode this information.

Mulder et al. (2021) investigated the influence of word-to-text integration on L2 reading comprehension. One of the manipulations applied to the experimental passages was the embedding of anomalies, i.e. words that cannot be integrated into the actual mental representation of the text. A sample of Dutch 7th graders, non-proficient English readers (L2), performed a self-paced task in which they read different passages in L2 word by word on a computer screen. The readers' decoding fluency was controlled, as well as their gender and age. They were assessed at two different points in time, thus students had a higher English domain in the second than in the first. In the second reading, the students read faster in general, but the differences between consistent and anomalous words (delay) increased (better monitoring). At both times, the presence of delays on anomalous words significantly predicted offline comprehension.

Hessel and Schroeder (2022) analyzed how word processing difficulty and executive control influenced comprehension monitoring in a sample of German 9th and 10th graders when reading in English. Although most of these students were considered to have a medium to high L2 domain, word reading and vocabulary knowledge were assessed and controlled. Comprehension monitoring was evaluated indirectly through the readers' eye movements when reading anomalous words. Inconsistent targets took longer to be processed and they were reread more often than consistent targets, but students did not necessarily slow down for inconsistencies on the first reading. Interestingly, participants' executive control influenced the way in which monitoring was adapted according to their word processing difficulties. Students with a low control reduced their monitoring when reading difficult passages, but students with a high one increased their monitoring when reading difficult passages compared to easy ones.

In most of the studies mentioned above, once an anomaly or inconsistency has been detected, rereading tends to be an important regulatory strategy in an attempt to repair a failure in comprehension (Anita & Wahyudi, 2021; Hessel & Schroeder, 2022; Okyar, 2021; Yan & Jaeger, 2020).

In summary, L2 readers have more comprehension monitoring barriers than L1 readers, mainly due to word processing difficulties and word-text integration problems, but self-regulation can reduce these problems if the control executive is well developed. Modern technologies—such as eye-tracking and computer environments—allow researchers to observe consistent reader behavior, such as an increase in gaze duration when processing an anomaly compared to processing non-conflicting information (the inconsistency effect); or more rereading after inconsistency detection in an attempt to reestablish the broken coherence.

The Present Study

In the above-mentioned studies using online measures, gaze duration, the number of fixations and rereading have been repeatedly observed in association with evaluation and regulation in comprehension monitoring in both L1 and L2. However, less work has been done to causally relate the variables that account for readers' processing behavior to independent "product" measures of their comprehension monitoring. If these causal links could be reliably established, teachers would have good clues to infer their students' reading difficulties from the observed task outcomes (the "product") and, thus, be able to help them more efficiently.

Therefore, in the present study, readers' task behavior and task outcomes were independently assessed. In addition, the readers' proficiency in English was taken into account, as it involves word reading, vocabulary and syntactic knowledge, as well as other higher-order skills that influence reading comprehension.

The hypothesized causal relationship between certain processing behavior variables and task products was formulated from a theoretical model proposed in the field of reading comprehension psychology. The model is presented below.

A Model for Inconsistency Detection When Monitoring a Text for Comprehension

Frequently, comprehension monitoring is assessed by the Error Detection Paradigm (Winograd & Johnston, 1982). Inconsistencies are embedded in texts and readers' comprehension monitoring behavior is assessed by their ability to detect and report them.

Vosniadou, Pearson, and Rogers (1988) identified several mental actions that are necessary for readers to detect inconsistencies in a text: (a) the reader must mentally construct each of the two (at least) contradictory propositions (units of meaning); (b) the subject must process the two contradictory propositions simultaneously; (c) the two propositions must be related during processing in working memory; the reader compares them, becomes aware of the inconsistency, and rejects their incompatibility. If one or both propositions are not constructed, processed simultaneously, or related, the reader may not be aware of the inconsistency.

In the present study, Kintsch's Construction-Integration model (CI; Kintsch & Welsch, 2013) was used to implement the above necessary conditions for inconsistency detection by Vosniadou et al. (1988). According to the CI model, when a reader detects an inconsistency between two propositions, they should at least construct these propositions in mind (meaning extraction) and process them in working memory (WM) in the same "processing cycle." If both propositions result activated at the end of the cycle, they can be compared in the integration phase. Thus, the detection of the error is due to the reader's failed attempt to impose coherence on his or her mental representation of the text.

Advanced or low proficient readers process the information in different ways. Non-proficient readers are expected to show word-based processing and to apply syntactic rules consciously (Perfetti & Stafura, 2014). Added to this, in the case of L2/FL readers, constant translation into their L1 is used to access meaning (Gómez et al., 2014). Therefore, when information units in both languages and syntactic rules enter the working memory (WM), it may be overloaded and this may hinder higher-order processing, such as monitoring for coherence. This was found by De Bruïne, Jolles, and van den Broek (2021) by comparing loading and non-loading reading tasks. To avoid WM overload, the reader is forced to break the text into shorter units. This fragmentation increases the number of processing cycles, making it more difficult to establish coherence between a larger number of units.

Thus, taking into account these models and research studies, the specific goals of the present study were:

G1. To associate readers' processing behavior online data, while performing the task, with the task outcome by means of a psychological model for inconsistency detection when reading.

G2. To analyze the influence of English (L2) proficiency level on Spanish university students' processing behavior and task outcomes.

Method

Research Design

A quantitative correlational study was developed in two phases. A first study was conducted to provide a detailed analysis of each participant's behavior during the task. Individual data were collected using the Read & Answer software. In a second phase, the individual behaviors were pooled and analyzed to test the predictions (stated below) beyond individual differences.

Participants

A total of 169 male and female Spanish pre-service teachers (aged 18–25) participated in the experiment. They belonged to two intact groups from a teacher training university in a large Spanish city. Their level of English was assessed individually using the Oxford Online Placement Test (Purpura, 2010). This test relates its scores to the levels defined by the Common European Framework of Reference for Languages (CEFR; Council of Europe, 2001). The participants' levels of English were distributed as follows: 9.5% at A1 level, 34.9% at A2 level, 21.9% at B1 level and 33.7% at B2/C1 level.

Materials and Measurements

Texts

Four expository texts on different basic science topics were used: "Cloning," "The Greenhouse Effect," "Helium in the Atmosphere" and "Superconductivity." They all had the same structure (3 paragraphs), length (150–155 words) and level of difficulty (A2-B1). The texts were adapted from university access exams. They belonged to the area of English as a Foreign Language; therefore, they were not science specific, but general knowledge texts about science phenomena. Hence, specific science prior knowledge on the topics was not necessary to understand the texts.

Each text contained an incorrect idea that was explicitly incompatible with another correct previous idea (internal inconsistency). Thus, the "target" inconsistency involved two text segments (two different ideas), the second of which was incorrect. Five "filler" sentences (14–18 words each) were placed between the two incompatible text segments to reduce the availability of information in the reader's memory and, thus, increase the demands of monitoring for coherence (Currie et al., 2021). This reduced the likelihood that a reader would carry one of the incompatible ideas into their working memory while reading the other one. For example, in the text "The Greenhouse Effect" (see Appendix), the idea in S8 "*The greenhouse effect must totally disappear in order to make the Earth a more habitable planet*" was incompatible with the previous idea S2 "*Without the greenhouse effect, the Earth would have an extremely freezing temperature.*" These inconsistent ideas create the "target inconsistency" in this study. The remaining text segments did not contain conflicting information from the expert's point of view and were considered "non-conflicting" segments.

Data Collection

"Read and Answer" (Vidal-Abarca et al., 2011) was used to collect all the individual data. This software has been compared with other reading test, such as eye-tracking (Vidal-Abarca et al., 2011) and paper-and-pencil test (Gil, Martinez, & Vidal-Abarca, 2015), and the results was similar. "Read and Answer" was initially conceived to study the readers' comprehension searching information in a text to answer some questions (Cerdán, Gilabert, & Vidal-Abarca, 2011), but it can also be used in other text-related tasks. So, it has been chosen in recent years to investigate comprehension monitoring in university students when solving mathematical problems (Sanjosé, Gómez-Ferragud, & Solaz-Pórtoles, 2024; Sanjosé, Gómez-Ferragud, Verdugo-Perona, & Solaz-Portolés, 2022), strategies used by students while reading and reading-to-write (Castells, Minguela & Nadal, 2023), impacts of text access on reading behavior (Ferrer, Vidal-Abarca, Serrano, & Gilabert, 2017; Mañá, Vidal-Abarca, & Salmerón, 2017), bridging skills (Higgs, Magliano, Vidal-Abarca, Martínez, & McNamara, 2017) or strategic reading literacy skills (Gil et al., 2015).

Read and Answer displays a text on the screen that has been "masked," so it is unreadable at first sight, although its structure in segments of information, and even words, can be observed. Researchers should divide the text into different units or segments of information. In the present study, each text segment corresponded to a complete sentence (see Figure 1 below). When the reader clicks the mouse on a segment, it becomes unmasked and readable, but the rest of the segments are masked so that only one segment can be read with each "click." Thus, it is possible to know what segment was being read at each moment along the task. The reader is free to read and reread the text segments in any order and as

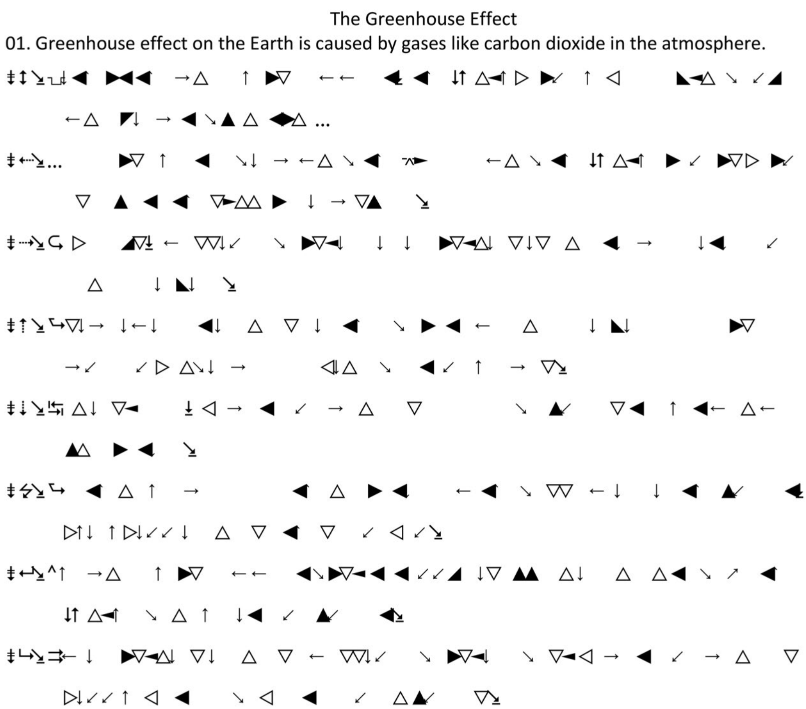

Figure 1. Experimental text on the computer screen. All the sentences are masked except the one clicked which can be read.

many times as necessary. Figure 1 shows the way the experimental texts are displayed on the computer screen.

There is also a second screen where the proposed task has to be executed, such as reporting the inconsistencies found in the text or answering specific questions. Subjects can switch between screens as many times as they wish by clicking on the visible buttons provided. These actions are typically performed to consult the text and/or to complete or modify a task-related answer. When each participant considers that the task has been completed, there is also a button to end the activity and quit.

The software records the entire sequence of the reader's actions as well as the time spent on each one: reading visits to each segment of the text and its order, partial writing, or modification of the written report, switching between screens, and exit.

Variables

As in the study by Currie et al. (2021), product and process variables were defined and measured. The "product" variable was defined as the explicit mention or absence (dichotomic) of the embedded inconsistencies in the students' written partial and final reports. Likewise, the processing variables were defined from reading sequences and reading times, independently of the product variable. These variables were defined and measured as follows:

- Reading pace. For each reader, the time per word (milliseconds/word) and the standard deviation of all their reading visits to the text segments were averaged to obtain their normal reading pace (only if the visit exceeded 100 ms/word, which is the minimum time for lexical access).
- Reading slowdowns. If a particular reader's time per word in a reading session exceeded their individual Mean + Standard Deviation, a severe slowdown ("Slowdown" onwards) was recorded as an indication of comprehension difficulty. Times per word below Mean - Standard Deviation were considered as superficial reading, partial reading or scanning; for instance, checking for certain information in the sentence.
- Reading Links between inconsistent segments. According to the model, an inconsistency can be detected when the contradictory ideas are processed simultaneously. For most readers, this requires them to be read (almost) consecutively in a deliberate action, because the inconsistent ideas were placed apart in the experimental texts. A "reading link" between two inconsistent segments (or simply, a "Link") was defined as a reading sequence starting in one

inconsistent segment and ending in the other, with a percentage of reading time in the sequence greater than 70% accumulated in both segments. The threshold of 70% was taken as a provisional value which will be adjusted in future studies.

- The Processing Effort in a particular segment α was defined as the time accumulated reading α divided by the time needed to read α once at a normal speed (mean). An increase in processing effort in certain segments could indicate comprehension difficulties.

Procedure

Two class sessions were required to collect the data. In the first one, participants' level of English was assessed using the Oxford Online Placement Test. They were given a computer and completed the test online. The session lasted less than 60 min. In the second one, students completed the comprehension monitoring task individually on a computer using the "Read & Answer" software. The four experimental texts were randomly assigned. The instructions were given individually and read aloud. In order to gain confidence in using the software and to ensure understanding of the task, a practice text similar to the four experimental ones was used. Participants' doubts were clarified, and they were asked to read the texts and assess their comprehensibility by writing down any reading difficulty they may find (in the form of inconsistencies, errors, contradictions). They were not warned about the inconsistencies embedded in the texts. The reason for this was to make the task as natural as possible and to avoid it becoming a "search for errors" exercise. Although there was no time limit, the experimental task typically took between 15 and 30 min.

Once collected, product and processing data were analyzed individually. All these measures were pooled and then analyzed again using descriptive and inferential statistics.

Predictions

According to the theoretical model outlined above and the processing variables defined, when the embedded inconsistency has been correctly reported by a reader, the reader's behavior should show:

a. Normal reading speed on both inconsistent ideas to ensure that they are constructed correctly.
b. The presence of at least one reading "Link," as defined above, to ensure simultaneous processing of the inconsistent ideas.

c. The presence of at least one “Slowdown” on one inconsistent segment (the “inconsistency effect”), specifically a slowdown associated with a “link” (i.e., an “on link slowdown”) as a consequence of the reader’s failed attempt to establish coherence.
d. An increase in processing effort on the inconsistent segments compared to the non-conflicting segments. The reader’s regulatory actions after detecting the inconsistency are likely to involve more rereading of the inconsistent information than of the non-conflicting sentences, in an attempt to reestablish the broken coherence or to ensure that the inconsistency was actually in the text. Rereading implies more reading time accumulated on certain segments of the text and, thus, more processing effort.

   Finally, the level of English proficiency was expected to cause observable effects, since it is related to different reading processing, as mentioned above:
e. Readers with low English proficiency will show significantly less comprehension monitoring than readers with higher English proficiency.

There were no model-based predictions when the embedded inconsistency was not detected.

Results

Product of the Task: Correct Reporting of the Embedded Error

Only 42.0% of the participants explicitly reported the “target” inconsistency embedded. An example of correct detection by participant ATL in the text “Cloning”: “*Sentence 05: I don’t understand this idea because it seems to contradict sentence 10, since in sentence 05 it says that plants and animals could be cloned at a lower price, but in sentence 10 it says that it is expensive and without great advantages.*”

The remaining 58.0% did not mention the “target” inconsistency but offered different reports declaring absence of comprehension obstacles or suggesting that the text should improve its structure. For example, participant PRS stated (Text: “Superconductivity”): “*The information in paragraph number 05 is fine as a curiosity, but I don’t think it should be in the middle of the text because it has made me doubt what I was understanding and mixed it with the most relevant concepts.*” Moreover, some readers mentioned difficulties in understanding specific English words.

The readers’ level of proficiency had a significant influence on the task product, according to the point-biserial correlation (r_{pb}= .40; p < .001). Only 12.5% of the students on the A1 level were able to report the embedded error; similarly, 20.3% of the subjects on the A2 level reported the inconsistencies, whereas 59.5% on the B1 and 61.4% on the B2/C1 reported the errors. All the A1 and A2 students but none of the B2/C1 reported unknown words in the texts.

Readers' Processing Behavior Along the Task

Careful Reading of Text Segments

The mean value of the individual normal reading paces for the sample was $M = 129.4$ words/minute with a standard deviation $SD = 39.6$. Its distribution in the sample was not significantly different from a normal curve (Kolmogorov-Smirnov test: $Z = 0.95$; $p = .330$). All participants read all segments of the text at least once at normal speed or slower. The average reading time per word was $T = 1935.3$ ms/word ($SD = 866.3$).

The reading speed was significantly higher (Spearman-$\rho = .32$; $p < .001$) when the proficiency level increased from A1 to B2/C1: 111.4 ($SD = 40.3$); 118.2 (39.6); 130.8 (29.2); 145.2 (40.1) words/min.

"Links" and "Slowdowns" on Inconsistent Ideas

Table 1 shows the relationship between the reporting of the target inconsistency, and two processing variables: the existence of reading "links" between the two inconsistent segments, and the presence of "slowdowns" (as defined in the Methods section) inside or outside those "linking sequences" ("on link" or "off link" slowdowns, i.e. presence of some linking sequence or outside the linking sequence).

The correct report of the embedded inconsistency was significantly associated with the presence of some "linking sequence" with an "on link slowdown" ($\chi^2(1) = 113.79$; $p < .001$).

Table 1. Relationship between the presence or absence of "links" and "slowdowns" on inconsistent segments and the correct reporting or not of the target inconsistency

Correct report	"Link" presence	"Slowdown" presence	Frequency
NO	NO	NO	27
		YES-off link	64
	YES	NO	2
		YES-off link	3
		YES-on link	2
	Total		98
YES	NO	NO	0
		YES-off link	0
	YES	NO	2
		YES-off link	10
		YES-on link	59
	Total		71
TOTAL			169

The readers' English proficiency had a significant and positive association with the presence of reading "links" between the inconsistent text segments (r_{pb} = .35; p < .001) and with the presence of "slowdowns" when reading these segments (r_{pb} = .40; p < .001).

Processing Effort

Table 2 shows the relationship between the correct or incorrect report of the target inconsistency, the mean values of Global Effort, of the processing Effort spent in the two inconsistent segments or spent in the non-conflicting segments.

The logarithmic transformation $\log_{10}$(effort) was performed to normalize the distribution of the processing efforts (K-S: $Z < 0.714$; p > .688).

The point-biserial correlation between the variables Correct Report and the Global processing Effort was significant and positive, although of medium-to-low strength (r_{pb} = .31; p < .01). For the Effort in inconsistent segments the correlation was higher (r_{pb} = .47; p < .01), whereas for the Effort in non-conflicting segments the correlation was lower but still significant (r_{pb} = .23; p < .05). None of the three Effort variables considered was significantly correlated with the level of English proficiency (ρ < .06; p > .412).

Explanation of the Task Outcome by the Processing Variables

A binary logistic regression was computed for the criterion variable "Correct Report of the embedded inconsistency (yes/no)," using as predictors the level of English proficiency and the processing variables defined: normal reading speed, presence or absence of "links" between inconsistent segments, presence or absence of "on link" (presence of some linking sequence) and "off link slowdowns" (outside the linking sequence) on them, and processing Efforts in inconsistent and in non-conflicting segments. The "forward stepwise" regression method was used to retain only predictors with a significant unique contribution. This approach starts from the null model and adds a variable that improves the model the

Table 2. Mean values (and standard deviations) of the Processing Effort in consistent and inconsistent text segments, depending on whether the embedded inconsistency is correctly reported or not

Correct report of the embedded inconsistency	All segments	Inconsistent segments	Non-conflicting segments
YES	4.8 (2.3)	5.9 (2.6)	4.5 (2.4)
NO	3.6 (1.9)	3.9 (2.9)	3.5 (1.8)
Total	4.1 (2.2)	4.8 (2.9)	4.0 (2.1)

Note. The value 4.1 means that, in average, the readers cumulated 4.1 times more time reading the text segments than needed to read them once at a normal pace.

Table 3. Main data of the binary logistic regression for the criterion correct report of the inconsistency embedded in the text

Predictors	*B*	*SE*	Wald	*d.f.*	Sig.	Exp(*B*)
Presence of a "Link" with a "Slowdown" (Yes/(No)	4.838	0.796	36.916	1	<.001	126.237
Processing Effort in inconsistent segments	2.744	1.140	5.791	1	.016	15.555
English level (CEFRL)	0.618	0.305	4.118	1	0.42	1.855
Constant	−5.317	1.283	17.182	1	<.001	.005

most, one at a time, until the stopping criterion is met. Table 3 shows these predictors and the relevant data for the regression.

These predictors correctly classified 92.3% of the reports observed in the sample (85.9% of correct reports, and 96.9% of incorrect or missing reports).

The omnibus test indicated that the model helped to explain the observed report ($\chi^2(3)= 145.95$; $p < .001$). The −2log-likehood value was 84.00. Between 57.8% (Cox and Snell's $R^2= 0.578$) and 77.8% (Nagelkerke's $R^2= 0.778$) of the variance of the criterion variable was explained by these predictors. The most important predictor was the presence of a "Slowdown" in a "link" (i.e. an "on link Slowdown"), which explained 55.5–74.7% of the variance.

Discussion

The present study independently measured and related the product and the processing variables associated with readers' behavior while performing a monitoring task, as in the study by Currie et al. (2021). The participants read the texts carefully during the task, as the reading speed (129.4 wpm) was lower than the values obtained for adults (250–400 wpm reported by Carver, 1990), even for readers with a B2/C1 level of English. In part, the slow reading observed could be attributed to the reading procedure imposed on the readers (unmasking of text segments), but the global effort obtained suggested that participants were not engaged in superficial processing. Nevertheless, only 42% of them reported the embedded inconsistency correctly. This relatively low global percentage of success in a metacognitive task is comparable to similar previous studies in L2, such as those by Gómez and Sanjosé (2012) or Mahmoudi (2014).

Second, in the present study, the task and the Read and Answer software allowed participants to read the text at their own pace and to reread the text as many times as they wished. The possibility of free rereading allowed the researchers to consider different reading sequences involving text segments in any order and, in particular, to focus on sequences connecting the two (widely separated) incompatible text segments (i.e. reading "Links"). In addition, the software also allowed for the detection of reading “Slowdowns” as an indicator of significant reading difficulties. A “Slowdown” was defined as a reading time per word greater than the Mean plus one SD according to each reader’s data distribution. For participants who reported the embedded inconsistency, the data demonstrated the presence of slowdowns on the contradictory sentences. This effect of longer reading times on conflicting versus non-conflicting information (the “Inconsistency Effect”) has been repeatedly found in reading comprehension monitoring studies measuring eye fixation times, both in L2 (Hessel & Schroeder, 2022; Mulder et al., 2021) and in L1 (Connor et al., 2015; Zargar et al., 2020).

The model-based prediction about the need for simultaneous processing of inconsistent sentences with a failed integration attempt was fulfilled in a high percentage of cases. Looking only at readers with a correct report of inconsistency (71 out of 169), 83.1% of them had one or more “linking sequences” connecting the two inconsistent ideas with a “Slowdown” on one of them (“on link Slowdowns”). This processing variable (presence or not of “on link slowdowns”), explained 55.5–74.7% of the variance in the correct reporting (yes/no) of the embedded inconsistency. A further 14.1% of the cases of correct reporting had an “off link slowdown,” i.e., a slowdown out of the linking sequences. The resonance model predicts the possibility of partial activation of (distant) prior information when reading a related idea (Myers & O'Brien, 1998). It was possible for some readers to reactivate one of the recently read contradictory sentences without an explicit reading “Link,” or to transport it into working memory while reading the other sentence. In this case, the actions required to detect the inconsistency were performed “in mind” in a way that the Read & Answer software could not detect it.

Furthermore, it was not observed any reading “slowdown” on the inconsistent ideas in two readers with correct reporting, against the prediction. According to the assumed theoretical basis, this would correspond to the absence of obstacles in the integration phase, which was incompatible with the correct reporting of the inconsistency. One explanatory possibility is that these readers detected the inconsistency but did what Otero, Campanario, and Hopkins (1992) described as “inadequate regulation.” This could be due to the use of an “inconsistency repair strategy” which involves adding spurious information to the mental representation of the content (e.g., *“I don’t understand it, but this is because I have little knowledge of the subject*”; or *“There must be a mistake in the text*,” etc.). Other inappropriate regulatory actions have been observed. Mazzitelli, Maturano, and Macías (2008) found that participants detected the contradiction but did not report it or rejected the text as “inconsistent.” Instead, they performed several regulatory actions such as underlining words or sentences from the text, skipping the contradictory information, rephrasing some text segments and reinterpreting them, or thinking that they lack prior knowledge on the topic.

In Vosniadou et al. (1988) study, the main reason why children failed to detect an inconsistency in a text was that they did not compare the contradictory propositions, either because they did not construct them or because they did not process them simultaneously. In the present study with adults, but reading in L2/foreign language, the data suggest a similar main cause of failure to detect the inconsistencies: lack of simultaneous processing of the contradictory propositions (which were presumably constructed) and then lack of comparison. Most (93%) of the participants who did not report the embedded inconsistency also did not connect the two incompatible segments in a reading sequence. Therefore, these participants showed poor global coherence skills.

Third, in relation to rereading and integration difficulties, the mean number of reading visits per text segment and per reader was above 4. Higher values of processing effort were associated with greater processing difficulties or with rereading with special attention to information segments related to the task goal (i.e., to detect and report possible comprehension obstacles). The distribution of processing effort differed between subjects who reported the contradiction and those who did not report the contradiction. The former spent more processing effort on the inconsistent segments, especially on the incorrect second one, than the latter, compared to the effort spent on the non-conflicting segments. This means that subjects who detected the inserted inconsistency spent much more time cumulatively reading the inconsistent segments than the non-conflicting segments.

Re-reading difficult text segments was also the most frequently regulatory action used in previous studies, such as Bastola's (2020) on comprehension monitoring in English (as L2) of university students. Her results showed that the most common actions used by students to overcome comprehension problems were reading the text more slowly, rereading, and reading backwards and forwards. Rereading was also observed in studies using eye tracking when a comprehension barrier was detected (Connor et al., 2015; Hessel & Schroeder, 2022; Yan & Jaeger, 2020; Zargar et al., 2020).

Fourth, a small set of processing variables was able to explain an important percentage of the variance of the criterion, i.e. the variable accounting for the task product, "Correct reporting of embedded inconsistency (yes/no)." The three processing variables that emerged as significant predictors with unique contributions in the binary logistic regression were: the presence of a "linking sequence" with a "slowdown," the average processing effort for inconsistent ideas, and the level of English proficiency. Therefore, the theoretical predictions were supported by the data.

Readers' English proficiency, a crucial variable related to vocabulary, decoding and other higher-level reading skills, was significantly and positively associated with the task product (correct reporting of the embedded inconsistency), explaining 16% of its variance. This variable was also significantly associated with other variables considered in the study, such as the presence of "links" between the inconsistent segments and the presence of "on link slowdowns," suggesting a strong influence on processing.

Nevertheless, proficiency level still had a unique significant contribution to the task product. The positive effect of the L2 domain was consistent with many studies pointing to the relevance of word processing, vocabulary knowledge or decoding (Jeon & Yamashita, 2014; Kuperman et al., 2022).

Conclusions

The main goal of the present study was analyzing Spanish readers' mental processing when they monitored expository texts in English as L2/FL, considering their English proficiency. A set of processing variables was defined from Vosniadou et al. (1988) mental mechanism for inconsistency detection in texts. These variables linked mental processing with readers' behavior along a monitoring task based on inconsistency detection and reporting. The software "Read and Answer" was used to collect individual data of readers' processing behavior and individual reports. This software allows fruitful analysis similar to the ones made using eye-tracking techniques, but it is easy to use and less expensive.

Results showed a significant and strong connection between some processing variables and the task product, which supported the predictions made from the assumed theoretical basis. As texts were written in English, the possible effects of the individual were of specific interest. In agreement with the expectation, the level of L2 proficiency was significantly associated to the processing behavior, and then to the task product.

These results could be very useful to understand teaching and learning students' difficulties in English as a foreign language. For instance, this may help teachers and practitioners select tasks that may not involve working memory overload. Furthermore, it could help provide students with more accurate reading programs adapted to their necessities.

As usual in academic studies, the current one also has limitations which suggest taking the results with caution waiting for replication. First, using the software "Read and Answer" to show the text in a masked way forced the participants to read in a non-natural way, and this probably modified the reading paces obtained and inserted additional processing difficulties. However, these difficulties were the same for all the participants. Second, there was no sampling procedure and then, the results obtained cannot be generalized. Third, a specific methodology was used to measure the individual reading speed in the task, and, thus, to determine the reading slowdowns. This methodology needs to be validated in future similar studies. Finally, the participants' previous knowledge on the four text subjects were not assessed and could have had some influence on the ability to detect the embedded inconsistencies.

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No potential conflict of interest was reported by the author(s).

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APPENDIX

One of the experimental texts used. Please note that sentences 02 (correct) and 08 (incorrect) are contradictory.

The Greenhouse Effect

01. Greenhouse effect on the Earth is caused by gases like carbon dioxide in the atmosphere.

02. Without the greenhouse effect, the Earth would have an extremely freezing temperature…

03. … because heat coming from the Sun and from the Earth nucleus would escape to the surrounding space

04. Nowadays, fossil combustion in industries is creating additional carbon dioxide.

05. A significant increase in the amount of carbon dioxide can cause global warming and environmental changes.

06. For instance, vegetable gardens can become places too hot for food production.

07. Another change can be the reduction of the mass of ice in the planet, which will increase the sea level

08. The greenhouse effect must totally disappear in order to make the Earth a more habitable planet.

09. If industries increase fossil combustion most vegetable gardens will have to be moved to colder places.