

# Connectives and Layout as Processing Signals: How Textual Features Affect Students' Processing and Text Representation

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When students read their school text, they may make a coherent mental representation of it that contains coherence relations between the text segments. The construction of such a representation is a prerequisite for learning from texts. This article focuses on the influence of connectives (*therefore, furthermore*) and layout (continuous placement of sentences vs. each sentence beginning a new line) on the dynamics of the reading process as well as the quality of students' mental representation. The results shed light on the cognitive reading processes of students in secondary education, which allows us to explain effects of text features on off-line comprehension measures. Our eye-tracking data emphasize the importance of connectives: Connectives speed up students' processing, especially when texts have a continuous layout. In contrast, students' processing slows when they read texts with a discontinuous layout. Our data also show a correlation between reading times and scores on bridging inference tasks: Students who read faster have higher comprehension scores. These findings indicate that explicit texts with a continuous layout place fewer processing demands on students' working memory.

**Keywords:** connectives, on-line processing, secondary education, text comprehension, (dis)continuous layout

Text comprehension can be defined as “the ability to obtain meaning from written text for some purpose” (Vellutino, 2003). Comprehension involves the construction of an integrated and coherent mental representation of a text's meaning (Gernsbacher, 1990; Kintsch, 1998). The construction of a coherent mental representation is a prerequisite for learning from texts, because learning encompasses more than reproducing the content of individual clauses. Ideally, students should be able to construct a representation that is coherent, easily accessible (long after reading the text), and applicable in a variety of situations (Graesser & Clark, 1985; Kintsch & van Dijk, 1978; McMaster et al., 2012). Such a mental representation is determined by various text-based and knowledge-based connections within sentences, between sentences, and between larger parts of text (Coté, Goldman, & Saul, 1998; van den Broek, Lynch, Naslund, Ievers-Landis, & Verduin, 2003). Therefore, the process of creating connections by generating inferences is a critical feature of text comprehension (Best, Rowe, Ozuru, & McNamara, 2005).

Many readers, especially in educational contexts, fail to construct a proper mental text representation: 25% of the eighth graders in the United States do not have basic reading skills

(National Center for Education Statistics, 2012), and 14.3% of Dutch adolescents are considered low literate (OECD, 2010). This explains why the RAND report on reading for understanding emphasized the need to improve text comprehension in schools (Snow, 2002) and why, in 2010, the Institute of Education Sciences created the Reading for Understanding Research Initiative to develop comprehensive and effective approaches that would lead to improvement in reading comprehension of students in prekindergarten through Grade 12.

In light of the RAND call for comprehension improvement, an important, socially relevant, question arises: How can students' text comprehension be improved? Previous studies have shown that text comprehension is a product of complex interactions between what readers bring to the reading situation and the properties of the text (Braasch, Goldman, & Wiley, 2013; McNamara, Kintsch, Songer, & Kintsch, 1996; Snow, 2002). Comprehension difficulties can be caused by a lack of basic reading skills, such as decoding, fluency, and vocabulary knowledge. However, a lack of higher order skills is an arguably more important cause. Higher order skills encompass understanding concepts and ideas conveyed by text, making inferences, maintaining coherence, and activating background knowledge to fill in missing details (Bohn-Gettler, Rapp, van den Broek, Kendeou, & White, 2011; Cain, Oakhill, & Bryant, 2004; Kendeou, van den Broek, White, & Lynch, 2009; Oakhill, 1994; Perfetti, 1985; Rapp, van den Broek, McMaster, Kendeou, & Espin, 2007; Zwaan & Singer, 2003). Inadequate higher order skills seem to be the major obstacle for students in secondary education when learning new information from study texts (Linderholm et al., 2000; Oakhill, 1994; Snow, 2002).

Therefore, teaching higher order skills is one way to improve text comprehension. For example, training in structure strategies about the causal structure of texts results in better recall, better text comprehension, and more effective use of signals in the text

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(Broer, Aarnoutse, Kieviet, & van Leeuwe, 2002; Meyer & Poon, 2001; Wright & Rosenberg, 1993).

Another way to improve text comprehension, one that will be at the heart of the current study, is to change the characteristics of educational texts. Kintsch's construction-integration model (1998) suggests that comprehension can be improved when the need to make inferences is reduced. Readers who have inadequate higher order skills, in particular, may require text characteristics that guide them in establishing connections between various parts of a text and/or to relevant background knowledge (McMaster et al., 2012). Therefore, this study focuses on the effects of two text features—coherence marking and layout—on students' cognitive processes and mental representations.

### The Influence of Coherence Markers

The use of cohesive devices, such as connectives and an optimal layout, is posited to reduce inferencing on the part of the reader. Connectives such as *so*, *therefore*, *then*, and *moreover* act as a guide, because they make conceptual coherence relations explicit. In other words, connectives help readers to identify text structure and mentally connect ideas in a text (Degand & Sanders, 2002; Graesser & McNamara, 2011; Sanders & Noordman, 2000; Sanders & Spooren, 2007). Example 1 shows a causal relation that is made explicit by the Dutch connective *omdat* (because). However, when there is no connective, as in Example 2, readers have to connect the new information to the previous information themselves, which involves higher order processing. Therefore, we expect the presence of connectives to be an important factor in creating comprehensible texts for students in secondary education who have difficulty performing processes that are crucial for the construction of a coherent situation model.

1. Een bad met warm water was er alleen voor de rijke mensen, *omdat* het moeilijk was om aan warm water te komen.

"A bath with hot water was only for rich people, *because* it was difficult to get hot water."

2. Een bad met warm water was er alleen voor de rijke mensen. Het was moeilijk om aan warm water te komen.

"A bath with hot water was only for rich people. It was difficult to get hot water."

Our study extends previous research in several ways. First, we focus both on students' text comprehension and on the cognitive processes that underlie students' text comprehension. Specifically, we combine off-line measures collected after reading with processing measures collected during reading to describe and explain the relation between students' on-line processing and students' off-line comprehension scores (cf. the recommendations in Kendeou & van den Broek, 2005). Earlier studies focused either on processing or on the quality of the mental representation. For example, several studies have shown that connectives and other linguistic coherence markers influence the quality of the text representation. For skilled adult readers, the presence of coherence markers leads to faster and more accurate responses on recall tasks (Lorch & Lorch, 1986; Millis & Just, 1994) and faster and better answers to comprehension questions (Degand & Sanders, 2002; Kamalski, Sanders, & Lentz, 2008; McNamara et al., 1996). For students in secondary education, coherence markers lead to better answers to comprehension questions (Land, 2009; Sanders, Land,

& Mulder, 2007). However, these studies provide no insight into the dynamics of the on-line processes that explain why coherence markers lead to better text comprehension.

In addition, a growing number of studies have investigated the effects of coherence markers on readers' on-line processing. Most studies reported that coherence markers speed up the immediate processing of subsequent information on children (Cain & Nash, 2011) and adults (Cozijn, Noordman, & Vonk, 2011; Haberlandt, 1982; Millis & Just, 1994; Noordman & Vonk, 1997; Sanders & Noordman, 2000). In contrast, some studies reported faster processing only for markers of consequence-cause or claim-argument relations, such as *because*, and not for markers of cause-consequence or argument-claim relations, such as *so* (Maury & Teisserenc, 2005), or for contrastive (*however*) but not for additive or causal connectives (Murray, 1997). Although most studies reported an initial speedup effect (cf. Traxler, Bybee, & Pickering, 1997), some studies also reported a slowdown effect at the end of the sentence following the coherence marker (Cozijn et al., 2011; Millis & Just, 1994). However, these studies have not explained how various reading processes relate to differences in text comprehension. In our study, we investigate the effects of both the presence and the timing of various connectives on the quality of students' mental representations and cognitive processes during early or later sentence processing.

Most studies tested only undergraduates, who may be classified as "more experienced" and "more skilled" readers. For younger, less experienced readers, however, fewer studies have shown the benefit of coherence markers. And if they have, several text characteristics were manipulated simultaneously (Land, 2009) or the "texts" consisted of sentence pairs containing one or two clauses before and one clause after the coherence marker (Cain & Nash, 2011). The question is whether such sentence pairs, which also occurred in studies among adults (Haberlandt, 1982; Maury & Teisserenc, 2005; Millis & Just, 1994; Murray, 1997; Traxler et al., 1997), provide a natural reading environment. There have been only two studies in which participants read real texts: short narratives varying from seven to 15 sentences (Cozijn et al., 2011; Sanders & Noordman, 2000). Hence, by providing whole passages, containing at least 260 words, we intended to gain insight into students' processing of full-length texts.

In addition, we use a noninvasive method: a remote eye-tracker in a natural school context. In the majority of studies, the processing data were collected with head-mounted eye-trackers in a lab environment (Cozijn et al., 2011; Traxler et al., 1997) or by a self-paced reading paradigm in which texts were presented one sentence or one word at a time (Cain & Nash, 2011; Haberlandt, 1982; Maury & Teisserenc, 2005; Millis & Just, 1994; Murray, 1997; Sanders & Noordman, 2000).

Apart from having the theoretical and methodological motivations mentioned above, we have a practical rationale for investigating coherence marking. In many school texts, connectives are removed (Graesser, McNamara, Louwerse, & Cai, 2004; Land, 2009), because educational publishers are known to shorten sentences and remove coherence markers for the purpose of downsizing the grade levels of their texts (Graesser et al., 2004). This phenomenon indirectly points to an important role that educational publishers may play in influencing text comprehension.

### The Influence of Layout

Apart from studying the role of connectives, we also investigated the effects of layout. Previous studies have shown that it is a complex maneuver to move eyes from the end of one line to the beginning of the next. The first word of a new line usually takes longer to read than other words (Haberlandt & Graesser, 1985) and is often skipped, which sometimes requires the reader to make a corrective movement (Rayner, 1998). This might suggest that educational publishers should try to reduce the number of return sweeps in a text and use a continuous layout, as in Example 3, instead of a discontinuous one, as in Example 4.

3. The man was seen as the head of the family. The woman was subordinate to the man. That's why the woman had to listen to him. Especially the men earned the money. The woman had to work at home. Sometimes, the woman also worked outdoors.

4. The man was seen as the head of the family.  
The woman was subordinate to the man.  
That's why the woman had to listen to him.  
Especially the men earned the money.  
The woman had to work at home.  
Sometimes, the woman also worked outdoors.

However, a continuous layout may generate other reading problems. Consider, for example, the clause "the men earned the money" in Example 3. This clause should be parsed as one unit, but it is interrupted by a line break. Therefore, reading the clause can only be completed after a return sweep to the next line. Proficient readers automatically segment the sentences of a text into syntactically and semantically appropriate units or phrases (Just & Carpenter, 1987; LeVasseur, Macaruso, Palumbo, & Shankweiler, 2006), but for many inexperienced, developing readers, parsing a sentence into phrases and clauses seems to be problematic (Fuchs, Fuchs, Hosp, & Jenkins, 2001; LeVasseur et al., 2006). LeVasseur et al. (2006) found that when phrasal constituents were interrupted by a line break, as in Example 3, 7- to 9-year-olds obtained lower fluency ratings and made more than twice as many false starts than they did with texts in which the end of a line corresponded to a clause boundary, as in Example 4. One explanation for this result is that the processing of a major syntactic unit is easier if it is completed before the reader has to undertake a complex return sweep.

There is another reason why it remains to be seen whether educational publishers should opt for the layout in Example 3 or the one in 4: A disruption of the on-line reading process does not necessarily mean that students' off-line text comprehension is also impeded. Previous studies do not clarify this issue, because they focused either on the way in which layout affects students' on-line text processing (cf. LeVasseur et al., 2006) or on the effects on students' off-line text comprehension, but not on the combination of the two. For example, Bever, Jandreau, Burwell, Kaplan and Zaenen (1990) and Jandreau and Bever (1992) found that presenting phrases in a discontinuous layout resulted in a better off-line understanding, but other studies in which larger phrases or full clauses were investigated found similar manipulations to be ineffective (Land, 2009; LeVasseur, Shankweiler, & Macaruso, 2001). Therefore, in our study we investigated the effects of layout manipulations both on students' text processing and on students' text comprehension.

A practical rationale for studying layout is that many Dutch school texts are presented in a discontinuous layout, with each sentence starting at a new line. In a corpus-based study, Land (2009) found that texts with short sentences in a discontinuous layout were predominant in Dutch textbooks for students in the lowest levels of pre-vocational secondary education. Only 31% of their school texts were presented in a continuous layout. In comparison, at the higher education levels one third of the mathematics texts and only 10% of the other school texts were presented in a discontinuous layout. In interviews, some publishers and teachers mentioned that they believe this to be a good strategy for developing optimal texts for pre-vocational education, because they thought texts in a discontinuous layout and without connectives place fewer processing demands on lower level cognitive processes (Land, 2009; see also Graesser et al., 2004).

### Current Study and Hypotheses

The experiment reported in this article intends to address the following research questions:

*Question 1:* What influence do coherence markers and layout have on students' on-line processing?

*Question 2:* What is the relation between students' on-line processing and their off-line comprehension scores?

Various predictions can be made on the basis of previous research. On the one hand, Land (2009) and Cain and Nash (2011) have suggested that developing and less experienced readers are less capable of interpreting coherence relations than more experienced, adult readers, and therefore the less experienced readers benefit more from coherence marking. On the other hand, it can be argued that when a coherence marker is inserted, sentence length increases. As a result, more processing demands are placed on a limited working memory.

All in all, based on on-line studies of skilled adults though, we hypothesize that adolescents in secondary education will use the information provided by a coherence marker immediately after reading that marker (Cozijn et al., 2011; Traxler et al., 1997). In combinations "Clause<sub>1</sub>, (connective) Clause<sub>2</sub>," we expect that the addition of coherence markers will result in shorter on-line processing time of the initial part of Clause<sub>2</sub>, because these markers reduce the number of alternative coherence relations between clauses. We will examine this assumption using natural texts and noninvasive methods.

With respect to layout, we have no specific hypotheses. On the one hand, a discontinuous layout with one clause on each line has a better arranged view, and the processing of phrases and clauses could be easier because return sweeps only occur after complete clauses, as in Example 4. If fragmentation reduces the number of false starts and makes corrective eye movements unnecessary (cf. LeVasseur et al., 2006), one possibility is that students' processing times in the first part of a clause decrease. On the other hand, sentence fragmentation is inconsistent with the conventional way texts are presented. Fragmentation causes visual breaks that do not prompt the reader to mentally connect the current clause to the previous one. These visual breaks make texts less coherent and entails that students have to fill in the coherence gaps. This additional processing load would call upon their limited working



memory capacity and might result in longer processing times, especially at the first part of a clause.

Finally, we expect a relationship between students' processing times and their comprehension scores: When processing load decreases (which will result in shorter reading times), text comprehension will increase. Thus, it is posited that text features that reduce processing load will have a positive effect on text comprehension.

## Method

Our aim in this experiment was to examine the impact of layout and the presence or absence of coherence markers on text comprehension of Dutch students in secondary education. Text comprehension was tested with on-line measures (several reading times) and an off-line measure (students' score on bridging inference questions).

## Participants and Design

All students read four texts: (a) a continuous version marked with connectives, (b) a continuous version that is not marked with connectives, (c) a marked discontinuous version, and (d) an unmarked discontinuous version. Text versions and text orders were randomly assigned to students.

Participants were 134 students (80 boys and 54 girls) from the eighth grade in Dutch secondary education. Students were from two different school levels: 67 students were from senior general secondary education (Dutch havo) or pre-university education (Dutch vwo) and 67 students were from pre-vocational education (Dutch vmbo). Vmbo is divided into four levels ranging from mainly theoretical (high level, vmbo-tl) to vocational training (low level, vmbo-bb).

We have several main reasons for selecting and comparing reading times and comprehension scores of students from the higher educational levels and students from the lower levels. In general, the population of eighth graders in Dutch education can be characterized as a very heterogeneous group. In our study, we also found considerable variance in reading times and comprehension scores between students from the two levels. Furthermore, Dutch publishers design textbooks for each educational level separately.

Students were 12 to 15 years old (mean 13 years and 2 months). All but eight students were native speakers of Dutch. About one sixth of the participants were dyslexic: 11 pre-vocational and 9 pre-university students. The distribution of respondents over school levels was found to be comparable in terms of gender ( $\chi^2 = 2.35$ ;  $df = 1$ ;  $p = .13$ ), native language ( $\chi^2 = 2.00$ ;  $df = 1$ ;  $p = .16$ ), and dyslexia ( $\chi^2 = 0.33$ ;  $df = 1$ ;  $p = .56$ ) but not in terms of age ( $t = 3.03$ ;  $df = 107$ ;  $p = .003$ ). Pre-vocational students were significantly older (13 years and 5 months) than pre-university students (13 years and 1 month).

## Materials

**Texts.** The experimental material consisted of four Dutch texts of approximately 290 words (minimum 260/maximum 317). The experimental texts were based on educational texts from history textbooks used in pre-vocational education. We intentionally focused on history texts, because these books have a substan-

tial size and contain a large amount of textual information; many less skilled students are unable to read these texts accurately (Bowen, 1999; Land, 2009). Also, the history texts have a greater structural complexity and a greater information density than narrative fiction texts, and hence they are inherently more complex (Ben-Anath, 2005; Coté et al., 1998; Spyridakis & Standal, 1987). Topics included hygiene in the Middle Ages, Dutch slave trade in the 17th century, wigs in the 18th century, and feminism. Only topics that had not been taught during the first years of secondary education were included.

There were two independent variables: presence versus absence of connectives and continuous versus discontinuous layout. To make local coherence explicit, we added informative additive connectives, such as *also*, *moreover*, *furthermore*, and *besides*, and causal connectives, such as *so*, *because* and *therefore*, in clause-initial position to signal the relations between sentences or clauses. Example 5 shows a causal relation made explicit by the causal connective *daarom* (that's why) and an additive relation marked with the additive connective *ook* (also). Example 6 shows the implicit counterpart of Example 5.

5. Veel mannen deden de Franse koning in alles na. *Daarom* kochten ze net zo'n pruik als de koning. *Ook* droegen veel mannen een pruik om indruk te maken.

"Many men imitated the French king in everything. *That's why* they bought a wig just like the king. *Also*, many men wore a wig to impress."

6. Veel mannen deden de Franse koning in alles na. Ze kochten net zo'n pruik als de koning.

Veel mannen droegen een pruik om indruk te maken.

"Many men imitated the French king in everything.

They bought a wig just like the king.

Many men wore a wig to impress."

There were three to four additive connectives in the explicit versions, and the number of causal connectives ranged from five to 11, resulting in a total of eight to 14 connectives per text. We selected more causal than additive connectives, because several studies have shown that causal relations are a particularly important type of coherence relations (Kendeou et al., 2009). Furthermore, we wanted to include different subtypes of causal connectives: We added markers of cause-consequence, such as *therefore*, *as a result*, and consequence-cause relations, such as *because*. Note that we only systematically varied the presence or absence of additive and causal connectives. Thus, both explicit and implicit versions could contain (one to three) temporal (*subsequently*) and contrastive connectives (*but*).

All texts contained sentences with a maximum of one subordinate clause. Apart from the presence of connectives, only word order was varied between the implicit and explicit versions. This was dictated by the fact that word order in Dutch main clauses differs from the one in subordinate clauses. In Example 7, the explicit version contains a subordinate clause with the finite verb *zaten* (were) near the end of the clause. The implicit version in Example 8 contains an unmarked main clause, with the finite verb after the subject.

7. In de Middeleeuwen verspreidden ziekten zich erg snel, *doordat* kelders, keukens en voorraadmasten vol met ratten zaten.

"In the Middle Ages diseases spread very fast, *because* basements, kitchens and cupboards were full of rats."

8. In de Middeleeuwen verspreidden ziekten zich erg snel. Kelders, keukens en voorraadkasten zaten vol met ratten.

"In the Middle Ages diseases spread very fast. Basements, kitchens and cupboards were full of rats."

The second variable we manipulated was layout. In the continuous versions, sentences were presented in a continuous layout. In the discontinuous versions, each main, coordinate, and subordinate clause started at a new line. Examples 3 and 5 show a text passage in a continuous layout, and Examples 4 and 6 show a text passage with a discontinuous layout.

In sum, there were four text versions: (a) an explicit text with continuous layout, (b) an explicit text with each clause starting at a new line, (c) an implicit text with continuous layout, and (d) an implicit text with each clause starting at a new line. A complete version of one of the explicit texts can be found in [Appendix A](#).

**Comprehension questions.** For each text, we constructed four or five bridging inference questions that specifically addressed the situation model representation, as is common in other studies ([Degand & Sanders, 2002](#); [Kamalski et al., 2008](#); [Kintsch, 1998](#); [Land, 2009](#)). All questions were open-ended, because such questions are a more sensitive measure of the reader's situation model than more global measures, such as free recall ([McNamara et al., 1996](#); [Spyridakis & Standal, 1987](#)).

We constructed two types of bridging inference questions. First, we constructed causal inference questions, such as *Why did women particularly do unskilled work and have lower positions in the 19th century?* The information for answering such questions was stated in separate sentences of the text: [*The public view was that women were less intelligent than men.*]<sub>S1</sub> [*(Therefore,) women did particularly unskilled work and they had lower positions.*]<sub>S2</sub>. Readers had to integrate the information of the second sentence into the mental representation of the first sentence as well as with their relevant prior knowledge about the 19th century and the position of women. In addition, they had to make the inference that women did unskilled work because they were classified as less intelligent.

Second, we constructed items that questioned several elements in a list relation, such as *Why did some men buy a wig made of horsehair? Give two reasons.* The information for answering such questions was stated in at least two separate sentences of the text: [*Other wigs were made of horsehair.*]<sub>S1</sub> [*Such wigs were a lot cheaper.*]<sub>S2</sub> [*Moreover, their curls stayed in place even when it rained.*]<sub>S3</sub> [*Therefore, poor men bought a wig of horsehair.*]<sub>S4</sub>. To answer these additive questions, readers had to establish list relations between at least two sentences. All inference questions were designed in such a way that students had to coordinate multiple pieces of information and infer numerical/additive or causal coherence relations, which in the explicit versions were marked with connectives.

## Pilot Study

All texts, comprehension questions, and tasks were pretested at several schools. One hundred twenty-six students from the eighth grade participated in the pilot study and did not participate in the main study. Each of the 67 pre-vocational students and the 59 pre-university students tested two of the four texts. The reliability

of the bridging inference questions per text was low ( $.30 < \alpha < .46$ ). Results also showed that some items were too easy (more than 90% correct response) and others appeared too difficult (less than 25%). On the basis of these results, difficult words were replaced, such as *feminism* in a heading, and several questions were modified or replaced when they were too easy or too difficult or when they led to a decrease in the overall reliability.

## Apparatus and Procedure

All tests were administered at school. Each student was tested individually in a quiet room. All texts were presented on a PC monitor. The distance between the students' eyes and the monitor was approximately 60 centimeters. The eye movements were recorded with a Tobii 1750 eye-tracker with remote cameras (Tobii Technology, Danderyd, Sweden). Both eyes were sampled at 50 Hz, which means that the position of both eyes was recorded every 20 milliseconds. We were aware that 50 Hz is not a very high temporal resolution for reading studies. For measuring eye movements in our study, however, we preferred using a noninvasive method in a natural school environment over a higher temporal resolution yet invasive method. Furthermore, we divided all target clauses into regions that consisted of at least two words (except for the connective region), and we found several effects of coherence marking and layout at the different regions. The finding shows that 50-Hz sampling is sensitive enough for our purposes.

Students were first informed about the texts, the Tobii eye-tracker, the procedure, and the comprehension task. After that, each student started with a calibration task during which a small circle on the screen moving through nine positions was followed to locate the position of the student's eyes. Once the calibration was successfully rendered, the first text was presented. All texts were cut up and presented on three slides on the screen. When students had finished reading a text slide, they pushed a button and the next text slide was presented on the screen. Before each text, a new calibration task was carried out. All students read two texts in a session. When they had read two texts, students started answering the questions. They received a booklet with some background questions about nationality, age, gender, first (and second) language, school level, and dyslexia. Then the questions about the two texts followed in the order in which the texts were read. After answering the questions and taking a five-minute break, the students had to read the next two texts. The procedure was repeated. The duration of one session with two texts was between 18 and 30 minutes. The experiments were conducted over a period of 2 weeks.

## Analyses

**Analysis of the on-line data.** The quality of the eye-tracking data was checked before the processing times were analyzed. The eye-tracking data of three students were excluded from the analyses because these students did not show active participation or their eye movements were of poor quality. Furthermore 11.9% of the eye-tracking data of the other participants was of poor quality and was therefore also excluded from the analyses. The poor quality of the data was due to technical problems during testing or was caused by students wearing too thick glasses, blinking too often, or skipping several sentences (especially at the end of the

slide/text). For each condition, all observations that were two standard deviations above or below item and subject mean were excluded from the analyses.

We divided all target clauses into three or four regions. The clauses that contained a connective in the explicit condition were divided into four regions, as in Example 9; in the implicit condition three regions were distinguished, as in Example 10.

9. Een hoge pruik was voor veel vrouwen veel te gewoon.  
[Daarom]<sub>0</sub> [versierden ze]<sub>1</sub> [hun pruik met bloemen]<sub>2</sub> [hoeden en bootjes]<sub>3</sub>  
"A high wig was not special enough for many women.  
[That's why]<sub>0</sub> [they decorated]<sub>1</sub> [their wig with flowers]<sub>2</sub> [hats and boats]<sub>3</sub>"

10. Een hoge pruik was voor veel vrouwen veel te gewoon.  
[Ze versierden]<sub>1</sub> [hun pruik met bloemen]<sub>2</sub> [hoeden en bootjes]<sub>3</sub>  
"A high wig was not special enough for many women.  
[They decorated]<sub>1</sub> [their wig with flowers]<sub>2</sub> [hats and boats]<sub>3</sub>"

Region 0 is the connective; region 1 is the region directly after the connective, which often contained a subject and verb. Region 3, the last region of the target sentence, often contained a prepositional phrase or verb. Region 2 contained the information between regions 1 and 3.

We computed four reading time measures per region: the first-pass reading time, the regression path duration, re-reading duration, and the total reading time. The first-pass reading time is the time spent in a region before the region is left in a forward or a backward direction. The regression path duration consists of the sum of fixations on a region before moving into a forward direction. It also includes the first-pass reading as well as the re-reading of previous text information. Re-reading duration consists of regression path duration minus first-pass reading time. Because 25.3% of the eye movements were in a backward direction, the analyses of re-reading duration were based on roughly one quarter of the data. Both regression measures were included to capture difficulty effects during processing, because readers often go back to earlier regions to solve reading difficulties. The total reading time is the sum of all fixations on a region, including re-fixations of the region after it was left. This measure is assumed to be indicative of textual integration processes for retrieving missing information or resolving reading difficulties.

**Analysis of the off-line data.** A correction model was developed to examine the answers to the comprehension questions. A score of one point was assigned to each correct answer to the causal inference questions. For additive inference questions, a score of one point was awarded for each correct item from the list. For each student, we computed the percentage of correct responses, because the number of questions differed per text and in some texts more points were available for the additive lists. Two raters, the first author and a research assistant, independently examined the answers to the comprehension questions. The interrater reliability was high (Cohen's  $\kappa = .92$ ). Occasional differences in rating were discussed until agreement was reached. For the multilevel analyses, one final data set was used.

**Analysis of the combined on- and off-line data set.** Finally, we computed correlation coefficients between the comprehension scores and different reading times per reading time (first-pass reading time, regression path duration, re-reading duration, and total reading time) and per region (region 0, 1, 2, and 3). We

computed partial correlation analyses, which involved studying the linear relationship between the two variables of comprehension score and reading time after excluding the effect of the independent factor school level (pre-university vs. pre-vocational level), because we found considerable variance in students' reading times and comprehension scores caused by the school level.

## Results and Discussion

### Reliability

We investigated whether comprehension questions per text gauge comprehension in a reliable way. Cronbach's alpha of the bridging inference questions per text was marginally acceptable for experimental purposes ( $.51 < \alpha < .61$ ). Because all students read four texts (albeit a different version per text), we also investigated whether the comprehension questions measure the same theoretical construct across all four texts and calculated their reliability from the relative proportion of between-person variance as compared to the residual variance (cf. Kamoen, 2012; Lord & Novick, 1968; Raudenbush & Bryk, 2002). This led to an acceptable reliability of the comprehension questions across four texts ( $\rho = .72$ ).

### On-Line Results and Preliminary Discussion

The distribution of the raw and untransformed data was not comparable to the normal distribution for any of the reading times. This is a common phenomenon for processing data (cf. Yan & Tourangeau, 2008). Therefore, log-transformations were performed on the data in order to meet the normality requirements for linear modeling.

For each reading time, a separate multilevel model was constructed to test whether effects of coherence marking and layout could be generalized across texts and students. This resulted in 2 (explicit vs. implicit)  $\times$  2 (continuous vs. discontinuous) conditions of average processing times for regions 1, 2, and 3. For region 0, average processing times were computed only for the different layout conditions. We also included school level (pre-university vs. pre-vocational level) and comprehension scores as fixed factors in the models, while text variance (more or less difficult to comprehend) and between-person variance (one person can comprehend a text better than another) were random parameters.

The results of the analyses of the first-pass reading time, the regression path duration, the re-reading duration, and the total reading time are shown in Table 1. The average fixation times are provided in milliseconds and natural logs (ln) used for the analysis. There were no interaction effects involving school level, which means that all observed effects of coherence marking and layout on the reading times apply to both school levels.

Table 1 shows that pre-university students had significantly shorter fixation times than pre-vocational students did. This pattern was observed in all regions and all reading times, except for the regression path duration and the re-reading duration in region 0 (the connective) and region 3 ( $p > .05$ ). For example, in all conditions and regions the natural logs of pre-university students' first-pass reading time were at least .12 shorter than the natural logs of pre-vocational students' first-pass reading.

Table 1

*Parameter Estimates of Reading Times in Milliseconds and Natural Logs (ln) per Condition and per Region*

Reading time	Pre-vocational level				Pre-university level	S <sub>2</sub> texts	S <sub>2</sub> persons
	Explicit		Implicit				
	Continuous	Discontinuous	Continuous	Discontinuous			
Region 0							
FP	260 (5.56)	317 (5.76)	N/A	N/A	−.13 (.06)	.06 (.01)	.30 (.01)
RP	327 (5.79)	334 (5.81)	N/A	N/A	−.10 (.06)	.08 (.02)	.35 (.02)
RR	464 (6.14)	721 (6.58)	N/A	N/A	−.16 (.12)	.14 (.10)	.57 (.12)
TT	302 (5.71)	327 (5.79)	N/A	N/A	−.11 (.05)	.07 (.01)	.32 (.01)
Region 1							
FP	459 (6.13)	412 (6.02)	550 (6.31)	672 (6.51)	−.13 (.04)	.03 (.01)	.64 (.01)
RP	728 (6.59)	889 (6.79)	773 (6.65)	821 (6.71)	−.22 (.05)	.09 (.01)	.45 (.01)
RR	871 (6.77)	963 (6.87)	863 (6.76)	1,086 (6.99)	−.27 (.06)	.04 (.02)	.60 (.03)
TT	735 (6.60)	812 (6.70)	781 (6.66)	804 (6.69)	−.17 (.05)	.08 (.01)	.44 (.01)
Region 2							
FP	420 (6.04)	469 (6.15)	446 (6.10)	433 (6.07)	−.12 (.05)	.05 (.01)	.54 (.01)
RP	659 (6.49)	685 (6.53)	677 (6.52)	697 (6.55)	−.20 (.05)	.08 (.01)	.44 (.01)
RR	837 (6.73)	916 (6.82)	880 (6.78)	944 (6.85)	−.24 (.07)	.08 (.02)	.50 (.02)
TT	661 (6.49)	699 (6.55)	678 (6.52)	698 (6.55)	−.12 (.05)	.08 (.01)	.39 (.01)
Region 3							
FP	508 (6.23)	513 (6.24)	498 (6.21)	518 (6.25)	−.15 (.04)	.04 (.01)	.54 (.01)
RP	757 (6.63)	757 (6.63)	757 (6.63)	796 (6.68)	−.07 (.05)	.06 (.01)	.54 (.01)
RR	561 (6.33)	483 (6.18)	590 (6.38)	561 (6.33)	.07 (.06)	.05 (.02)	.94 (.03)
TT	672 (6.51)	645 (6.47)	665 (6.50)	659 (6.49)	−.12 (.05)	.06 (.01)	.47 (.01)

*Note.* Reading times are as follows: first-pass reading time (FP), regression path duration (RP), re-reading duration (RR), and total reading time (TT). The deviations (in terms of standard error) of pre-university students' reading times, text, and person variances are only provided in natural logs (ln) with standard errors in parentheses. Z scores are computed by dividing the estimated parameters by their standard error. When a z score is greater than 1.965 or less than -1.965, it is significant ( $p < .05$ ). N/A = not available.

In several regions and different reading times, we found significant main effects of the layout indicating that a continuous layout resulted in shorter reading times. In first-pass reading time, effects of the layout were found at region 0 ( $\chi^2 = 27.66$ ;  $df = 1$ ;  $p < .001$ ) and region 1 ( $\chi^2 = 4.57$ ;  $df = 1$ ;  $p = .03$ ). The same effects were found in total reading time at region 0 ( $\chi^2 = 7.60$ ;  $df = 1$ ;  $p = .01$ ), region 1 ( $\chi^2 = 10.58$ ;  $df = 1$ ;  $p = .001$ ), and region 2 ( $\chi^2 = 6.17$ ;  $df = 1$ ;  $p = .01$ ). We also found a significant main effect of the layout at region 1 in the regression path duration ( $\chi^2 = 42.03$ ;  $df = 1$ ;  $p < .001$ ) and the re-reading duration ( $\chi^2 = 6.77$ ;  $df = 1$ ;  $p = .009$ ). We cannot interpret the main effects in first-pass reading time and in regression path duration at region 1, because we also found interaction effects on these reading times. Still, the other five main effects of the layout indicate that students read quicker and had shorter re-reading times in regions 0, 1, and 2 when they read a continuous version than when they read a discontinuous version. Contrary to the findings in LeVasseur et al. (2006), positive instead of negative effects of interrupting phrases and clauses by a line break were found: It was the discontinuous layout, with each clause starting a new line, in which students' re-reading times of the first regions increased. These longer reading times indicate that when the layout presents clauses as unrelated, readers' processing load increases. This implies that it takes additional effort to integrate discontinuous presented clauses into one coherent text representation.

At region 1, the region directly after the connective, we found a significant main effect of coherence marking in the first-pass reading time ( $\chi^2 = 189.90$ ;  $df = 1$ ;  $p < .001$ ) and a two-way interaction between coherence marking and layout ( $\chi^2 = 41.21$ ;  $df = 1$ ;  $p < .001$ ). Both versions with a connective were read faster than the implicit version with a continuous layout, which in turn was read faster than the implicit version in a discontinuous layout. In line with our hypothesis, the faster first-pass reading time at region 1 indicates that additional information provided by connectives contributes to the immediate integration of the two clauses. Specifically, the connective signals explicitly how to integrate the current sentence with the information from the previous one. Students in both levels of secondary education indeed use connectives as processing signals immediately after reading the connective, at a position at which they do not have enough information to establish the coherence relation on the basis of the content of the connective clause (compare the results in Canestrelli, Mak, & Sanders, 2012; Sanders & Noordman, 2000). This essentially means that students do not need to compute the relation between the sentences on the basis of the propositions in the sentences.

When there is no connective, it takes longer to process the first part of the sentence following the connective, because students have to make additional inferences about the nature of the coherence relations between sentences on the basis of the propositions in the sentences. Making these inferences naturally increases the



processing load and hence requires additional time. This may explain why we students' first-pass reading time was longer in the implicit condition, as found in this study.

However, the initial speeding-up effect of connectives does not show up consistently at other reading times. We found an interaction effect of coherence marking and layout in regression path duration at region 1 ( $\chi^2 = 12.62$ ;  $df = 1$ ;  $p < .001$ ). The shortest regression path durations were found for continuous texts with connectives (explicit condition). The regression path durations of the implicit texts (in both a continuous and a discontinuous layout) were a bit longer, but the longest times were found in the explicit versions with a discontinuous layout. These results confirm the facilitative effect of connectives but only when texts have a continuous layout. When texts are presented in a discontinuous layout, connectives actually slow down the reading process. This is probably because the information provided by connectives is not consistent with the information provided by the layout: A discontinuous presentation of clauses suggests that the visual break is also a content break and hence prompts the reader to start a new content structure. In contrast, connectives signal that there is a coherence relation between the current clause and the previous one, despite the visual break between them. Readers may try to integrate this contrasting information given by visual and lexical cues, which results in longer processing times than when there is no connective in a discontinuously presented text. Therefore, the presence of connectives gives rise to additional processing load, especially in the first part of the connective clause.

The facilitative role of connectives in continuous texts can also be derived from the interaction effect between coherence marking and layout on first-pass reading time at region 2 ( $\chi^2 = 11.07$ ;  $df = 1$ ;  $p < .001$ ): Students had shorter first-pass reading times when they read the explicit version with a continuous layout compared to the explicit version with a discontinuous layout and the implicit version with a continuous layout. At region 3, no effects of coherence marking and layout were observed ( $p > .08$ ). Surprisingly, we found no first-pass reading time differences between the explicit version with a continuous layout and the implicit version with discontinuous layout at region 2. That is when reading the implicit version with a discontinuous layout, readers are not prompted to integrate clauses, neither by connectives nor by layout. Some of the readers in this condition do not make integrative inferences. In the other two versions either connectives or layout activates readers to make inferences, which takes additional time.

### Correlations Between Off-Line and On-Line Data

The important question is whether information that is processed faster is understood better. Table 2 reports the coefficients of the correlation between reading times per region and comprehension scores.

As was shown earlier, pre-university students showed significantly faster reading times than pre-vocational students did. Therefore, we computed partial correlation coefficients, which represent correlations between comprehension scores and reading times after removing variance caused by school level.

Except for re-reading duration, there is a strong correlation between reading times in the different regions ( $r > .78$ ;  $p < .001$ ), which indicates that students had a similar reading behavior across regions. As for re-reading duration, we found lower correlation

Table 2

*Correlations and Strength of Correlations (in Parentheses) Between the Comprehension Score and Reading Times per Region*

Variable	Comprehension score	Region 0	Region 1	Region 2
First-pass reading time				
Region 0	-.50 (.25)	—		
Region 1	-.37 (.14)	.67 (.45)	—	
Region 2	-.46 (.21)	.77 (.59)	1.00 (1.00)	—
Region 3	-.39 (.15)	.83 (.69)	1.00 (1.00)	.95 (.90)
Regression path duration				
Region 0	-.43 (.19)	—		
Region 1	-.34 (.12)	1.00 (1.00)	—	
Region 2	-.39 (.15)	.94 (.88)	1.00 (1.00)	—
Region 3	-.19 (.04)	.87 (.76)	.90 (.81)	.86 (.74)
Re-reading duration				
Region 0	-.41 (.17)	—		
Region 1	-.31 (.10)	.78 (.61)	—	
Region 2	-.52 (.27)	1.00 (1.00)	1.00 (1.00)	—
Region 3	.16 (.03)	.29 (.08)	.88 (.77)	.67 (.45)
Total reading time				
Region 0	-.36 (.13)	—		
Region 1	-.30 (.09)	.95 (.90)	—	
Region 2	-.33 (.11)	.88 (.77)	1.00 (1.00)	—
Region 3	-.31 (.10)	.85 (.72)	1.00 (1.00)	.99 (.98)

scores between regions 0 and 3 ( $r = .29$ ;  $p < .01$ ) and regions 2 and 3 ( $r = .67$ ;  $p < .001$ ), indicating that students' re-reading behavior across these regions was less consistent.

For all reading times and all regions we observed significant negative correlations with comprehension scores ( $p < .04$ ), except for the regression path duration in region 3 ( $p = .20$ ): Pre-vocational and pre-university students who read the clauses faster obtain higher comprehension scores. In other words, the lower the amount of cognitive effort it takes to process the text, the higher the chance that students will construct a coherent mental representation.

We used the proportion of shared variance to classify the strength of correlations (Cohen, 1977). The overlap between the reading times and comprehension scores can be classified as moderate: for first-pass reading time between 14 and 25%, for regression path duration between 12 and 19%, for re-reading duration between 10 and 27% (except for region 3, showing 3%), and for total reading time between 9 and 13%. Thus, the results in our study suggest that the quality of students' mental representation is influenced by the amount of cognitive effort it costs to process text information.

### General Discussion

The results of this study helped to gain insight into the role of connectives and layout during and after reading of full-length texts in a natural school environment; in particular, the role they play in text comprehension of readers in secondary education. Reading times demonstrate that the presence of connectives speeds up text processing, in particular when students read texts presented in a



continuous layout, and that a discontinuous layout slows students' reading processes. Furthermore, with respect to the relation between text processing and comprehension, our study shows a negative linear relationship between reading times and comprehension scores, which implies that students who read faster had higher comprehension scores and vice versa.

On the basis of these results, we can identify text characteristics that make sentences easier to process (i.e., faster to read). We can conclude that all students benefit most from texts in a continuous layout that contain connectives. These texts lead to faster processing times and hence cost less cognitive effort. At the same time, we also found that the quality of the mental representation increases, as reflected in higher comprehension scores. Our finding is in line with the findings of Cain and Nash (2011) and Sanders and Noordman (2000), who used only experimental texts with a continuous layout. Cain and Nash (2011) found that the presence of connectives facilitates the processing of two-clause sentences embedded in short texts: Reading times were shorter for the first part of the second sentence if the connective was present. For adults, Sanders and Noordman (2000) also found that coherence markers lead to faster processing of subsequent information. This immediate effect of signals and connectives is corroborated in several recent eye-tracking studies (Canestrelli et al., 2012; Koornneef & Sanders, 2012; Mak & Sanders, 2013).

Our findings are not consistent with those of other studies in which the presence of connectives causes a speedup effect in the first part of the clause as well as a slowdown at the end of the sentence (Cozijn et al., 2011; Millis & Just, 1994). Millis and Just argued that a connective facilitates the initial processing, because readers wait until the end of the clause to construct the relation between the two clauses. However, the reading times and regression patterns in our study suggest that connectives influence the immediate interpretation of the unfolding sentence, especially when texts are presented in a continuous layout. The presence of a connective limits the range of possible interpretations and thus reduces the number of inferences students have to make. Secondary education students do not seem to have difficulties with increased sentence length as a result of the insertion of coherence markers. On the contrary, connectives guide students toward a coherent text representation, as is the case with children and adult readers (Gernsbacher & Givón, 1995; Mouchon, Fayol, & Gaonac'h, 1995; Sanders & Noordman, 2000).

Our findings also show sharp contrast with the current practice of many Dutch publishers. For less skilled readers and readers in secondary education, publishers select and compile books, narratives, and school texts containing short words and short, discontinuous presented sentences because they believe such texts would be easier to comprehend (Land, 2009; Sanders et al., 2007). Also such texts allegedly require fewer processing demands on lower level cognitive processes. Our research shows, however, that the opposite is true. Texts with a discontinuous layout increase the processing load, as suggested by longer reading times that are negatively correlated with comprehension scores.

### Validity of Measures

In this study, we investigated the effects of connectives on students' text processing and comprehension by constructing a single correlation model that contained the estimates of the reading

times as well as the comprehension scores. In contrast, in previous studies (cf. Millis & Just, 1994; Sanders & Noordman, 2000) the effects of coherence marking on the on-line processing and the off-line products were analyzed separately. We have shown that it is fruitful to combine on- and off-line data, because only the combination sheds light on the relation between the speed of text processing and the quality of the mental representation: Is information that is processed faster understood better as well? Our approach allowed to establish the effects of coherence marking and layout on students' processing of texts and, consequently, to investigate the implications for their mental representations of the texts.

Some caution is urged in interpreting the correlations. First, it is possible that processing times and comprehension scores are related to a common variable, for example to school level: The higher the school level, the faster students read and the higher they score on comprehension tests. That is exactly what we found in the first correlation models, and that is why we computed partial correlation analyses. By computing partial correlations, we were able to investigate the relationship between comprehension scores and reading times, excluding variance caused by school level. Still, there is also variance in comprehension scores and reading times within school level that is not captured by our model. Second, we estimated only those correlations between the processing times at particular regions and the overall comprehension score. No correlations were estimated between the reading times of a sentence and the comprehension of that specific sentence.

Nonetheless, this approach allowed us to explain why students in secondary education benefit from cohesive texts with a continuous layout. We clearly show that there is a relation between students' processing of a text and the quality of students' overall text representation. Additionally, we could give a viable explanation for better text comprehension resulting from the presence of connectives in texts with a continuous layout (comprehension scores increase as reading times decrease).

### Further Research

This study leaves various questions unanswered, which are worth of investigating in future research. First, we have shown that additive and causal connectives lead to faster processing of text segments that directly follow the connective, in particular if texts are presented in a continuous layout. At the same time, we do not know whether these markers of various coherence relations are processed in the same way. Causal relations have often been identified as crucial for establishing a coherent text representation (Mulder & Sanders, 2012; Trabasso, Secco, & van den Broek, 1984; and many others). Given the variety of coherence relations, a question arises whether the effect of causal coherence markers holds for other relations as well. Cain and Nash (2011) found faster reading times for clauses linked by a causal connective than for clauses linked by the less informative *and*. It seems that *and* requires additional processing time for computing the appropriate relation between two clauses. Hence, further research into the differences between various coherence relations, their markers, and their effects on text processing and comprehension is imperative.

Second, students of different school levels participated in this study. We have found that students from both school levels benefit

from explicitly marked texts with a continuous layout. However, we have also found that pre-vocational students spend more time reading sentences than pre-university students do, regardless of coherence marking and layout. On the basis of the study, however, we cannot explain why pre-vocational students read more slowly than pre-university students. Do longer reading times indicate that lower level students use different reading strategies than higher level students do? For example, one possibility is that pre-vocational students have a poorer text memory.

Alternatively, reading proficiency difficulties could restrict performance, because less skilled readers draw fewer inferences than skilled readers and are less capable of accessing and integrating background knowledge (Cain & Oakhill, 1999; Hannon & Dane-man, 2001). However, we cannot simply classify pre-vocational students as less skilled readers and pre-university students as skilled readers, because our data show that the variance within school levels is very high: Sometimes pre-vocational students had the same score on comprehension tasks as pre-university students did.

Longer reading times could also indicate that lower level students apply the same reading processes but less efficiently than higher level students do. For example, Ashby, Rayner, and Clifton (2005) reported that processing differences between poor and skilled adult readers appear to be those of degree, rather than type: On-line processes of poor readers show longer fixation times, shorter saccades, and more regressions than those of average readers do. Further research should determine whether less skilled readers in secondary education benefit more from connectives than their more skilled peers. Therefore, it is imperative to construct independent readability tests to gauge whether students are skilled or less skilled in reading, regardless of school level.

Third, in this study we used history texts. History texts are of the expository type in that they convey new information, but they have a structure that is often narrative in form (Perfetti, Britt, & Georgi, 1995). Further research is needed to determine the effects of coherence markers in other genres and to answer the following questions: Can we extrapolate and generalize to narratives based on the established effectiveness of connectives on students' expository text comprehension? Or do readers benefit more from the presence of connectives in more abstract informative texts, in subjects such as economics, biology, and geography?

## Conclusion

The results of the present study show that explicating the text structure by means of connectives reduces the processing load for students in secondary education, especially because such students often have difficulty in establishing the connections between text segments. We have shown that less experienced readers benefit from texts with coherence markers during reading: Explicitly marked texts with a continuous layout place fewer processing demands on students' higher level processes (in this case of inference making). Given the fact that effective interventions should affect the processes that occur during reading (Rapp et al., 2007), we believe that such explicitly marked and continuous texts are appropriate and effective tools for improving reading and learning in a school context.

## References

- Ashby, J., Rayner, K., & Clifton, C., Jr. (2005). Eye movements of highly skilled and average readers: Differential effects of frequency and predictability. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, 58(A), 1065–1086. doi:10.1080/02724980443000476
- Ben-Anath, D. (2005). The role of connectives in text comprehension. *Working Papers in TESOL and Applied Linguistics*, 5, 1–27.
- Best, R. M., Rowe, M., Ozuru, Y., & McNamara, D. S. (2005). Deep-level comprehension of science texts: The role of the reader and the text. *Topics in Language Disorders*, 25, 65–83. doi:10.1097/00011363-200501000-00007
- Bever, T. G., Jandreau, S., Burwell, R., Kaplan, R., & Zaenen, A. (1990). Spacing printed text to isolate major phrases improves readability. *Visible Language*, 25, 74–87.
- Bohn-Gettler, C. M., Rapp, D. N., van den Broek, P. W. Kendeou, P., & White, M. J. (2011). Adults' and children's monitoring of story events in the service of comprehension. *Memory & Cognition*, 39, 992–1011. doi:10.3758/s13421-011-0085-0
- Bowen, B. A. (1999). Four puzzles in adult literacy: Reflections on the National Adult Literacy Survey. *Journal of Adolescent and Adult Literacy*, 42, 314–323.
- Braasch, J. L., Goldman, S. R., & Wiley, J. (2013). The influences of text and reader characteristics on learning from refutations in science texts. *Journal of Educational Psychology*, 105, 561–578. doi:10.1037/a0032627
- Broer, N. A., Aarnoutse, C. A. J., Kieviet, F. K., & van Leeuwe, J. F. J. (2002). The effect of instructing the structural aspect of texts. *Educational Studies*, 28, 213–238. doi:10.1080/030556902200003681
- Cain, K., & Nash, H. M. (2011). The influence of connectives on young readers' processing and comprehension of text. *Journal of Educational Psychology*, 103, 429–441. doi:10.1037/a0022824
- Cain, K., & Oakhill, J. V. (1999). Inference making ability and its relation to comprehension failure in young children. *Reading and Writing*, 11, 489–503. doi:10.1023/A:1008084120205
- Cain, K., Oakhill, J., & Bryant, P. (2004). Children's reading comprehension ability: Concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology*, 96, 31–42. doi:10.1037/0022-0663.96.1.31
- Canestrelli, A. R., Mak, W. M., & Sanders, T. J. M. (2012). Causal connectives in discourse processing: How differences in subjectivity are reflected in eye movements. *Language and Cognitive Processes*, 28, 1394–1413. doi:10.1080/01690965.2012.685885
- Cohen, J. (1977). *Statistical power analysis for the behavioral sciences*. New York, NY: Academic Press.
- Coté, N., Goldman, S. R., & Saul, E. U. (1998). Students making sense of informational text: Relations between processing and representation. *Discourse Processes*, 25, 1–53. doi:10.1080/01638539809545019
- Cozijn, R., Noordman, L. G. M., & Vonk, W. (2011). Propositional integration and world-knowledge inference: Processes in understanding *because* sentences. *Discourse Processes*, 48, 475–500. doi:10.1080/0163853X.2011.594421
- Degand, L., & Sanders, T. J. M. (2002). The impact of relational markers on expository text comprehension in L1 and L2. *Reading and Writing*, 15, 739–757. doi:10.1023/A:1020932715838
- Fuchs, L. S., Fuchs, D., Hosp, M. K., & Jenkins, J. R. (2001). Oral reading fluency as an indicator of reading competence: A theoretical, empirical, and historical analysis. *Scientific Studies of Reading*, 5, 239–256. doi:10.1207/S1532799XSSR0503\_3
- Gernsbacher, M. A. (1990). *Language comprehension as structure building*. Hillsdale, NJ: Erlbaum.
- Gernsbacher, M. A., & Givón, T. (Eds.). (1995). *Coherence in spontaneous text*. Amsterdam, the Netherlands: Benjamins.

- Graesser, A. C., & Clark, L. F. (1985). *The structures and procedures of implicit knowledge*. Norwood, NJ: Ablex.
- Graesser, A. C., & McNamara, D. S. (2011). Computational analyses of multilevel discourse comprehension. *Topics in Cognitive Science*, 3, 371–398. doi:10.1111/j.1756-8765.2010.01081.x
- Graesser, A. C., McNamara, D. S., Louwerse, M. M., & Cai, Z. (2004). Coh-Metrix: Analysis of text on cohesion and language. *Behavior Research Methods, Instruments, & Computers*, 36, 193–202. doi:10.3758/BF03195564
- Haberlandt, K. (1982). Reader expectations in text comprehension. In J. F. Le Ny & W. Kintsch (Eds.), *Language and language comprehension* (pp. 239–249). Amsterdam, the Netherlands: North-Holland.
- Haberlandt, K. F., & Graesser, A. C. (1985). Component processes in text comprehension and some of their interactions. *Journal of Experimental Psychology: General*, 114, 357–374. doi:10.1037/0096-3445.114.3.357
- Hannon, B., & Daneman, M. (2001). A new tool for measuring and understanding individual differences in the component processes of reading comprehension. *Journal of Educational Psychology*, 93, 103–128. doi:10.1037/0022-0663.93.1.103
- Jandreau, S., & Bever, T. (1992). Phrase-spaced formats improve comprehension in average readers. *Journal of Applied Psychology*, 77, 143–146. doi:10.1037/0021-9010.77.2.143
- Just, M. A., & Carpenter, P. A. (1987). *The psychology of reading and language comprehension*. Boston, MA: Allyn & Bacon.
- Kamalski, J., Sanders, T., & Lentz, L. (2008). Coherence marking, prior knowledge, and comprehension of informative and persuasive texts: Sorting things out. *Discourse Processes*, 45, 323–345. doi:10.1080/01638530802145486
- Kamoen, N. (2012). *Positive versus negative: A cognitive perspective on wording effects for contrastive questions in attitude surveys* (Doctoral dissertation, Netherlands Graduate School of Linguistics, Utrecht). Retrieved from <http://www.lotpublications.nl/publish/articles/004426/bookpart.pdf>
- Kendeou, P., & van den Broek, P. (2005). The effects of readers' misconceptions on comprehension of scientific text. *Journal of Educational Psychology*, 97, 235–245. doi:10.1037/0022-0663.97.2.235
- Kendeou, P., van den Broek, P., White, M. J., & Lynch, J. S. (2009). Predicting reading comprehension in early elementary school: The independent contributions of oral language and decoding skills. *Journal of Educational Psychology*, 101, 765–778. doi:10.1037/a0015956
- Kintsch, W. (1998). *Comprehension. A paradigm for cognition*. Cambridge, United Kingdom: Cambridge University Press.
- Kintsch, W., & van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review*, 85, 363–394. doi:10.1037/0033-295X.85.5.363
- Koornneef, A. W., & Sanders, T. J. (2012). Establishing coherence relations in discourse: The influence of implicit causality and connectives on pronoun resolution. *Language and Cognitive Processes*, 28, 1169–1206. doi:10.1080/01690965.2012.699076
- Land, J. F. H. (2009). *Zwakke lezers, sterke teksten? Effecten van tekst-en lezerskenmerken op het tekstbegrip en de tekstwaardering van vmbo-leerlingen* [Less skilled readers, well-built texts? Effects of text and reader characteristics on text comprehension and text appreciation]. Delft, the Netherlands: Eburon.
- LeVasseur, V. M., Macaruso, P., Palumbo, L. C., & Shankweiler, D. (2006). Syntactically cued text facilitates oral reading fluency in developing readers. *Applied Psycholinguistics*, 27, 423–445.
- LeVasseur, V. M., Shankweiler, D., & Macaruso, P. (2001, April). *Piece-meal reading*. Paper presented at the meeting of the Eastern Psychological Association, Washington, DC.
- Linderholm, T., Everson, M. G., van den Broek, P. W., Mischinski, M., Crittenden, A., & Samuels, J. (2000). Effects of causal text revisions on more- and less-skilled readers' comprehension of easy and difficult texts. *Cognition and Instruction*, 18, 525–556. doi:10.1207/S1532690XCII1804\_4
- Lorch, R. F., Jr., & Lorch, E. P. (1986). On-line processing of summary and importance signals in reading. *Discourse Processes*, 9, 489–496. doi:10.1080/01638538609544654
- Lord, F. M., & Novick, M. R. (1968). *Statistical theories of mental test scores*. Reading, MA: Addison-Wesley.
- Mak, W. M., & Sanders, T. J. M. (2013). The role of causality in discourse processing: Effects of expectation and coherence relations. *Language and Cognitive Processes*, 28, 1414–1437. doi:10.1080/01690965.2012.685885
- Maury, P., & Teisserenc, A. (2005). The role of connectives in science text comprehension and memory. *Language and Cognitive Processes*, 20, 489–512. doi:10.1080/01690960444000151
- McMaster, K. L., van den Broek, P., Espin, C. A., White, M. J., Rapp, D. N., Kendeou, P., . . . Carlson, S. (2012). Making the right connections: Differential effects of reading intervention for subgroups of comprehenders. *Learning and Individual Differences*, 22, 100–111. doi:10.1016/j.lindif.2011.11.017
- McNamara, D. S., Kintsch, E., Songer, N. B., & Kintsch, W. (1996). Are good texts always better? Interactions of text coherence, background knowledge, and levels of understanding in learning from text. *Cognition and Instruction*, 14, 1–43. doi:10.1207/s1532690xcii1401\_1
- Meyer, B. J., & Poon, L. W. (2001). Effects of structure strategy training and signaling on recall of text. *Journal of Educational Psychology*, 93, 141–159. doi:10.1037/0022-0663.93.1.141
- Millis, K. K., & Just, M. A. (1994). The influence of connectives on sentence comprehension. *Journal of Memory and Language*, 33, 128–147. doi:10.1006/jmla.1994.1007
- Mouchon, S., Fayol, M., & Gaonac'h, D. (1995). On-line processing of links between events in narratives: Study of children and adults. *Current Psychology of Cognition*, 14, 171–193.
- Mulder, G., & Sanders, T. J. M. (2012). Causal relations and levels of discourse representation. *Discourse Processes*, 49, 501–522. doi:10.1080/0163853X.2012.692655
- Murray, J. D. (1997). Connectives and narrative text: The role of continuity. *Memory & Cognition*, 25, 227–236. doi:10.3758/BF03201114
- National Center for Education Statistics. (2012). *The Nation's Report Card: Reading 2011. National assessment of educational progress at Grades 4 and 8*. Retrieved from <http://nces.ed.gov/nationsreportcard/pdf/main2011/2012457.pdf>
- Noordman, L. G. M., & Vonk, W. (1997). The different functions of a conjunction in constructing a representation of the discourse. In M. Fayol & J. Costermans (Eds.), *Processing interclausal relationships in production and comprehension texts* (pp. 75–93). Mahwah, NJ: Erlbaum.
- Oakhill, J. V. (1994). Individual differences in children's text comprehension. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 821–848). New York, NY: Academic Press.
- OECD. (2010). *PISA 2009 results: What students know and can do: Student performance in reading, mathematics and science* (Vol. 1). Retrieved from doi:10.1787/9789264091450-en
- Perfetti, C. A. (1985). *Reading ability*. New York, NY: Oxford University Press.
- Perfetti, C. A., Britt, M. A., & Georgi, M. C. (1995). *Text-based learning and reasoning: Studies in history*. Mahwah, NJ: Erlbaum.
- Rapp, D. N., van den Broek, P. W., McMaster, K. L., Kendeou, P., & Espin, C. A. (2007). Higher-order comprehension processes in struggling readers: A perspective for research and intervention. *Scientific Studies of Reading*, 11, 289–312. doi:10.1080/10888430701530417
- Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Newbury Park, CA: Sage.



- Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, 124, 372–422. doi:10.1037/0033-2909.124.3.372
- Sanders, T., Land, J., & Mulder, G. (2007). Linguistic markers of coherence improve text comprehension in functional contexts. *Information Design Journal*, 15, 219–235. doi:10.1075/idj.15.3.04san
- Sanders, T. J. M., & Noordman, L. G. M. (2000). The role of coherence relations and their linguistic markers in text processing. *Discourse Processes*, 29, 37–60. doi:10.1207/S15326950dp2901\_3
- Sanders, T. J. M., & Spooren, W. (2007). Discourse and text structure. In D. Geeraerts & J. Cuykens (Eds.), *Handbook of cognitive linguistics* (pp. 916–941). Oxford, United Kingdom: Oxford University Press.
- Snow, C. (2002). *Reading for understanding: Toward an R&D program in reading comprehension*. Santa Monica, CA: RAND.
- Spyridakis, J. H., & Standal, T. C. (1987). Signals in expository prose: Effects on reading comprehension. *Reading Research Quarterly*, 22, 285–298. doi:10.2307/747969
- Trabasso, T., Secco, T., & van den Broek, P. (1984). Causal cohesion and story coherence. In H. Mandl, N. L. Stein, & T. Trabasso (Eds.), *Learning and comprehension of text* (pp. 83–111). Hillsdale, NJ: Erlbaum.
- Traxler, M. J., Bybee, M., & Pickering, M. J. (1997). Influence of connectives on language comprehension: Eye-tracking evidence for incremental interpretation. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, 50(A), 481–497. doi:10.1080/027249897391982
- van den Broek, P., Lynch, J. S., Naslund, J., Ievers-Landis, C. E., & Verduin, K. (2003). The development of comprehension of main ideas in narratives: Evidence from the selection of titles. *Journal of Educational Psychology*, 95, 707–718. doi:10.1037/0022-0663.95.4.707
- Vellutino, F. R. (2003). Individual differences as sources of variability in reading comprehension in elementary school children. In A. P. Sweet & C. E. Snow (Eds.), *Rethinking reading comprehension* (pp. 51–81). New York, NY: Guilford Press.
- Wright, R. E., & Rosenberg, S. (1993). Knowledge of text coherence and expository writing: A developmental study. *Journal of Educational Psychology*, 85, 152–158. doi:10.1037/0022-0663.85.1.152
- Yan, T., & Tourangeau, R. (2008). Fast times and easy questions: The effects of age, experience and question complexity on web survey response times. *Applied Cognitive Psychology*, 22, 51–68. doi:10.1002/acp.1331
- Zwaan, R. A., & Singer, M. (2003). Text comprehension. In A. C. Graesser, M. A. Gernsbacher, & S. R. Goldman (Eds.), *Handbook of discourse processes* (pp. 83–121). Mahwah, NJ: Erlbaum.

## Appendix A

### Example of an Experimental Text

The following is an example of an explicit version of a text with a continuous layout, as used in the experiment. (The connectives are underlined>. We included the connectives only in the explicit version.)

#### Wig or No Wig

In the seventeenth and eighteenth centuries wigs were very fashionable. Louis the Fourteenth began wearing a wig, *because* he was ashamed of his bald head. Many men imitated the French king in everything. *That's why* they bought a wig just like the king. *Also*, many men wore a wig to impress. They spent a lot of money to buy a new wig. Other men thought a wig prevented the occurrence of lice. *That's why* they shaved their heads entirely bald. This way the vermin could not settle in their hair anymore. But that was not true, *because* the lice crawled just as happily in a wig as in real hair.

There were many types of wigs for sale. The expensive wigs were made of women's hair. This hair mainly came from poor

women, *because* they could earn some money with their hair. For rich women, there was no need to sell their hair. Other wigs were made of horsehair. Such wigs were a lot cheaper. *Moreover*, their curls stayed in place even when it rained. *Therefore*, poor men bought wigs of horsehair.

Not only men wore wigs. Women also wore them. Very big wigs were especially popular among women, *because* Queen Marie Antoinette wore these wigs at parties. Many women imitated her. However, the women with big wigs had to be careful where they walked, *because* the wigs became easily entangled. The big wigs were not very hygienic, *because* they were full of lice and other critters. Sometimes there were even mice in the wigs. *Hence*, wearing a big wig was no fun at all.

For many women, a big wig was not special enough. *Therefore*, they decorated their wig with flowers, hats and boats. Sometimes, they put birdcages with birds in their wigs. Some wigs weighed more than one kilo because of all the decorations.

(Appendices continue)



## Appendix B

### Parameter Estimates of the Connections Between the Comprehension Score and Reading Times per Region

Variable	Comprehension score	Region 0	Region 1	Region 2	Region 3
First-pass reading time					
Comprehension score	.158 (.044)				
Region 0	-.047 (.017)	.058 (.012)			
Region 1	-.027 (.012)	.029 (.007)	.033 (.006)		
Region 2	-.041 (.014)	.042 (.008)	.042 (.006)	.052 (.008)	
Region 3	-.030 (.012)	.039 (.007)	.038 (.006)	.042 (.006)	.037 (.007)
Regression path duration					
Comprehension score	.158 (.044)				
Region 0	-.047 (.018)	.078 (.015)			
Region 1	-.037 (.015)	.078 (.011)	.073 (.011)		
Region 2	-.042 (.016)	.071 (.011)	.076 (.010)	.074 (.011)	
Region 3	-.018 (.014)	.059 (.010)	.059 (.009)	.057 (.009)	.059 (.009)
Re-reading duration					
Comprehension score	.158 (.044)				
Region 0	-1.315 (.468)	.058 (.012)			
Region 1	-.731 (.330)	.029 (.007)	.033 (.006)		
Region 2	-1.131 (.385)	.042 (.008)	.042 (.006)	.052 (.008)	
Region 3	-.848 (.335)	.039 (.007)	.038 (.006)	.042 (.006)	.037 (.007)
Total reading time					
Comprehension score	.158 (.044)				
Region 0	-.037 (.016)	.068 (.012)			
Region 1	-.033 (.015)	.068 (.010)	.075 (.011)		
Region 2	-.036 (.015)	.062 (.010)	.075 (.010)	.073 (.010)	
Region 3	-.029 (.014)	.052 (.009)	.066 (.009)	.063 (.009)	.056 (.009)

*Note.* Standard errors are shown in parentheses.

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