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Updating Situation Models During Reading of News Reports: Evidence From Empirical Data and Simulations

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Updating Situation Models During Reading of News Reports: Evidence From Empirical Data and Simulations

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Two studies explored the conditions under which readers update their representation of news reports in the presence of alternative plausible explanations for a target event. To do so, this study asked readers to read news reports that mentioned 2 different causes to explain the occurrence of a single event. This study manipulated which of the 2 causes was emphasized at the end of the news report. Experiment 1, through an inference judgment task and a simulation using the Landscape Model, evaluated which of the 2 potential causes was represented in the readers' final situation model. Experiment 2 collected think-aloud protocols to investigate the content of readers' thoughts when they were faced with alternative plausible explanations in accounts of a single event. The findings indicate that readers update their representation as new causes appear in the text but that the nature of the updating is a function of the order of presentation of the causes: They either select 1 cause over another or draw causal inferences between the 2 causes to maintain the coherence of their situation models under construction. These findings are discussed within the theoretical framework of the Landscape Model.

For a reader to be successful in comprehending a text, there must be a continual integration of incoming information with current representation in memory. A significant component of this integration process involves updating or accommodating this representation to take into account the newly encoded information. Indeed, a basic component of all current models of reading comprehension is that readers engage in this updating process (e.g., Blanc & Brouillet, 2003, 2005; Kintsch, 1988; Graesser, Singer, & Trabasso, 1994; Rapp & van den Broek, 2005; Sanford & Garrod, 1981, 1988; Tzeng, van den Broek, Kendeou, & Lee, 2005; van den Broek, Rapp, & Kendeou, 2005; van den Broek, Ridsen, Fletcher, & Thurlow, 1996; van den Broek, Young, Tzeng, & Linderholm, 1999). These updating processes, however, can be both successful and unsuccessful. For instance, there are numerous studies demonstrating that readers successfully engage in updating while reading narrative texts (e.g., Blanc, 2002; Blanc & Tapiero, 2001; Guéraud, Harmon, & Peracchi, 2005). However, there are also numerous other studies demonstrating that updating often fails and that readers continue to make inferences based on information that has been corrected earlier in the text (Johnson & Seifert, 1994, 1999; van Oostendorp, 1996; van Oostendorp & Bonebakker, 1999; Wilkes & Leatherbarrow, 1988; Wilkes & Reynolds, 1999). In view of these conflicting findings, the aim of this study is to examine readers' updating processes and to explore conditions that foster updating.

We investigate readers' updating processes in the context of news reports (Johnson & Seifert, 1994, 1999; van Oostendorp, 1996; van Oostendorp & Bonebakker, 1999; Wilkes & Leatherbarrow, 1988; Wilkes & Reynolds, 1999). News reports differ from simple narratives in that they are designed to convey a set of coherent facts about real-world situations and to explain the occurrence of these facts. Therefore, they provide an excellent opportunity to investigate updating using ecologically valid materials. Consider, for instance, this excerpt from a news report:

On September 21 at 10:15 am, an explosion occurred at the factory AZF located near the downtown of Toulouse. According to the police investigation, the explosion was the result of an unavoidable chemical reaction that took place in a building where *Nitrate powder* was stored. Very quickly, firemen, psychologists, doctors, and nurses went to the factory to give assist the injured. The explosion took a heavy toll of human life, with 29 people killed, and more than 2000 injured; many apartments, schools, hospitals and shops were also destroyed. The explosion, which was caused by *employee negligence*, was very violent, equivalent to an earthquake of 3.2 on the Richter scale. Fortunately, a chain reaction with the National Company of explosives and powders was avoided

To understand why the explosion at the factory AZF took place, readers must engage in a variety of processes such as drawing connections between text elements as well as between text elements and prior knowledge. In addition, they need

to update their episodic memory representation as it unfolds to account for newly encoded information. For instance, readers first encode that the explosion was caused by nitrate powder. Later in the report they learn that the explosion was caused by employee negligence.

One way to foster readers' updating processes is to discredit previously encoded information (e.g., Otero & Kinstch, 1992). Simply discrediting information, however, does not always foster readers' updating (Rapp & Kendeou, 2007; van Oostendorp, 1996; van Oostendorp & Bonebakker, 1999). Indeed, even when later information contradicts what was encoded earlier (as in the previous example), the earlier information remains available and influential in memory (Johnson & Seifert, 1994; Wilkes & Leatherbarrow, 1988). An alternative to simply discrediting earlier information is to provide new, plausible information later in the text. Does the presence of new, plausible information foster updating of previously encoded information? If so, under what conditions does that occur?

Recent work on updating utilizing expository texts (van Oostendorp, 2002) has demonstrated that the strength of the new, plausible information also needs to be considered. Specifically, van Oostendorp (2002) examined the degree to which readers replaced old information with new information by manipulating their respective strength. The results showed that the presence of two contradictory statements led readers to update their representation and maintain the information that was strengthened by the content of the text. In line with these findings, we investigate the conditions under which new, plausible information fosters updating by manipulating whether this or the old information is strengthened by the content of the text.

A useful framework within which to address these issues is the Landscape Model of reading (Tzeng et al., 2005; van den Broek et al., 1996, 1999) because it captures the dynamic aspects of the updating process in the context of text comprehension. The Landscape Model assumes that, during the reading process, concepts (e.g., propositions) fluctuate in their activation as a function of this text, prior reading cycles, inferential processes, access of memory for the prior text, and the reader's background knowledge. Two types of mechanisms guide access to these sources of activation. The first type is *cohort activation*. This mechanism is similar to the spread-of-activation mechanism described by the Resonance Model (Myers & O'Brien, 1998; O'Brien & Myers, 1999; O'Brien, Rizella, Albrecht, & Halleran, 1998; Tzeng et al., 2005; van den Broek et al., 2005). The second type of mechanism is *coherence-based retrieval*, a strategic mechanism by which information is retrieved with the aim of meeting a reader's standards of coherence or goals during reading (Linderholm, Virtue, Tzeng, & van den Broek, 2004; Tzeng et al., 2005; van den Broek et al., 2005). The degree to which each mechanism contributes varies across readers and situations. Thus, the Landscape Model incorporates both automatic and strategic processes that (re)activate information from the episodic memory representation of the text and from background knowledge.

In this study we use the Landscape Model to make predictions with respect to the nature of readers' final text representations. Specifically, we use the model to assess the extent to which the old (e.g., nitrate powder) and the new, plausible explanations (e.g., employee negligence) mentioned in each news report would be represented in readers' memory and integrated with later text information.

The aim in this study is to explore the conditions under which readers update their representation of news reports in the presence of alternative plausible explanations in accounts of a single event. We conducted two experiments. In each experiment readers read three versions of news reports in which two alternative causes for a primary event were presented. For an example, see the news report presented earlier. Each report introduced a primary event (e.g., an explosion at a factory) that was followed by two plausible but alternative causes for the event (first cause: nitrate powder; second cause: employee negligence). Two sentences intervened between the first and the second causes. Five sentences of backgrounding information followed presentation of the second cause. Readers were then presented with one of three possible critical sentences. The critical sentence provided support for either the first cause of the primary event (e.g., the conclusion from the police investigation that the nitrate powder stored in the factory was too volatile), the second cause (e.g., the conclusion from the police investigation that accused the factory employees of being responsible for the accident because it has been discovered that the building has not been regularly inspected), or was neutral with respect to the first or the second cause (e.g., the only positive consequence of this dramatic event was the solidarity observed between neighborhoods, friends, and families). The critical sentence enabled us to manipulate the strength of each cause as a function of text content (see van Oostendorp, 2002).

In Experiment 1, we examined whether readers update their text representations in the presence of two plausible explanations in accounts of a single event. To do so, we employed an inference judgment task to assess which one of the two explanations readers retained in their memory representation of the text. We also conducted a simulation using the Landscape Model to investigate the relative strength of each plausible cause into readers' emerging text representation and compared the experimental and simulation results. In Experiment 2, we examined readers' online updating processes using a think-aloud task.

EXPERIMENT 1

Readers read three versions of news reports in which two causes, first cause and second cause, were presented as plausible explanations for the primary event described in the report. Readers were then presented with one of three possible criti-

cal sentences. The critical sentence provided support for the first cause of the primary event, the second cause, or neither. In line with previous work (van Oostendorp, 2002), we expected that the first cause would be retrieved and integrated into readers' representation as the most plausible cause when the critical sentence supported this first cause. When the critical sentence supported the second cause, we expected that readers would most likely maintain the second cause in focus as the most plausible cause. When the critical sentence was neutral with respect to the first or the second cause, we expected that readers would either select the first cause as the most plausible (consistent with Johnson & Seifert, 1994, findings) or engage in elaborative processes to resolve the "inconsistency." In such a case, if the inconsistency is resolved, readers would maintain in memory either one of the causes. If the inconsistency is not successfully resolved, readers would most likely hold both causes in memory as plausible causes. Readers' representation of the two causes was assessed using an inference judgment task and a simulation using the Landscape Model.

Method

Participants. Thirty-two undergraduate psychology students from the University Lyon 2 (France) participated in the experiment. All participants were native French speakers.

Materials. We constructed six news reports (see the appendix for an example). Each report referred to a dramatic primary event (e.g., an oil slick, an explosion of a chemical factory, a crash of a space shuttle). All reports were written using the following format. The 1st sentence introduced the primary event that was reported in the report. The 2nd sentence stated the first cause of the reported event. The 3rd and the 4th sentences continued the report without mentioning any additional information about the first cause. The 5th sentence introduced the second cause responsible for the primary event. Five filler sentences followed before encountering the 11th sentence, which was the critical sentence. Readers were then presented with one of three possible critical sentences. The critical sentence provided support for the first cause of the primary event, the second cause, or was neutral with respect to both the first and second cause. Three sentences were then presented to provide an ending to the report. Six filler news reports were also constructed. They were similar in structure, content, and length to the experimental ones. They described a real event but, unlike for the experimental news reports, only one cause was mentioned to explain the occurrence of the primary event.

To assess the content of the readers' final representation of each news report, six inference statements were constructed for each report. Two statements focused on the critical information, one referring to the first cause and the other referring to the

second cause. The other four inference statements related to the rest of the article: Two inferences concerned information encountered at the beginning of the article (i.e., before the introduction of the second cause), and the other two concerned information encountered after the critical sentence.

To ensure the validity of the experimental material, we carried out a preliminary experiment. One hundred and ninety-two students from the University Montpellier 3 participated in this pilot study. Our objective was to assess whether the strength of the two alternative causes was similar. To explore the relative strength of each cause, we manipulated their order of appearance in the reports (the order was counterbalanced across the participants). In addition, we manipulated which cause was strengthened at the end of the report, the first or the second one. Twelve news reports were used in this pilot study. Participants were instructed to read each report and judge whether inference statements that followed each report were true or false with respect to the report they had just read. The pilot study revealed that nine reports showed no effect of the order by which the causes in the report appeared. Indeed, the pattern of response observed to the inference judgments task remained the same for those reports independently of which cause was mentioned first. We randomly selected six of these reports to be used in Experiment 1. We used as fillers the six remaining reports by removing one of the two causes so there was only one plausible cause for the main event.

Procedure. Participants were instructed to read at their own pace all 12 news reports one sentence at a time and use the space bar to advance from sentence to sentence. Reading times per sentence were recorded. Participants were informed that an inference judgment task would follow the reading of each article but they did not know in advance how many inferences they would have to judge. Six inference statements were presented at the end of each experimental report and two statements after each filler report. Participants were always instructed to judge whether the statement that appeared on the screen was true or false with respect to the news report they had just read. Participants pressed a key on the keyboard marked “O” to respond yes and a key marked “N” to respond no. They were instructed to give their answer with the same hand, keeping one finger on the “O” key and one finger on the “N” key for the duration of each judgment task. The experiment lasted approximately 1 hr.

Participants were assigned to one of three sets of news reports. Each set was counterbalanced to ensure that every participant received an equal number of reports in each of the three versions, and that each report was seen equally often in each of its three versions across the participants. The presentation of each experimental report was preceded by the presentation of a filler report. The first filler report was also used as a training text to familiarize readers with the procedure.

Results and Discussion

First, we assessed the representation of the two causes in readers' memory for the news reports by focusing on the participants' answers to the inference judgments. Second, we further examined the representation of the two causes in readers' memory by focusing on the simulations conducted using the Landscape Model.

The inference judgment task. We first analyzed the proportion of inference judgments in favor of each of the two causes. We conducted a 3 (Report Version) \times 2 (Cause) repeated-measures analysis of variance (ANOVA). There was a significant main effect for the factor *cause*: $F(1, 31) = 10.10, p < .01$. The proportion of responses favoring the second cause was significantly higher than those favoring the first cause. However, this main effect was qualified by an interaction between *cause* and *report version*: $F(2, 62) = 4.91, p < .01$. As can be seen in Figure 1, the proportion of responses favoring the second cause was higher than those for the first cause only when the critical sentence supported the second cause: $F(1, 62) = 19.55, p < .01$. There were no significant differences with respect to the preference for the two alternative causes in the neutral version and in the version that strengthened the first cause. In addition, the responses favoring the first cause were significantly lower in the version that later strengthened the second cause compared to the version that strengthened the first cause: $F(1, 62) = 4.33, p < .05$. With respect to the second cause, the analysis showed that it was significantly favored in

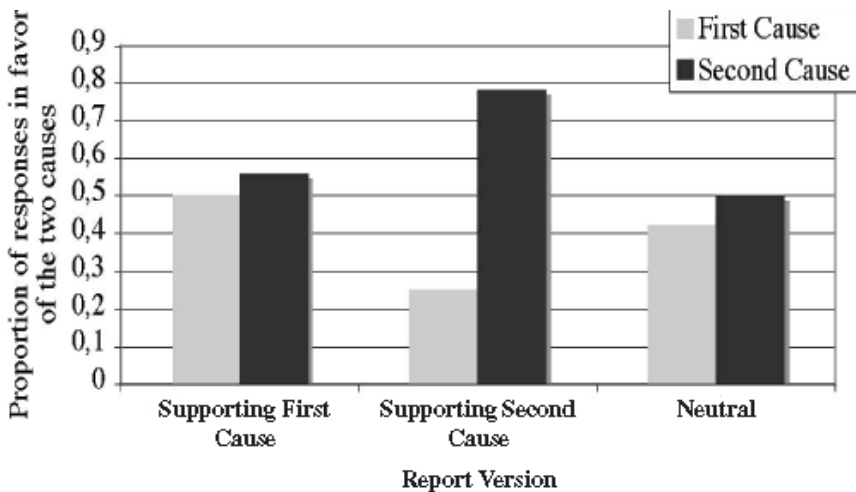


FIGURE 1 Experiment 1 judgment task: The proportion of responses in favor of each of the two causes as a function of the report version.

the version that strengthened the second cause compared to the neutral version: $F(1, 62) = 5.48, p < .05$. No other factor or interaction was significant.

Simulations. To explore the representation of the two causes in readers' memory, we performed a series of simulations using the Landscape Model. To determine how strong the two causes are in the memory representation, these simulations were performed on each version of the news report provided in the appendix. The 14 sentences that comprised each version of this report were parsed into idea units based on main clauses. This resulted in a total of 25 idea units and, thus, 25 reading cycles. Activations reflected direct input as well as relations between idea units as a result of causal inferences, enabling conditions, and referential inferences.

We explored the representation of each cause in readers' memory when reading is completed by comparing the auto-connection strengths for the idea units for each of the two causes. The auto-connection strength for each idea unit is a function of the total activation each unit received over the course of reading and the degree to which the unit has become connected to other idea units (see Tzeng et al., 2005, for a detailed description of the model output), so it is an indication of the strength an idea unit has in readers' mental text representation. When the critical sentence supported the first cause or was neutral relative to the two causes, both causes obtained approximately the same auto-connection strength (supporting first cause version: first cause = 1.90, second cause = 1.87; neutral version: first cause = 1.33, second cause = 1.85). When the critical sentence supported the second cause, however, the second cause obtained a higher auto-connection strength than did the first cause (supporting second cause version: first cause = 1.33, second cause = 2.42). These findings are consistent with the empirical findings: In both simulation and empirical data, the second cause was more prominent in the report versions in which the second cause was supported, whereas there was no difference between the first and second cause when the first cause was supported at the end of the text.

This set of results indicates that the second cause is favored as a plausible cause in readers' representation when it is strengthened later in the report. Indeed, when the critical sentence supported the second cause, readers favored the second cause over the first cause as indicated by their responses to the judgment task. It is interesting to note that when the critical sentence supported the first cause, it was not necessarily favored over the second cause. Readers' responses suggest that when the critical sentence supports the first cause both causes are kept as viable options in accounts of the event described in the report. Similarly, when the critical sentence is neutral, both causes also remain viable options in the readers' representation of the news report.

The results of the judgment task are consistent with simulations of the reading processes for the versions of the report. When the critical sentence supported the second cause, the second cause received more activation during reading and, therefore, had higher auto-connection strength than did the first cause. When the

critical sentence supported the first cause or was neutral, both causes received about the same activation during reading and their auto-connection strengths did not differ.

In summary, when the critical sentence supports the second cause, the second cause is strengthened in readers' representation, whereas the first cause is weakened. In contrast, when the critical sentence supports the first cause, both causes remain available. The Landscape model was able to capture this pattern of results.

One possible interpretation of this finding is that after the introduction of the second cause, the reader attempts to draw connections between the two causes to maintain coherence of the situation model under construction. When the critical sentence supports the second cause, the strength of the second cause is increased and can be easily selected over the other one. When the critical sentence supports the first cause, however, the first cause is reinstated (assuming it was backgrounded after the introduction of the second cause) in addition to the second cause that recently was in focus. Consequently, both causes end up in readers' situation model. To test this interpretation we conducted a second experiment in which we asked participants to think aloud during reading. This methodology will allow us to examine readers' moment-by-moment updating processes.

EXPERIMENT 2

The main objective of this experiment was to investigate readers' online processing of news reports in which two causes, first cause and second cause, were presented as plausible explanations for the primary event described in the report. The same passages were used as in Experiment 1, and think-aloud protocols were collected during reading (see also van Oostendorp, 2001). We were particularly interested in the content of readers' thoughts at three critical points: when the second cause was introduced, when the critical sentence was read, and when readers reached the end of the news report. In line with our interpretation of the findings in Experiment 1, we expected that participants would notice the presence of an alternative explanation for the occurrence of the reported event and that they would attempt to draw connections between the first and second causes to fully integrate these two plausible causes in their memory representation. Further, we expected that when the critical sentence supported the second cause the second cause would remain in focus, whereas when the critical sentence supported the first cause both causes would remain in focus.

Method

Participants. Thirty undergraduate psychology students enrolled at the University Montpellier 3 (France) participated to the experiment. All participants

were native French speakers. None of the participants from the previous experiment took part in this study.

Materials. The news reports were identical to those used in Experiment 1. No inference statements were presented after each report.

Procedure. Instructions were displayed on a computer screen, explaining that participants were to read 12 news reports. Participants were informed that the reading of each report could be interrupted several times by the following question, “At this moment, what comes to your mind about the information you have just read?” Each time participants encountered this question, they were instructed to say aloud what they were thinking. We collected think-aloud protocols every two sentences (i.e., 7 times for each news report). Participants used the space bar to advance from sentence to sentence and were encouraged to read at a normal pace. The experiment lasted approximately 45 min.

Results and Discussion

We analyzed the content of the verbal protocols after the presentation of the second cause. We coded whether readers mentioned the presence of the two causes to explain the occurrence of a primary event. We also coded the content of verbal protocols after the presentation of the critical sentences as well as after the last sentence of the news report. Our goal was to examine whether participants mentioned the first cause, the second cause, or both causes. When they mentioned both causes we examined whether they provided a connection between the causes. We also noted whether participants mentioned experiencing any comprehension difficulties.

First, we examined participants’ responses after reading the second cause. For each news report, we calculated the proportion of participants who mentioned the presence of the two causes at that point in the reports. The results, reported in Table 1 (with their corresponding p values issued from the table of probabilities in the binomial test), revealed that most of the participants mentioned that two causes were provided to explain the occurrence of the primary event. Further analysis of readers’ responses showed that most of the time participants mentioned that the event reported in the news report could be explained by the cause encountered last (i.e., the second cause), but that it was earlier explained by a different cause (i.e., the first cause). Specifically, participants either mentioned that they probably misunderstood information provided earlier in the text or expressed criticisms regarding the way the report was written.

Second, we examined the content of the verbal protocols obtained after the critical sentence and at the end of the report. For each version, we computed the number of times participants explicitly referred to the first cause or the second cause. We conducted a 2 (Location: after the critical sentence or at the end of the report) \times

TABLE 1
 Experiment 2: Proportion of Participants Who Mentioned Both Causes
 After the Second Cause was Introduced in Each News Report
 (out of a Maximum of 30)

<i>Report 1</i>	<i>Report 2</i>	<i>Report 3</i>	<i>Report 4</i>	<i>Report 5</i>	<i>Report 6</i>
24/30	23/30	25/30	23/30	23/30	24/30
.01a	.04a	.002a	.04a	.04a	.01a

^aRepresents the corresponding *p* value from the table of probabilities of the binomial test.

3 (Report Version: neutral, supporting first cause, supporting second cause) × 2 (Cause: first cause, second cause) repeated-measures ANOVA to examine whether there were differences between the number of times participants mentioned the first cause and the second cause as a function of the report version and the location. This analysis showed a three-way interaction between the factors Location × Article Version × Cause: $F(2, 58) = 47.93, p < .01$. As can be seen in Figure 2, when the critical sentence supported the first cause, both first and second causes were mentioned. Thus, although the critical sentence reinstated the first cause, participants did not discard the second cause from their situation model. Also, when the critical sentence was neutral, both causes were mentioned at the end of the text suggesting that both causes remained active in readers' memory representation. Finally, when the critical sentence strengthened the second cause, participants mentioned the second cause more so than the first cause: $F(1, 58) = 287.6, p < .01$. Thus, when the critical sentence provided support for the most recent of the two causes, this cause was retained and the other, earlier cause discarded. When the critical sentence supported the second cause, no cause was mentioned at the end of the article.

Third, we examined readers' responses in which both causes were mentioned to further identify the types of connections readers drew between the two causes. Specifically, we analyzed the content of verbal protocols collected after the critical sentence and at the end of the text. This analysis showed that, most of the time, the two causes were linked through causal connections. For example, in the news report entitled, "The Explosion of the Chemical Factory AZF," most of the participants mentioned that "because of the employees' negligence, an unforeseeable chemical reaction had occurred." The same pattern of response was observed with the other news reports. For instance, in the news report entitled, "The Oil Slick," most participants mentioned that "The new oil slick was due to a natural phenomenon (second cause) but this phenomenon was amplified by petrol leak coming from the wreck of the tanker (first cause)." This pattern suggests that readers established causal connections between the two causes in an attempt to establish coherence of the situation.

Finally, for each news report we computed the number of participants who explicitly mentioned that they encountered comprehension difficulties. We con-

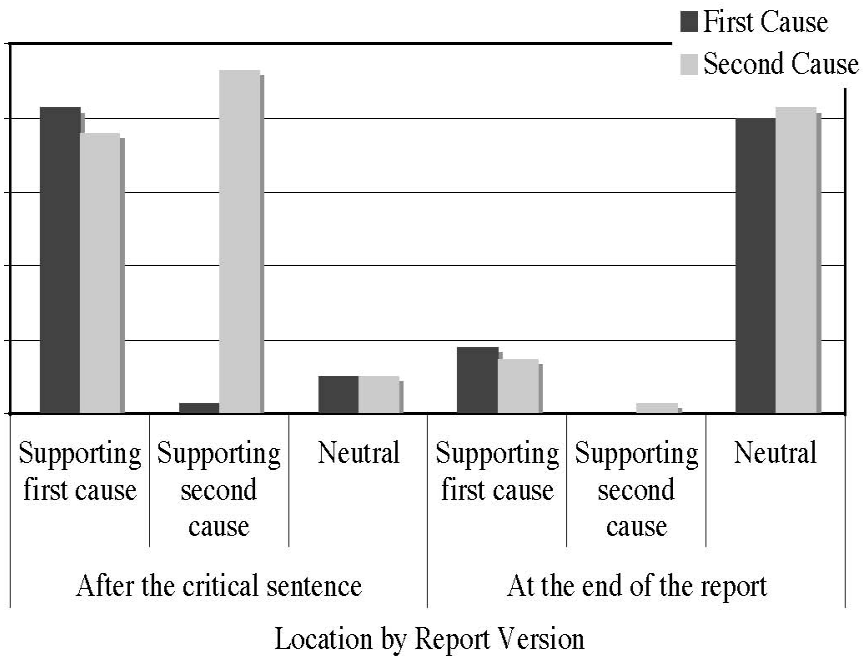


FIGURE 2 Experiment 2 think-aloud task: Probabilities of mentioning the two causes during reading as a function of the report version and the location.

ducted a repeated-measures ANOVA to determine whether comprehension difficulties were a function of the report version. The analysis revealed a significant effect of the factor *report version*: $F(2, 58) = 77.13, p < .01$. Higher number of comprehension difficulties were mentioned after reading the versions that either supported the first cause ($M = 0.83$), $F(1, 58) = 131.84, p < .01$, or were neutral ($M = 0.73$), $F(1, 58) = 96.86, p < .01$, than after reading the version that strengthened the second cause ($M = 0.13$). This pattern again suggests that when the second cause is strengthened by the text, readers maintained that cause as the most plausible one and abandoned the first cause.

In summary, the findings from Experiment 2 show that readers noticed the presence of alternative causes in accounts of a primary event in news reports when they read the second cause. When a subsequent sentence (the critical sentence) supported the second cause, readers selected this second cause as the most plausible explanation; and, thus, this cause became more salient compared to the first mentioned cause. When the critical sentence supported the first cause or was neutral, readers were not able to select one cause over the other. Instead, they maintained both causes in their situation model and drew causal connections between them, either during reading (at the critical sentence if that sentence supported the first

cause) or postponed to the end of the text (if the critical sentence was neutral). Consistent with this account, participants reported experiencing more comprehension difficulty in the neutral and first cause supported conditions than in the second cause supported condition. Apparently, readers settled on the second cause when subsequent text supported this cause, but they remained uncertain when subsequent text supported an earlier cause or no cause at all.

GENERAL DISCUSSION

The purpose of this set of experiments was to investigate the conditions under which readers update their situation models in the presence of alternative explanatory information when reading news reports. In two experiments, readers read three versions of news reports in which two causes were presented to explain a primary event. In Experiment 1, readers completed a judgment task after reading, whereas in Experiment 2 readers completed a think-aloud task during reading. The results demonstrate that when the second cause was introduced, readers realized the presence of two alternative explanations for the primary event. Furthermore, when later in the news report the second cause was strengthened, the first cause was discarded from readers' representation. In contrast, when later in the news report the first cause was strengthened, the second cause was not discarded but the two causes were integrated into the situation model under construction. Indeed, in that case readers did not select one explanation over the other, but instead maintained both causes in memory and generated causal connections between them. The simulation results from the Landscape Model provided convergent evidence for these updating processes. Our interpretation of the empirical results is consistent with the simulation results in which processes that are known to take place during reading—including updating processes—are identified for these texts and do result in activation and co-activation patterns that dovetail with the empirical results.

The findings of this investigation extend previous work on the updating process during reading of news reports (Johnson & Seifert, 1994, 1999; van Oostendorp, 1996, 2001; van Oostendorp & Bonebakker, 1999; Wilkes & Leatherbarrow, 1988; Wilkes & Reynolds, 1999) by providing new insights into the mechanisms by which such updating processes take place. In the specific situation in which two alternative but plausible causes are provided to account for a primary event, these results point to conditions under which one cause would be preferred over another. We observed that the order by which the two causes were mentioned (and, hence, strengthened) played a more important role than the number of times each cause was mentioned.

When the first cause was later strengthened in the text, readers updated their situation models but without discarding the second cause from their representation. Instead, readers integrated both causes and related them through causal con-

nections. According to van Oostendorp (2002), readers update their representation by maintaining the statement that is strengthened by the content of the text. We go beyond this finding by showing that when the critical sentence reinstates the first cause, both causes are maintained in readers' mental representation, although the first cause is mentioned twice. Therefore, the order by which the information is reinforced appears to be an important factor in the updating process. Future research on the updating process would strengthen the relevance of our data regarding this latter point but would also extend this study by considering a more important number of events.

When the second cause was later strengthened in the text, our results demonstrated that readers selected the second cause over the first one. This appears due to an "additive effect" of the activation of the second cause. In Experiment 2, the two causes were explicitly mentioned by participants after the introduction of the second cause. Although both causes must be co-activated when they are explicitly mentioned (i.e., Experiment 2), the second cause had higher activation because it was mentioned last in the text. This activation likely increases when the second cause is re-mentioned a few sentences later in the text. As a consequence, the second cause is selected as the most plausible cause in this situation. The first cause is no longer relevant and it is discarded from readers' mental representation to maintain coherence.

The results of this study also suggest that the Landscape Model (Tzeng et al., 2005; van den Broek et al., 1996, 1999) is a useful framework within which to explore the conditions that foster the updating of situation models. The convergence between simulation and empirical data lead us to conclude that the Landscape Model nicely captures the dynamic aspects of the updating process in the context of text comprehension. Specifically, the simulations using the Landscape Model provide evidence for a two-stage process that guides readers' updating. At the first stage, readers notice that two causes are provided to explain the occurrence of a primary event. For this to happen, the two pieces of information have to be co-activated in readers' mental representation. At the second stage, readers either select the cause that is strengthened after having been introduced (i.e., the second cause), or attempt to integrate both causes into their mental representation by connecting them causally. The two-stage interpretation we suggest is consistent with recent accounts of coherence building processes (e.g., Cook & Myers, 2004; van den Broek et al., 2005; van den Broek et al., 1999). At the first stage of coherence building, the content of active memory is connected to semantic or episodic information that has been retrieved from long-term memory through an automatic retrieval mechanism. At the second stage, information continues to be reactivated and integrated with the content of active memory, possibly involving more strategic processes.

To summarize, this study extends prior research on the conditions that foster updating in the domain of text processing in several ways. First, we focused on situa-

tions in which the presence of two pieces of information was manipulated further by strengthening one of those causes later in the article. Previous research investigated updating only with the presence of two (usually contradictory) pieces of information without the text providing further evidence that might assist the reader in updating (Guéraud et al., 2005; Linderholm et al., 2004; O'Brien et al., 1998; van Oostendorp, 1996, 2001; van Oostendorp & Bonebakker, 1999) or with the text providing further evidence but without manipulating the order of presentation of the two pieces of information (van Oostendorp, 2002). Second, we focused on both the readers' processing during reading (i.e., assessing through verbal protocols) and on the final text representation after the reading task has been completed. Previous research has focused primarily on the moment-by-moment reading to explore what is activated during reading (Albrecht & Myers, 1995, 1998; Albrecht & O'Brien, 1993; Guéraud et al., 2005; Linderholm et al., 2004; O'Brien et al., 1998; van Oostendorp, 2001). We believe that consideration of both the activation patterns during reading and their effects on the resulting memory representation is important to fully understand the updating process. Finally, we collected both behavioral data and computational simulations to provide converging evidence for the obtained findings. Computational techniques, when coupled with behavioral analysis, are powerful methods for investigating cognitive processing (Goldman, Golden, & van den Broek, 2007).

Finally, the strong correspondence between predicted and observed data indicates that the Landscape Model has considerable psychological validity. The architecture of the model, and in particular the dynamic interaction between spread of activation and coherence-based processing, unifies reading comprehension into a single conceptual framework that has high predictive power (Rapp & van den Broek, 2005; van den Broek et al., 2005). An important question for future research is to determine the boundary conditions of the updating processes—spontaneously as well as strategically—within this framework.

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APPENDIX:
Example of a News Report Translated From French

“The Explosion of the Chemical Factory AZF”

On September 21 at 10:15 am, an explosion occurred at the factory AZF located near from the downtown of Toulouse.

First Cause: According to the police investigation, the explosion was the result of an unavoidable chemical reaction, which has occurred in a building where powder of Nitrate was stored.

Very quickly, firemen, psychologists, doctors, and nurses went to the factory to give assistance to the injured people. The explosion took a heavy toll of human life, with 29 people killed, and more than 2000 injured; many apartments, schools, hospitals and shops were also destroyed.

Second Cause: The explosion, which was caused by employee negligence, was very violent, equivalent to an earthquake of 3.2 on the Richter scale.

Fortunately, a chain reaction with the National Company of explosives and powders was avoided. Even though the chain reaction had been avoided, some toxic compounds were discharged in the environment with a red cloud being observed just after the explosion. As soon as the health risk was eliminated, the traffic was authorized on a circular route around Toulouse, in an attempt to recover a normal pace. Now, it was time for reconstruction, and the town attempted to be revived. To determine the cause of the explosion, the police of Toulouse were helped by ten specialists of the technical and scientific police department.

Critical Sentence

Supporting first cause: The conclusions issued from the police investigation revealed that the Nitrate powder stored in the factory was too volatile.

Supporting second cause: The conclusions issued from the police investigation accused the factory employees of being responsible for the accident because it has been discovered that the building was not regularly inspected.

Neutral: The only positive consequence of this dramatic event was the solidarity observed between neighborhoods, friends and families.

The disaster victims actively protested against maintaining this very dangerous factory closed to the downtown of Toulouse. There were also questions of how authorities had authorized the development of an urban area around a highly risky factory. This question is still unanswered and conclusions have to be drawn for the future.

Inference Probes:

Inference 1: This disaster could have been more murderous if the chain reaction with the National Company of explosives and powders had not been avoided. Part 1—True

Inference 2: The disaster victims did not asked for the removal of that dangerous factory far from the downtown of Toulouse. Part 2—False

Inference 3: An unforeseeable chemical reaction due to the too important explosive property of the product stored is the only plausible explanation of this dramatic accident. First Cause

Inference 4: The damage provoked by the explosion was not too important because the chemical factory was located far from the downtown of Toulouse. Part 1—False

Inference 5: The defaults noticed in the maintenance of the factory installations caused the disaster, not the nature of the product the chemical factory produced. Second Cause

Inference 6: The responsibility of those in power in the occurrence of that dramatic accident has to be evoked. Part 2—True