THE ROLE OF TOP-DOWN AND BOTTOM-UP PROCESSES IN BETWEEN-TEXT INTEGRATION

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This study examined the extent to which readers integrate information from related texts as a function of both top-down evaluation processes and bottom-up resonance. In Experiment 1, participants read and recalled ambiguous texts about events that were preceded by a descriptive text (primer) of the event. Participants’ recall of the ambiguous texts was highly integrated in content and structure, including a heightened sensitivity to predicates shared between texts. Experiment 2 manipulated whether the primer or ambiguous text was read first and the degree of conceptual overlap between texts. Participants’ accuracy in an inter-textual anaphor resolution task showed a top-down and a bottom-up influence in inter-textual integration.

Understanding new experiences, including text, often requires readers to integrate them with prior experiences (Kintsch, 1998), which is often the case in an educational setting such as history (Britt, Perfetti, Sandak, & Rouet, 1999). The understanding of a historical document requires the integration of other historical documents a person has read. This integration allows one to connect an array of related, or overlapping, events into a composite representation. Suppose that through a period of time, one read a number of texts about the first manned moon landing. Each of those texts most likely would share titles, characters, entities, places, and events. For example, a text on this topic could mention Neil Armstrong, Edwin “Buzz” Aldrin, and Michael Collins, the astronauts on this first trip. The mere fact that multiple texts mention the same individuals, however, does not necessarily imply that the texts should or will be integrated. For example, a text describing John Glenn’s first flight into space most likely would not be integrated with one describing his career in the United States Senate. Indeed, there may be multiple
cues that may signal the relatedness of previously read texts and some of these cues may provide a stronger source of integration than others. Little or no research, however, indicates which of these cues would be most important to facilitate integration across texts.

Readers often use information from various sources to aid in interpreting a current story or text. For instance, low-knowledge readers can enhance their interpretation of the text when they are given a structured outline (Dee-Lucas & Larkin, 1995) and background texts (Kintsch & Franzke, 1995) that can be integrated with information from the current text. Readers also use information from multiple sources to build a coherent model of a little known historical event (Britt, Perfetti, Sandak, & Rouet, 1999; Catrambone, 2002; Wiley & Voss, 1999). Even clearly fictitious information from novels and movies can be integrated into students’ representation of historical events (Britt & Aglinskas, 2002; Seixas, 1994; Wineburg, 2000) as well as general factual knowledge (Marsh, Meade, & Roediger, 2003). The degree of integration is influenced by the structure of one’s representation of a prior text (Britt & Sommer, 2004), the type of overlapping material (Catrambone, 2002; Kim & Millis, in press), and the presence of support for comparison (e.g., Britt et al., 1999).

Although it is clear that readers integrate information across multiple sources, the factors that mediate this integration are not well understood. As such, the goal of this study was to investigate the possible factors that influence inter-text integration. In particular, this study investigated the extent to which readers make use of information gained from a descriptive text to understand an ambiguous version of that text. A variation of the ambiguous text paradigm (Bransford & Johnson, 1972; Dooling & Lachman, 1971) was used in which participants read ambiguous texts that had a title vs. no title, and primer texts, which were encyclopedic-like versions of the events referred to by the ambiguous texts. Experiment 1 consisted of a reanalysis of recall data from Wahlberg and Magliano (2004) and provided an assessment of integration between primer and ambiguous texts, and Experiment 2 consisted of a new experiment that investigated the influence of a related text on on-line reading, and off-line inter-textual anaphor resolution.
Mechanisms of Text Integration

It may be the case that the same factors that are involved in establishing coherent relations within a text also mediate between-text integration. As such, we drew on theories of discourse processing to provide a framework for the present study. Specifically, the event-indexing model (Magliano, Zwaan, & Graeser, 1998; Zwaan & Radvansky, 1998; Zwaan, Langston, & Graesser, 1995) provided the theoretical framework for the current exploration of text integration. The event-indexing model assumes that narrative comprehension emerges upon the construction of a mental representation that reflects the underlying situation referenced in a text. A number of elements and relations may be involved in the structure of the situation model (e.g., protagonists, space, time, causality and intentionality). According to the model, readers focus their attention during reading and structure their memories around the events that involve these elements and relations. For instance, when a history text mentions that the U.S. president has a meeting with a Panamanian revolutionary immediately before the Panama Revolution, the reader will notice the meeting involves the two main protagonists in an official office in the United States a week before the revolution and how this meeting affected the occurrence of the revolution.

These events are structured around both static and dynamic dimensions (e.g., see Zwaan & Radvansky [1998] for an extensive review). In terms of the static dimension, event boundaries are defined and bounded by a spatial–temporal framework. This is the region of space that contains the situation, and the stretch of time that the situation is in force. Within the spatial–temporal framework, readers monitor the entities that are within this framework such as people, animals, objects, and abstract concepts (e.g., Magliano, Radvansky, & Copeland, in press; Zwaan & Radvansky, 1998). In terms of the dynamic component, events may be joined by a collection of linking relations, which primarily involve inferred causal relationships (e.g., The discovery of drift wood helped prevent a mutiny during Columbus’ first voyage to the new world).

There is a hierarchy of importance of both static and dynamic dimensions within situation models. Of the dimensions specified by the event-indexing model, readers monitor most closely
the implied causal relationships between events (e.g., Zwaan, Magliano, & Grassser, 1995). Furthermore, events are more integrated in memory to the extent that readers can infer a network of causal relationships (e.g., see van den Broek [1994] for an extensive review). Also, evidence suggests that readers closely monitor the agents depicted in a text (Ozyurek & Trabasso, 1997; Rich-Scott & Taylor, 2000). Readers do not devote resources to establishing a detailed representation of the spatial–temporal framework unless they have the explicit goal to do so or have extensive prior knowledge (Zwaan & van Oostendorp, 1993). A growing body of evidence, however, indicates that readers closely monitor and index events with respect to their implied temporal relationships (e.g., Magliano & Schleich, 2001; Zwaan, 1996). Just as there is a hierarchy of dimensional importance within a text, there is likely a hierarchy of dimensional importance in the extent to which overlap in dimensions across texts mediates between-text integration.

We argue here that the event-indexing model provides a framework for investigating factors that mediate text integration (see also Kim & Millis, in press). Texts may be integrated to the extent that they describe similar events that take place in the same spatial–temporal framework and/or describe the same entities. The relative importance of shared situation dimensions in guiding integration is, however, unclear. Some evidence suggests that overlapping events may serve as a stronger cue for integration than overlap between entities or characters. For example, continuities along situation dimensions such as causality and time account for more variance in within-text integration than shared entities, as indicated by anaphoric referents (Zwaan, Magliano, & Graesser, 1995). Additionally, Radvansky and Zacks (1991) found that when participants studied a list that associated multiple objects with a single location, recognition for those objects was faster than when a single object was associated with multiple locations. This suggests a “situation bias” of text integration such that concepts will resonate more strongly with each other when they are part of the same situation or event, rather than when they are part of many situations and events. Thus, when reading multiple texts on the same topic, between-text references to common situations should be more helpful in aiding integration than common people, places and things.
Resonance and Evaluative Processes During Text Integration

Two additional discourse processing models have proven useful in explaining how readers establish coherent relationships within a text. According to the Memory-based models, the process of resonance determines the activation of prior information that may be used to interpret the current sentence (Albrecht & Myers, 1995, 1998; Albrecht & O’Brien, 1993; Klin, 1995; McKoon, Gerrig, & Greene, 1996; Myers & O’Brien, 1998). Resonance is the bottom-up, data driven, and “dumb” process by which conceptual or semantic associates of the current and immediately prior sentences are activated (e.g., Ratcliff, 1978). The degree to which the current information conceptually or semantically overlaps with information in long-term memory is one of the primary factors that influences intra-text integration and it was of primary interest in the current study.

Although Memory-based processes of resonance have been well-established as a mechanism for the activation of knowledge (Albrecht & Myers, 1995, 1998; Albrecht & O’Brien, 1993; Myers & O’Brien, 1998), Long and Lea (2005) argued that it is not sufficient for explaining within-text integration. They argued that readers search for meaning when evaluating the extent to which activated knowledge is related to the current sentence in order to determine how it is related in the unfolding situation model. According to the search after meaning principle (Bartlett, 1932; Graesser, Singer, & Trabasso, 1994), integration is an effortful, top-down process of evaluating and interpreting active information. The amount of effort required in this process of evaluation may vary based on factors such as the causal distance of the activated knowledge to the current sentence (e.g., Myers, Shinjo, & Duffy, 1987).

We believe that both resonance and search-after-meaning processes play a role in inter-text integration. Information in a text currently being read can resonate (via conceptual overlap) with information from prior texts along a number of dimensions, such as shared entities, characters, or situations of related texts. This impact of shared entities/characters and events/situations in aiding integration can be indicated by overlap of predicates and arguments from related texts. Argument overlap across texts may indicate that the texts share entities (e.g., Eagle) or characters (e.g., Neil Armstrong), at least to the extent that the arguments
do indeed have the same referents. Overlapping predicates may indicate that the texts are describing the same events/situations (e.g., landing and viewing). Zwaan, Langston, and Graesser (1995) used verbs as an indicator of events and found that participants listed verbs as related to each other depending on which situation dimension they shared. This overlap of referents, predicates, and arguments should cause resonance between concepts in the mental representations of texts.

Top-down processes, such as search-after-meaning, may also guide the integration of texts. If a reader is consciously aware that a current text is related to a prior text, then that understanding could guide the evaluation of knowledge that is activated from the prior text via bottom-up resonance mechanisms. One potential cue for this evaluative process is a title. It is well established that a title can help a reader understand a text they are reading, particularly when that text is relatively difficult to understand (e.g., Bransford & Johnson, 1972).

Wahlberg and Magliano (2004) provided preliminary data that suggest previously read texts are used to understand a new text. They used a variation of the ambiguous text paradigm (e.g., Bransford & Johnson, 1972; Wiley & Rayner, 2000) to investigate the ability of readers with and without autism to use multiple cues to background knowledge in order to comprehend ambiguous texts. They presented participants with ambiguous passages describing historical events that were either preceded by an informative title (e.g., “Columbus Discovers America”) or a non-informative title (e.g., “Peaks and Valleys”). The presence of primer texts was varied such that before reading the ambiguous passages participants were presented with concrete, encyclopedic-like descriptions of the events discussed in each ambiguous text. After reading, participants were asked to recall the ambiguous passages. Recall, from readers without autism, showed that the presence of a primer not only facilitated recall of event-related information, it also facilitated the production of information that was an interpretation of the ambiguous text. These interpretations often involved information from both the primer and ambiguous text, as well as concepts from general knowledge. The presence of a title only improved memory when a primer was not present. Readers with autism recalled more event-related information when a primer was present, but the primer had no effect on
the production of interpreted information. This evidence suggests that readers without autism use relevant event-related material to interpret and comprehend new events currently being processed, whereas readers with autism may have difficulty with this integration process.

**Experiment 1**

Experiment 1 examined the relative importance of overlap of events and entities as cues for guiding the integration of text. Specifically, we assessed the extent to which the overlap of events (predicates) and characters and entities (arguments) mediate the integration of related texts. We conducted a reanalysis of the Wahlberg and Magliano (2004) recall protocols for readers without autism after it became evident that much of the information produced by participants was an integration of both primer and ambiguous texts. Consider three participants’ recall of the primer-ambiguous sentence pair presented at the top of Table 1.

1. It told that to those in the craft the Earth looked like a blue-green rubber ball.

**TABLE 1** Example Scoring Template for Each Type of Proposition (Both, Ambiguous Only, and Primer Only) for a Pair of Text Segments from the Two Texts

<table>
<thead>
<tr>
<th>Ambiguous text</th>
<th>Flat familiar homeland now resembled a tiny rubber ball.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primer text</td>
<td>They did have small windows to look out of into the vastness of space to view the round, blue-green, earth and other objects as they traveled</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scoring</th>
<th>Predicate</th>
<th>Argument 1</th>
<th>Argument 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both:</td>
<td>RESEMBLE</td>
<td>Homeland</td>
<td>Ball</td>
</tr>
<tr>
<td>Ambiguous</td>
<td>or</td>
<td>or</td>
<td>or</td>
</tr>
<tr>
<td>Primer</td>
<td>VIEW</td>
<td>Earth</td>
<td>Round</td>
</tr>
<tr>
<td>Ambiguous:</td>
<td>MOD</td>
<td>Ball</td>
<td>Rubber</td>
</tr>
<tr>
<td>Primer</td>
<td>MOD</td>
<td>Earth</td>
<td>Blue-green</td>
</tr>
</tbody>
</table>
2. On their way to the moon they saw the earth and it looked like a blue and green marble.
3. The place that was formally known as their flat home now resembled a small bluish green ball.

The first participant’s recall shows several points in which the primer sentence is used to disambiguate and elaborate on the corresponding sentence in the ambiguous text. These include a replacement of “Earth” for “Homeland,” and an integration of the phrases “round, blue-green, Earth” and “tiny rubber ball” into the phrase “blue-green rubber ball.” Also, notice that this participant replaced “resemble” with “looked like,” suggesting that the overlap of the situation was a factor for this participant in the integration of the texts. Similar blends can be seen in the other two participant examples.

Experiment 1 examined the extent of integration in these recall protocols as well as three possible sources of integration: the overlap of (1) events (predicates, such as verbs), (2) entities, and characters (arguments, such as nouns and pronouns), and (3) the presence of a title. If degree of overlap guides points of integration, then those events and entities common to the two texts should be recalled more frequently. Because the re-analysis was conducted at the propositional constituent level, the relative impact of shared predicate and shared arguments can be assessed. If the title provides expectations that can effectively guide the resolution of ambiguous referents, then the informative title condition should lead to more integrated recall protocols than the uninformative title condition.

Two hypotheses predict possible patterns of recall data from this re-analysis. The Entity-Driven Hypothesis assumes that the integration of related texts is driven by the overlap of characters and entities. The Entity-Driven Hypothesis predicts that recall will be greater for arguments shared between each primer-ambiguous text pair than predicates shared between each primer-ambiguous text pair. The Situation-Driven Hypothesis assumes that the integration of related texts is driven by the overlap of events. The Situation-Driven Hypothesis predicts that recall will be greater for predicates shared between each primer-ambiguous text pair than arguments shared between each text pair. Thus, both hypotheses predict that
the information most recalled will be the shared constituents; the predictions differ as to which constituent drives integration.

Method

Participants

Fifty-three undergraduates in an introductory psychology class at Northern Illinois University participated for course credit.

Materials

Participants read texts recounting four well-known historical events: the first Moon landing, the first flight of the Wright Brothers, Columbus’s discovery voyage to the Americas, and Paul Revere’s famous ride. For each topic, two types of texts were constructed: primer and ambiguous texts. The primer texts explicitly described the events in the form of short (average length 256 words) encyclopedia-style articles providing many details such as names and dates. Each primer text was preceded by an informative title that explicitly described the event that would be discussed in the text (e.g., “The First Warning of the British Attack”).

The corresponding ambiguous text presented the same historical event, however, using intentionally vague and ambiguous language. This was accomplished in three ways. First, the nouns and verbs were overly general forms that failed to add content. For instance, “cramped quarters” and “companions” replaced primer referents for “spacecraft” and “astronauts” respectively, while “go,” “went,” and “begin” replaced primer action terms of “sail,” “ride,” and “lift off,” respectively. Second, there were few modifiers and those present did not provide specific detailed content. For example, the number and label of objects were vaguely presented and character names and dates were omitted. Finally, many important events and entities were referred to using metaphorical language such as Columbus’s 3 ships were referred to as 3 sisters, or the British troops were referred to as a storm in a story about Paul Revere. These ambiguous texts were also short, averaging 172 words in length. Each ambiguous text had either an informative title that explicitly mentioned the main theme of the text (e.g., “Columbus Discovers America”) or a non-informative title that did not provide
any relevant information helpful in understanding the text (e.g., “Peaks & Valleys”). The ambiguous texts about Columbus and the first Moon landing were adopted from Bransford and Johnson (1972).

PROPOSITIONALIZATION, SOURCING, AND SCORING

To examine the role of inter-textual semantic overlap on textural integration, the information from both texts was propositionalized (Bovair & Kieras, 1984). First, the main clause predicates and arguments were identified for all primer and ambiguous text sentences as shown in the ambiguous-primer sentence pair in Table 1. In order to get a measure of shared overlapping content, a single scoring template was constructed (Perfetti, Britt, & Georgi, 1995). All propositions from the primer text were merged into the propositional list for the ambiguous text. When both texts had a proposition that referred to the same state or event and shared propositional constituents, it was marked as both as shown in Table 1. Both sentences refer to common predicates (e.g., RESEMBLE and VIEW) and arguments (e.g., HOMELAND and EARTH) and (e.g., BALL and ROUND). Because the ambiguous text was purposely vague, an exact match was rare. More commonly, the match was a specific synonym. This template allowed us to determine the source of any constituent (both, ambiguous, or primer). For the Table 1 example, the source of the main proposition was scored as both, that is, both primer and ambiguous texts, because all constituents were mentioned in both texts. The source of constituents that occurred exclusively in the ambiguous text (e.g., rubber ball) was scored as ambiguous, meaning from the ambiguous text only. The source of constituents that occurred exclusively in the primer text (e.g., blue-green earth) was scored as primer, meaning from the primer text only.

Design

The design of the analysis was a 2 Title (informative vs. non-informative) × 2 Constituent (predicate vs. argument) × 3 Source (ambiguous vs. primer vs. both) within-subjects design. Title varied across text item pairs whereas constituent and source varied within text. The Wahlberg and Magliano (2004) recall protocols analyzed here will be limited to those in which a primer text preceded
the ambiguous text and the participants were only those without autism.

Procedure

Participants read each text on a computer screen one paragraph at a time and advanced to the next paragraph by pressing the spacebar. Participants were instructed to read and understand the texts because they would be asked questions about them later in the experiment. They were then given the two primer texts as practice. Participants were told that the two texts described well-known historical events and were to provide practice for reading on a computer, although they may be relevant later in the experiment. After reading the primer texts, participants then read four ambiguous texts that they were told would sound a “little weird” but they should try to understand them as best they could. An informative title preceded each ambiguous text in the informative title condition and a non-informative title preceded each text in the non-informative title condition. After reading all four of the ambiguous passages, participants were given the first sentence of each passage on four separate sheets of paper and asked to write down as much as they could remember of the passage. They were allowed to recall the passages in any order and were told that if they could not remember complete sentences to just write down as many ideas as possible.

Results and Discussion

In this re-analysis, we address two main questions. The first question focused on the extent of integration in the recall protocols. The second question focused on the mechanism of integration by assessing whether the presence of a title and the degree of overlap of propositional constituents between the ambiguous and primer texts increased recall of the information from the ambiguous text.

Integration in Recall Protocols

The degree of integration was determined by analyzing first the content and then the structure of the recall protocols. The analysis of content assessed the proportion of the recall that came from each source. The entire recall protocol was classified as to
whether its source was Ambiguous Dominate (i.e., 67% of information uniquely from ambiguous text), Primer Dominate (i.e., 67% of information uniquely from primer text), or Both (i.e., a balance of information from both texts). Of all recall protocols, only 5% were Primer Dominate and 2% were Ambiguous Dominate. This finding is surprising because the participants’ task was to recall only the ambiguous text and as such all recall protocols should have been Ambiguous Dominate. This was clearly not the case. Most of the recall protocols (93%) were in fact an integration of material mentioned in both texts.

The analysis of structure assessed the degree of integration that occurred throughout the recall. The content for a recall may be balanced across sources; however, the structure may be unintegrated. For example, the first half of the events could be from the ambiguous text whereas the second half of the events could be from the primer text. In contrast, a well-integrated recall would contain many switches between information from the ambiguous text with that from the primer text. Therefore, a second measure of integration assessed the structure of the recall protocols to determine the degree of integration at the sentence level. The source of each sentence was classified as Primer only, Ambiguous only, or Blended (i.e., content from both texts) depending on its content. Then, the number of source switches for each recall was computed by counting the number of sentences in which a participant switched source focus from one source to another. To illustrate, the recall protocol shown in Table 2 has three focus switches: one from a Primer only sentence to an Ambiguous only sentence, another from Ambiguous only to several Blended sentences, and the final from the Blended sentences to an Ambiguous only sentence. Across participants there were an average of 3.97 (sd = 2.29) sentences where a switch could occur. Of these, 2.07 (sd = 1.61) sentences involved a focus switch from the previous sentence, which was reliably different from no switches, \( t(52) = 10.90, MSE = .34, p < .05 \). Approximately half of the sentences switched focus (52%), which indicates that integration was common in the recall protocols.

**MECHANISMS OF INTEGRATION**

In order to further examine the mechanisms of integration, the content was classified into two types of propositional
TABLE 2 Example Focus Switches from a Participant’s Recall. Each Source of Each Sentence was Determined as Either: Primer Only, Ambiguous Only, or Blended. Uniquely Identifiable Primer Text Terms are in Bold and Ambiguous Text Terms are Underlined

<table>
<thead>
<tr>
<th>Source</th>
<th>Recall Sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primer only</td>
<td>It sounded as though it was looking from the perspective of Neil Armstrong.</td>
</tr>
<tr>
<td>Ambiguous only</td>
<td>It spoke <strong>buttons</strong> being pushed and complex <strong>flying patterns</strong> being navigated.</td>
</tr>
<tr>
<td>Blended</td>
<td>It told that to those in the <strong>craft</strong> the <strong>Earth</strong> looked like a <strong>blue-green</strong> rubber ball.</td>
</tr>
<tr>
<td>Blended</td>
<td>The passage said the people on <strong>Earth</strong> knew that there would be no life among the mountains and caverns.</td>
</tr>
<tr>
<td>Blended</td>
<td>The passage ended by saying the three <strong>astronauts</strong> knew that the <strong>flight</strong> was only half the work.</td>
</tr>
<tr>
<td>Ambiguous only</td>
<td>It spoke of those <strong>famous words</strong> and also the fact that many <strong>important papers</strong> would be waiting.</td>
</tr>
</tbody>
</table>

constituents (predicates and arguments) and the source of these constituents (ambiguous and primer vs. both). Then a 2 (Title: informative vs. non-informative) × 2 (Constituent: predicate vs. argument) × 3 (Source: ambiguous vs. primer vs. both ambiguous and primer) within-subjects ANOVA was conducted on the proportion of each propositional constituent recalled (predicate vs. argument). This proportion controlled for the differing amount of predicates and arguments that can be shared between texts. Title was not significant nor did it participate in any significant interactions so Title was collapsed for the presentation of the means in Table 3. The ANOVA revealed a significant main effect of Source such that items mentioned in both texts was recalled better than information mentioned only in the ambiguous

TABLE 3 Experiment 1: Mean (Percentage) Recall and Standard Deviations for Constituent X Source

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Source</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ambiguous</td>
<td>Primer</td>
<td>Both</td>
<td></td>
</tr>
<tr>
<td>Predicate</td>
<td>10.953 (.95)</td>
<td>7.736 (1.01)</td>
<td>24.972 (1.92)</td>
<td></td>
</tr>
<tr>
<td>Argument</td>
<td>10.085 (.86)</td>
<td>7.396 (.99)</td>
<td>21.811 (1.59)</td>
<td></td>
</tr>
</tbody>
</table>
or primer texts, with means of 23.39, 10.52, and 7.57, respectively, $F(2, 104) = 72.40$, $MSE = 103.67$, $p < .001$. Tukey’s post-hoc tests confirmed that recall for the constituents sourced both was greater than recall for the ambiguous and primer sources. There was also a main effect of Constituent such that predicates were better recalled than arguments with means of 14.55, and 13.10, respectively, $F(1, 52) = 69.73$, $MSE = 2.42$, $p < .001$. Finally, there was a significant Source X Constituent interaction such that the advantage for predicates was limited to those constituents that occurred in both texts, $F(2, 104) = 10.64$, $MSE = 11.20$, $p < .001$. Tukey’s post-hoc tests confirmed that predicates were recalled better than arguments for items from both texts but there was no difference between predicates and arguments for ambiguous only and primer only information. This suggests that predicates are more important to integrating information across sources.

Across all measures, we found evidence of integration. First, participants rarely recalled information from only a single text. In fact, almost all of the recalls were blends of information from the two texts. Second, participants frequently switched the source throughout the recall showing that the blends were truly blends. That is, the information was not chunked segments from single texts but rather integrated across the temporal retelling of the story. Finally, participants recalled more information mentioned in both texts than by each individual text. This support for integration is more profound given the instructions to recall only the ambiguous text, the time between presentation of the primer and ambiguous texts, and the cover story of the primer as practice for the procedure. Furthermore, events and situations appear to drive this integration process as predicted by the Situation-Driven Hypothesis. We found that overlapping events tended to be recalled more frequently than overlapping entities. When texts share events, they are more likely to be integrated than when they merely share entities.

The analysis to clarify the mechanism of this integration suggested that the resonance between text constituents was strong enough to reduce separation of the texts themselves creating blended recall protocols. Thus, the most frequently recalled items were those mentioned in both texts. This integration was driven more by the overlap of predicates (events) than arguments (entities). As was expected based on the findings of Wahlberg and Magliano (2004), the presence of title had no effect on recall.
This does not, however, strongly suggest that top-down processes are not active during text integration because the presence of a primer may attenuate this effect. The primer may have served to activate a relevant subset of knowledge that could then be used to comprehend the ambiguous texts in a top-down fashion. In Experiment 2, we further investigated the role of both top-down and bottom-up processes during text integration. Thus, the focus was not on the effect of entities vs. events, but rather the role of the top-down evaluation process and bottom-up resonance during text integration.

**Experiment 2**

Experiment 2 was conducted to provide a better assessment of the influence of top-down processing on availability after comprehension. As such, we manipulated whether the primer passage was read before or after the ambiguous passage. By providing a primer before reading an ambiguous text, comprehension of the ambiguous text can proceed in a top-down conceptually driven process (e.g., Bransford & Johnson, 1972). Disambiguation of entities and events can occur while reading the ambiguous text. Also, overlap of situations between the texts may activate primer information. The primer information can then be used online in an evaluation process that may be akin to, “Does what I’m reading make sense?” The focus of this experiment was to assess the impact of this top-down process in an off-line assessment of integration.

Integration was assessed by both an on-line and an off-line measure. The on-line measure, reading times, have been shown to be sensitive to integration processes among related texts. For example, Millis and Erdman (1998) found that participants read a news story faster after reading a related story than participants who did not read the prior stories.

We also believe that bottom-up processes are involved in text integration. Thus, we varied the degree to which the primer and ambiguous texts overlapped. Because we wanted to promote the integration of these texts, all of the critical sentences shared underlying situations. We varied whether the critical sentences shared these situations on both a propositional and situation level or on a situation level only. The propositional and situation overlap sentences represent a high degree of overlap, and the situation-only
TABLE 4  Ambiguous Version of the 6 Target Overlap Event with the Corresponding Primer Sentences for the Space Text

<table>
<thead>
<tr>
<th>Ambiguous Target Sentence</th>
<th>Propositional and Situation Overlap (Primer text)</th>
<th>Situation-only Overlap (Primer text)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  A chosen few began the task.</td>
<td>Three astronauts were picked for the challenge.</td>
<td>Three astronauts won the right to go.</td>
</tr>
<tr>
<td>2  The mighty creation rivaled the force of nature.</td>
<td>The Saturn V escaped the gravitational pull of the earth.</td>
<td>The Saturn V made it into the Earth’s upper atmosphere.</td>
</tr>
<tr>
<td>3  One companion manipulated buttons in the craft.</td>
<td>Michael Collins operated the controls of the ship.</td>
<td>Michael Collins piloted the ship.</td>
</tr>
<tr>
<td>4  Flat familiar homeland resembled a rubber ball.</td>
<td>The Earth looked like a basketball.</td>
<td>The Earth was a round orb.</td>
</tr>
<tr>
<td>5  With a thud, the vessel reached its destination.</td>
<td>With a thud, the Eagle arrived on the moon.</td>
<td>Before they knew it, the Eagle was on the moon.</td>
</tr>
<tr>
<td>6  The first then proclaimed a memorable declaration.</td>
<td>Neil Armstrong said his famous quote.</td>
<td>Neil Armstrong’s famous quote was heard by all.</td>
</tr>
</tbody>
</table>

overlap sentences represent a moderate to low degree of overlap. As such these different types of overlap should cause varying degrees of resonance. For example, as shown in Table 4, for the critical ambiguous sentence, “Flat familiar homeland resembled a rubber ball,” the propositional and situation overlap sentence was, “The Earth looked like a basketball,” and the situation-only overlap sentence was, “The Earth was a round orb.” As can be seen here, there is a direct mapping of events and entities between the propositional and situation overlap sentences and the critical sentences, whereas the situation-only overlap sentences shared implied events with the critical sentences.

In Experiment 2 we wanted a naturalistic measure of integration of the sort that students and news readers would utilize in their normal activities, namely anaphor resolution for noun phrases. A truly integrated representation would have events that refer to the same situation connected closely together. For example, in the
Top-Down and Bottom-Up Integration

primer and ambiguous sentences in Table 1 both refer to the same situation. If the reader integrated these sentences in memory, then they should be able to accurately state that homeland and Earth refer to the same entity. If the reader did not integrate these two representations, then they should be inaccurate or very slow at stating these nouns are co-referential. This task, for example, reflects precisely the skill that students should possess when reading about a topic after listening to their teacher lecture on the topic. Thus, integration will be assessed by an anaphor resolution task in which two noun phrases are presented and participants have to state whether they refer to the same entity.

Experiment 2 had an acquisition phase and a test phase. In the acquisition phase, participants read primer-ambiguous text pairs one sentence at a time. Text order was varied such that one group read the primer text first followed by the ambiguous text (primer-first), a second group read the ambiguous text followed by the primer text (ambiguous-first), and a final group read only the ambiguous text (ambiguous-only) serving as a control. As mentioned earlier the degree of semantic overlap between the primer and ambiguous texts was also varied such that critical sentences shared both propositional and situation information (propositional/situation overlap) or shared only situation information (situation-only overlap). In the test phase of this experiment, participants made speeded anaphor resolution judgments in which they had to decide if a word or phrase from the primer text (e.g., Earth) referred to a word or phrase in the ambiguous text (e.g., familiar homeland).

Top-down and bottom-up processes of integration may have differing influences on the accuracy of making the anaphor resolution judgments. If bottom-up processes are the only influence on integration then there will be an effect of text order such that accuracy should be better when the primer is present (i.e., the ambiguous-first and primer-first conditions) than when it is absent (i.e., the ambiguous-only condition). The order of the presentation of the ambiguous and primer passages, however, should not matter. That is, there will be the same degree of resonance between the anaphor in the ambiguous passages and its referent in the primer passages at the time of making the resolution judgment, regardless of the order that the passages were read. There should also be an effect of degree of overlap, that is, the more
overlap the stronger the resonance between texts. Thus, the propositional/situation overlap condition should lead to better recall than the situation-only overlap condition.

In contrast, top-down processes may influence integration. Evaluation processes that compare and incorporate activated prior knowledge with the information in the current sentence to construct a more elaborated situation model. Thus, if top-down processes are the only influence on integration, then the primer-first condition should be greater than the ambiguous-only condition, which should not differ from the ambiguous-first condition. For the information to aid in the integration process, it must be available during the reading of the ambiguous passage, and this occurs only when the primer is read first.

If both top-down and bottom-up processes are involved, then the degree of overlap is expected to interact with text order. In this mixed model of integration, bottom-up processes of integration may only occur if there is a high degree of resonance between text information (i.e., propositional and situation overlap). This model predicts that for the primer-first condition both the propositional/situation and situation-only conditions will be greater than the ambiguous-only condition, and for the ambiguous-first condition, the propositional/situation overlap condition will be greater than the ambiguous-only condition whereas the situation-only condition will be equal to the ambiguous-only condition. When the primer text precedes the ambiguous text, the integration will be facilitated by a conceptually driven process by which ambiguous information would be evaluated on-line in a process akin to “Does this make sense?” (Long & Lea, 2005). When the primer text follows the ambiguous text, integration depends on resonance through a higher degree of overlap.

In terms of reading times, both the bottom-up and top-down positions assume an order effect. That is, the critical sentences will be read faster when the primer precedes the ambiguous passage than when it does not (i.e., primer second or primer absent conditions). A strong top-down position may assume that the degree of overlap will not have an effect. As long as readers are engaged in this evaluative process, overlap between events is sufficient. On the other hand, a strong bottom-up position assumes that the degree of overlap would mediate reading times. That is, reading times for
sentences with both situational and propositional overlap will be faster than situational overlap.

Method

Participants

Ninety-three undergraduates in an introductory psychology class at Northern Illinois University participated for course credit.

Materials

The primer-ambiguous text pairs from Experiment 1 were modified such that the information overlapped on only six target sentences. These six target events were selected to ensure that they were well-distributed temporally across the story. The texts were then modified to ensure that the agents of the target sentence were not mentioned anywhere else in the text. Finally, the ambiguous version of the target sentence was transformed into a subject-verb-object syntactic structure as shown in the first column of Table 4. Two versions of overlapping primer sentences were constructed for each of the six ambiguous target sentences such that they shared either propositional and situation overlap (propositional/situation), or situation overlap only (situation-only). Examples of the corresponding primer sentences are provided in Table 4. The propositional/situation overlap sentences were created by substituting disambiguating synonyms for all ambiguous constituents. For instance, the ambiguous noun phrase, “Flat familiar homeland” was transformed to be “the Earth.” The situation-only overlap sentences described the same situation implied in the ambiguous sentence by selecting a predicate that did not directly map onto the predicate in the ambiguous sentence. For instance, the predicate “resembled” in the ambiguous target sentence was changed to be “was” in the situation-only overlap sentence rather than “looked like” in the propositional/situation sentence. The subject noun phrase was identical for both the propositional/situation and situation-only overlap sentences, but no other phrases were identical. All ambiguous sentences were identical for all
conditions. Only the 6 overlap sentences for the primer texts were modified.

ANAPHOR RESOLUTION TEST

An anaphor resolution test was created to determine whether participants correctly mapped the co-references between texts. For example, the “Flat familiar homeland” and “the Earth” both refer to the same entity and that mapping is required for integration to occur. For each text, the subject noun phrases for the 6 overlap sentences were tested in a speeded judgment test. For example, participants would see the ambiguous text referent “mighty creation” and then they would see the primer text referent “Saturn V.” The overlap items for the Moon Landing text are the underlined elements in Table 4. Six foil items per text were also created to balance the number of no responses. The foil items were item pairs from the texts that did not refer to the same person or thing (e.g., adventure—United States).

Design

The design of the experiment was a 3 Order (primer-first vs. ambiguous-first vs. ambiguous-only) × 2 Overlap (propositional/situation vs. situation-only) design. Order was a between-subjects variable. Overlap varied within-text such that half of the target sentences, selected randomly, had propositional/situation overlap, and half had situation overlap only. The assignment of participants to order and overlap conditions was based on a 4 × 4 Latin Square such that each text pair order and target sentence occurred in all four conditions an equal number of times across participants.

Procedure

There were two phases to the experiment. During the acquisition phase, participants read each text one sentence at a time by pressing the spacebar to advance to the next sentence. They first read a practice text and then read each pair of primer-ambiguous texts. Each pair was announced by a screen that said, “Press the spacebar when you are ready to read the next pair of texts.” After pressing the spacebar, participants were
presented with a non-informative title of the text they were about to read (i.e., Text 1 or Text 2). After participants finished reading each text pair, they then began the testing phase of the experiment.

In the testing phase of the experiment, participants completed the anaphor resolution test. This test presented noun phrase pairs from the two texts and asked participants to decide whether they referred to the same person or thing. Each prime was shown for 450 milliseconds and participants were asked to decide as fast and as accurately as possible. They were instructed to press the “j” key for “yes” responses and the “f” key for “no” responses. Participants first received eight practice items to familiarize themselves with the task. Then they were given the experimental trials, in which they were asked to consider each text pair, one set at a time. For example, participants were given the topic of the text or pair of texts. This procedure was followed by each of the four primer-ambiguous text pairs.

Results and Discussion

Table 5 presents the means and standard errors for the reading times and anaphor resolution accuracies for each condition. To assess the role of top-down and bottom-up processes a series of planned t-tests were conducted that tested each condition against the ambiguous-only (control) condition. The control

<table>
<thead>
<tr>
<th></th>
<th>Amb-Only (control)</th>
<th>Propositional/ proposition-only situation</th>
<th>Situation-only</th>
<th>Primer-First</th>
<th>Propositional/ proposition-only situation</th>
<th>Situation-only</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accuracy</strong></td>
<td>0.73 (0.02)</td>
<td>0.81 (0.12)</td>
<td>0.77 (0.17)</td>
<td>0.81 (0.14)</td>
<td>0.80 (0.15)</td>
<td></td>
</tr>
<tr>
<td><strong>Reading Time</strong></td>
<td>302.02 (12.78)</td>
<td>312.12 (15.70)</td>
<td>305.17 (16.14)</td>
<td>246.72 (15.96)</td>
<td>250.71 (16.41)</td>
<td></td>
</tr>
</tbody>
</table>
group average was calculated by collapsing the overlap conditions in the ambiguous-only condition because that group did not actually read any primer texts. Then each of the four conditions were compared to this control condition.

**READING TIME**

Average per syllable reading time greater than three standard deviations from the grand mean were transformed to the value at three standard deviations from the mean (1.9% of the data). A priori contrasts found that the reading time for both primer-first conditions were significantly different than the ambiguous-only group (propositional/situation t(60) = 3.26, p = .002 and situation-only t(60) = 2.93, p = .005). In contrast, neither ambiguous-first group was significantly different from the reading times of the ambiguous-only group (propositional/situation t(61) = 0.41, p = .68 and situation-only t(61) = 0.13, p = .90). These data suggest that participants were using the information contained in the primer text in order to understand the ambiguous text. These data suggest that as long as there is an opportunity for top-down processing and some level of overlap between sentences, there will be facilitation.

**ACCURACY ANAPHOR RESOLUTION TEST**

The accuracy of identifying co-referential elements was used to determine the role of top-down and bottom-up processes in integration. A series of planned t-tests were conducted that tested each condition against the ambiguous-only (control) condition. The tests revealed that for the primer-first group both the propositional/situation, t(60) = 2.18, p = .03, and situation-only, t(60) = 1.99, p = .05, overlap conditions were greater than the control. These tests also revealed that for the ambiguous-first group the propositional/situation overlap condition was greater than the control, t(61) = 2.53, p = .01, whereas the situation-only condition was not, t(61) = 1.11, p = .27. These tests support the mixed model and suggest that a strong degree of resonance is needed for bottom-up processes to facilitate integration; otherwise, top-down availability is required.

The results provide evidence for a mixed model of text integration. Namely, both top-down and bottom-up processes
contributed to the integration process. First, the enhanced anaphor resolution accuracy when the primer was present supports a role of bottom-up resonance. The analysis revealed, however, that there must be a high amount of resonance between texts for bottom-up integration processes to occur. Otherwise, top-down availability is required to integrate text information. The facilitated reading times for the primer-first group suggests that participants were using primer information in a top-down fashion in order to disambiguate ambiguous information. This on-line processing then had an effect on the memory representation of those texts after the fact.

**General Discussion**

Students must often integrate information from multiple sources (e.g., multiple texts, lectures) in order to construct an understanding of a larger event. This is particularly the case in the domain of history, but by no means restricted to it. Although there is a growing body of research that suggests that readers do routinely integrate information across texts (e.g., Britt et al., 1999; Catrambone, 2002; Kim & Millis, in press; Wiley & Voss, 1999), relatively little is known about the mechanisms that mediate integrative processes. We adopted the perspective that the same factors that mediate within-text integration are also involved when integrating information across texts. Therefore, this present study was motivated by theories of text comprehension. The event-indexing model helped specify dimensions that could potentially overlap across texts, namely entities and dynamic events. There is some controversy, however, with respect to whether integration is mediated by bottom-up or top-down processes (Long & Lea, 2005). Memory-based models, such as the resonance model, assume that bottom-up mechanisms make information available for integration, which may then be sufficient to promote integration. On the other hand, integration may ultimately require top-down processes, such as those assumed by the search for meaning principle (Bartlett, 1932; Graesser, et al., 1994). Finally, it may be the case that both top-down and bottom-up processes mediate integration (e.g., Long & Lea, 2005). As such, top-down processes may be particularly important when there is moderate to low overlap between texts.
First, there is strong evidence that readers do indeed integrate texts, even when there is no explicit instruction to do so. Both on-line and off-line data support this claim. With respect to on-line data, the critical sentences were read faster in Experiment 2 when the primer passage preceded the ambiguous passage. This strongly suggests that the information from the primer passage was available when reading the ambiguous passage, and in particular the target sentences. With respect to off-line data, the recall data from Experiment 1 proved the strongest source of evidence for text integration. These data strongly suggest that participants integrated information from a primer text to aid in the interpreting of an ambiguous text. The majority of recall protocols were a blend of information from both the ambiguous text and the primer text and more than half of the sentences switched the focus of content from the immediately prior sentence. In terms of content and structure, the recall protocols were clearly integrated.

In a first step toward understanding the mechanism of integration, we found support for the Situation-Driven Hypothesis in that the predicates of information mentioned in both texts were recalled better than the arguments. Thus, integration is common and is primarily driven by predicates. It is important to note that it is not shared predicates, per se, but shared events between texts that facilitates their integration. It can be assumed that texts that describe the same events will use conceptually similar predicates. This is not to say that shared entities will not have an influence on text integration, but rather that it is less important than shared events.

An important goal of this study was to assess whether intertext integration was mediated by top-down processes, bottom-up processes, or both. The reading time data from Experiment 2 suggested that top-down integration in that critical target sentences were read faster when the primer was read first, regardless of whether or not there was propositional overlap (see Wiley & Rayner, 2000 for similar findings). The anaphor resolution data from Experiment 2 most strongly support the conclusion that both top-down and bottom-up mechanisms influence integration across texts. When the primer text was presented first, regardless of degree of overlap, participants were more accurate at judging two nouns as co-referential than the group given only the
ambiguous text. This supports a top-down influence. When the ambiguous text was read first, participants were only more accurate in making anaphor judgments when there was strong conceptual overlap (i.e., both propositional and situational overlap). Thus, without the possibility for top-down influence, a higher degree of overlap is required to activate the information from the ambiguous text in order to disambiguate it. This suggests an important role of bottom-up information in the integration process.

The results have educational implications. Acquiring knowledge in school is a series of demands for integration. In school content areas, the material learned in one lesson may be required knowledge for, or at least built on, subsequent knowledge. Similarly, class lectures comment on and supplement the information in the textbook. In order for students to integrate two texts, they must first have them co-active. Occasionally the teacher or author of a text will directly reactivate that information for the student, but more often the student must accomplish this task without assistance. The current experiments show that college students do integrate without instruction and that both the type and degree of overlap influence this integration process. When the disambiguating information comes after the ambiguous text, participants required a high degree of situational overlap. When the detailed disambiguating information was provided first, even minimal overlap facilitated integration. This suggests that students can make use of situational overlap or prior detailed knowledge to aid them in this co-activation and integration process.

Our finding that the degree of overlap between texts increases integration is consistent with other research results. For example, Kim and Millis (in press) presented participants pairs of “news updates” that overlapped on either three situational dimensions (protagonist, space, and causality) or no overlap. They found that overlap led to improved integration. Kim and Millis (in press) also found that two texts with the same source were more highly integrated than the same texts with different or no sources. Thus, source information and situational dimensions are cues that students can use to improve integration. Students can be directly taught about these situational dimensions and given practice monitoring them across texts.
Our findings of enhanced integration with the primer first is consistent with prior research showing that tasks that make the initial text more distinctive improves integration. Britt and Sommer (2004) had college students read a pair of related texts. They manipulated the intervening task and found that having students engage in tasks that solidify the macro-structure of the initial text (either by answering macro-level questions or writing a higher-level summary of the text) prior to reading the subsequent text lead to improved integration. They also found that instructions to strategically integrate were helpful. Thus, students can be instructed in making stronger, more distinctive representations of the texts they read. They can also be instructed to read the more detailed information first to ensure that the required information is accessible when it is later referred to leading to an increased probability that the information from the prior text is accessible to be activated from the cues in the current text.

References


