Processing Strategies for Comprehension and Integration of Multiple Texts

by

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ABSTRACT

The current study explores the extent to which different processing strategies affect comprehension accuracy and integration of information across multiple texts. Reading comprehension of single texts is a difficult task, in which the challenges are compounded by the need to integrate information across texts. Processing strategies, such as self-explanation and source-evaluation, help reduce the challenges that readers face when attempting to comprehend texts. Self-explanation has been a successful strategy for coherence-building processes in single text comprehension, but the benefits for supporting inter-textual comprehension have not yet been explored. Source-evaluation supports identification of different sources, which helps resolve inconsistencies between texts; yet it remains unclear whether sourcing alone supports comprehension within as well as between texts. Think-aloud is a strategy intended to encourage further processing of the text without providing any explicit comprehension strategy. The differences between these two strategies prompts questions regarding the adequacy of either strategy for supporting inferencing and integration within and across texts. In this study, participants (n=80) were randomly assigned to one of three strategy conditions: self-explanation, source-evaluation, or think-aloud. Students read four texts after which they completed three types of open-ended comprehension questions (i.e., textbase, intra-textual inference, and inter-textual inference), a source memory task, and individual difference measures. Prior knowledge and reading skill were strongly correlated (r = .65) and showed moderate correlations (r = .31 to .60) with participants’ comprehension accuracy, total number of integrations within their responses, and their memory for sources. Participants were more likely to respond accurately and demonstrate integrations
across texts for the text-based questions in comparison to the more challenging inference questions. There was a marginal effect of condition on comprehension question accuracy, wherein participants who self-explained responded more accurately than those who engaged in the think-aloud task. In addition, those in the self-explanation or source-evaluation conditions recalled more sources than those in the think-aloud condition. There were no significant differences in performance between the self-explanation and the source-evaluation conditions. Overall, the results of this study indicate that encouraging students to self-explain and/or evaluate sources while they read multiple documents enhances comprehension and memory for sources.
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Processing Strategies for Comprehension and Integration of Multiple Texts

Readers often experience multiple challenges when reading and comprehending information presented in texts. One important challenge of comprehending single texts lies in connecting ideas within a text to construct a coherent mental representation of that information (McNamara & Magliano, 2009). Moreover, readers are often exposed to more than one text, thus needing to connect ideas across texts as well as within them. Different processing strategies can support inference generation and integration. The purpose of the current research is to explore how readers comprehend and integrate information from multiple texts with the support of processing strategies.

In this information age, readers are able to access a wide variety of information through the internet (Goldman & Scardamalia, 2013). Information is available from a variety of diverse and dynamic sources such as social media posts, blogs, news articles, tweets, and books. Comprehension of single texts is challenging because the reader is required to generate inferences to understand the information that is explicit in the text, make connections between ideas within the text, and make connections to prior knowledge (McNamara & Kintsch, 1996; McNamara & Magliano, 2009). Comprehension challenges may increase when readers are faced with the challenge of integrating multiple texts, potentially as a result of the disparateness of connections and minimal coherence between texts.

Reading strategies help reduce the challenges that readers face when attempting to comprehend texts. Constructed responses collected during the online reading process such as think-alouds (Coté & Goldman, 1999; Magliano & Millis, 2003) can reveal
strategies that readers use while reading. For example, self-explanation (Coté & Goldman, 1999; McNamara, 2004) and source-evaluation (Wiley, Goldman, Graesser, Sanchez, Ash, & Hemmerich, 2009) are examples of strategies that support readers’ processing of the text information. Thinking-aloud provides an opportunity for readers to monitor their comprehension or elaborate on some ideas, while self-explanation explicitly prompts readers to generate inferences between different areas of the text and their own prior knowledge. Source-evaluation helps a reader assess the reliability of a text by assessing the source and how the text content is written. However, the differing benefits of each of these strategies and how they may support inter-textual integration have not been fully explored in the context of multiple document comprehension.

The goal of this project is to examine how different strategies support comprehension and inference generation differently across texts. In this study, students will be asked to read multiple texts during which they will be prompted to generate constructed responses such as self-explanations and source evaluations after which they will complete a comprehension assessment.

In the following sections, text comprehension research including theoretical models of single and multiple text comprehension will be discussed first, followed by a review of research regarding online comprehension processes and the benefits of both self-explanation and source-evaluation.

**Reading Comprehension Models of Single and Multiple Texts**

*Inference model.* Reading comprehension involves a dynamic and integrative process; combining information from the immediate sentence being read, previous portions of the text, and prior knowledge in order to construct a coherent representation
of the textual content (McNamara & Magliano, 2009). Kintsch (1988, 1998) theorized that comprehension occurs through a combination of constructive and integrative processes (CI model). Whereas initial reading constructs meaning via a combination of text information and a retrieval base of related knowledge, it is then integrated via spreading activation. The CI model outlines several levels of understanding that comprise a mental representation; the most relevant to this study are the textbase and situation model.

The textbase level is a combination of the words and their syntax into a propositional representation of the information from each clause or sentence. The construction of a textbase level of understanding affords a basic representation of the meaning of the sentence. The textbase level representation is further elaborated in the situation model because it is rare that sufficient meaning can be derived purely at the textbase level. The reader's knowledge and experience need to be integrated for the reader to be able to produce a personal interpretation of the textual meaning. Thus, in the situation model, the reader integrates information between the various sentences with information from prior knowledge to create a more comprehensive mental representation of the textual information that is not constrained to single propositions or sentences.

This integration of the text with prior knowledge takes place through inferencing. Building inferences becomes increasingly challenging if the related concepts are more distally presented in the text and if the semantic relations between text ideas are weaker (Higgs, Magliano, Vidal-Abarca, Martínez, & McNamara, 2017). Thus, constructing a coherent situation model is assumed to be more difficult because it necessitates inferencing in addition to textbase level comprehension (Kintsch, 1988; 1998; McNamara
Various studies have demonstrated a positive correlation between reading comprehension of single texts and prior knowledge, where readers with higher prior knowledge demonstrate better comprehension skills and inferencing skills (Chiesi, Spilich, & Voss, 1979; McNamara & Kinstch, 1996; McNamara, Kintsch, Songer, & Kintsch, 1996; Means & Voss, 1985). When readers have more domain relevant knowledge, they experience an ease of activation in intra-textual inferencing, further facilitating their comprehension (Kintsch, 1993; McNamara & Magliano, 2009). Similar results have been found with regards to comprehension and integration of multiple texts (Bråten, Anmarkrud, Brandmo, & Strømsø, 2014; Bråten & Strømsø, 2011; Hagen, Braasch, & Bråten, 2014; Rouet, Britt, Mason, & Perfetti, 1996; Strømsø & Bråten, 2009; Wineburg, 1991).

**Document model.** Beyond the reader’s characteristics, comprehension is also influenced by textual factors, which differ across genres and individual texts. Texts are typically written in a specific style, something that is highly variable between texts. This diversity in style may impose additional challenges for comprehension and integration of separate information (Magliano Hastings, Kopp, Blaum, & Hughes, in press; Magliano, McCrudden, Rouet, & Sabatini, in press). There are discourse markers within a text that signal potential connections and relationships between ideas (Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012; Goldman & Rakestraw 2000), which do not exist between separate texts. These markers include connectives and reference words (e.g., “however,” “such as,” “therefore,” etc.) that help guide the reader to relevant information necessary to generate inferences. Separate texts lack these clear connections forcing readers to make connections without these aids.
Separate texts can offer implicit connections that can be unnoticeable to the reader, wherein information from one text could potentially be used to build on information from a previous text (e.g., providing an update of previously read information). Information from different texts can also be contradictory, requiring the reader to recognize the discrepancies and resolve them within their mental model (Perfetti, Rouet, & Britt, 1999). However, an inference model might not be sufficient to explain how readers are able to identify and differentiate the content. Motivated by the lack of explanation for how readers resolve contradictory information and develop a coherent understanding, Britt and colleagues (1999) proposed the Document Model Framework (DMF). The DMF suggests that in addition to the levels of representation described by the CI model, readers can develop an intertext model, which allows for an identification of the source information and the specific relations between different sources (Britt & Rouet, 2012; Perfetti, Rouet, & Britt, 1999). Each source is represented as a document node, which can form inter-text links to the situation model content as well as to other document nodes allowing for a comprehensive yet adequately segregated organization of mental information.

Some of the core assumptions of the DMF include the processing of document boundaries, consideration of author perspective, and the resolution of discrepancies between texts. Britt and Rouet (2012) contend that readers do not always develop an intertext model with document nodes, and that in fact source information can frequently be treated as peripheral with limited integration into the mental representation of the text. A reader that might not utilize document nodes would only have an integrated mental model of the information without tagging clear distinctions between the discrepant
information, thus reducing the coherence of the mental model. Contradictory information between texts can produce a significant break in coherence, thus the most salient benefit of developing an intertext model is the ability to reconcile differences between them by assigning the opposing perspectives to their respective document nodes.

**Reading Comprehension Strategies for Single and Multiple texts**

Comprehension is evidently challenging, but certain strategies can support various aspects of the reading process in the hopes of fostering a coherent mental representation. Different strategies may focus on different aspects of the reading process for which readers are experiencing difficulties. For example, readers sometimes lack the necessary inferencing skills or adequate domain knowledge to better comprehend the text. Reading strategies can prompt readers to produce inferences, facilitating their ability to create connections. Various writing tasks during online and offline comprehension have been used to encourage students to make connections across texts. Using verbal protocols, such as think-aloud (Côté & Goldman, 1999; Magliano Millis, Levinstein, & Boonthum, C., 2011) and self-explanation (Chi & Bassok, 1989; Chi et al., 1994; McNamara, 2004) responses generated while reading allow students to verbalize their thought processes as they read. Whereas think-aloud mainly prompts readers to verbalize the thoughts they currently have, self-explanation provides the added encouragement of directly explaining text content and attempting to create connections across text sections as well as with their own prior knowledge. Thus, self-explanation is generally more likely than think-aloud to prompt students to generate inferences while reading.

The enhanced benefits of self-explanations are due to the deep connections that readers are prompted to make as they read. Comprehension is enhanced when readers
produce high quality self-explanations that contain bridging and elaborative inferences (Allen, McNamara, & McCrudden, 2015; McNamara, 2004; 2013; 2017; McNamara O'Reilly, Best, & Ozuru, 2006). Strategies that focus solely on individual sentence content, such as paraphrasing, do not promote deep comprehension. Indeed, McNamara (2004) reported that correct paraphrases were not correlated with comprehension in a study using self-explanation as an intervention. Comparatively, strategies that promote the linking of text content or prior knowledge were predictive of both textbase and intra-textual questions. Allen, Jacovina, and McNamara (2016) conducted a linguistic analysis of readers’ responses to paraphrasing prompts and self-explanation prompts. They found that paraphrasing included greater overlap of ideas in the text, but that self-explanations contained more indications of prior knowledge and use of connectives to make causal connections. Over time and with self-explanation training, readers increased their causal connections and demonstrated a cohesive structure throughout their explanations, indicating that self-explanation training promoted a more coherent mental representation of text content.

Self-explanation has been used as a vehicle for strategic processing in single text research studies; however, this has not been fully explored with multiple texts where coherence between textual concepts is minimal if not absent. Furthermore, there is limited evidence for the benefit of self-explanation in resolving inconsistent information across texts. However, research with refutational texts (texts that identify misinformation and provide relevant refutations) indicate that self-explanation, in comparison to think-aloud or rereading strategies, was able to support comprehension of a text containing contradictory content (Allen, McNamara, & McCrudden, 2015). One caveat of this
research is that the content was coherently structured within a single text and that the potential for self-explanation to resolve inconsistencies has not been explored outside of single texts. Thus, further exploration is necessary to determine whether self-explanation is an adequate strategy for encouraging coherence building processes in light of the disparate and contradictory structure that may exist across texts.

Much of the previous research on interventions and strategies supporting intertextual integration has focused on source differentiation (see Brante & Strømsø, 2018, for a review). This research supports the Document Model Framework and the benefit to readers when treating each text as a separate entity; where source information is a tool used to identify, qualify, sort, and validate textual content (Britt & Rouet, 2012). Accordingly, this process allows readers to discern information within their mental representation of integrated information as being information from separate texts or entities.

Various interventions have tested the use of source evaluation as a strategy for multiple documents comprehension (see Brante & Strømsø, 2018, for a review). Attention to sources helps readers evaluate and interpret document content and then consider how information is related to external yet relevant material (Strømsø, Bråten, Britt, & Ferguson, 2013). Interventions have focused on training prior to reading to provide suggestions on how to evaluate sources (SEEK: Wiley, Goldman, Graesser, Sanchez, Ash, & Hemmerich, 2009). Training supports the reader in identifying the source information before reading (Britt & Aglinskas, 2002), and for evaluating sources after reading (Wiley et al., 2009). When students attend to source information they typically produce higher quality integrations (Wiley et al., 2009). However, the effect of
sourcing only manifests if students are prompted to pay attention to sources during the reading process. Simply attending to the source information before reading is not sufficient to support source evaluation after reading (Britt & Angliskas, 2002). Asking readers to recall or evaluate sources after reading also was also not beneficial. This suggests that, similarly to comprehension strategies, sourcing strategies are best applied throughout the reading process (Stadler & Bromme, 2008), and potentially, sourcing may need the accompaniment of other inference generation tasks in order to support coherence building processes.

An important problem with sourcing interventions is the inconsistency and variability in the methodologies. While the DMF stresses that some attention to source information is beneficial for comprehension, there are also clear indications that simply attending to source information is insufficient (Britt & Angliskas, 2002). In fact, successful interventions include critical thinking tasks that may be the main contributors to inference generation because they, like self-explanation, encourage deep connections. Wiley and colleagues (2009) conducted a study in which they found that the intervention, SEEK, supported reading comprehension. This intervention, was not solely focused on source information, but also on elements for critical thinking. SEEK prompts readers to consider source information, the nature of the sources’ evidence that was presented, the relevance of the evidence, and the fit of the text information with prior knowledge. Therefore, the results of this study do not demonstrate that sourcing alone can improve comprehension because inference related tasks were also prompted. A study by Stadtler and Bromme (2007) assessed whether having readers respond to evaluation prompts versus monitoring prompts, or the combination of both predicted comprehension. They
found no significant effect of the prompts on comprehension. While source evaluation was associated with enhanced knowledge of source information, it was not related to comprehension performance. This finding supports the assumption that comprehension must be achieved through inference generation, which is not supported by comprehension monitoring or source evaluation alone.

Considering the contrastive results regarding sourcing, there are nonetheless results suggesting that awareness or understanding of source information is related to comprehension (Bråten, Strømsø, & Britt, 2009; Strømsø, Bråten, & Britt, 2010). A correlation study between comprehension tasks and awareness for sources indicated that greater memory for sources was positively correlated with greater comprehension at the intra-textual \( (r = .42) \) and the inter-textual level \( (r = .41) \) (Strømsø, Bråten, & Britt, 2010). In another study, Bråten, Strømsø, and Britt (2009) demonstrated that trustworthiness ratings and the uses of various types of source and document information were correlated with reading comprehension measures at the sentence, intra-textual, and inter-textual levels. The document information to correlate the most with comprehension was the type of document used \( (\text{sentence, } r = .31, p < .01; \text{intra-textual, } r = .31, p < .01; \text{inter-textual, } r = .23, p < .05) \) and publisher \( (\text{sentence, } r = .32, p < .001; \text{intra-textual, } r = .31, p < .01; \text{inter-textual, } r = .23, p < .05) \), with some benefits from document content. Interestingly, the use of document information was mostly predictive of performance on sentence and on intra-textual comprehension tasks rather than of performance on inter-textual comprehension tasks. Tendencies to attend to sources and assess their trustworthiness are correlated to performance on comprehension measures, yet source-evaluation alone might not be a sufficient strategy for building coherence processes and
supporting comprehension. Successful sourcing interventions typically have involved other deep processing tasks; thus it is difficult to attribute comprehension improvements to sourcing alone if in fact multiple strategies are being used in tandem.

Both self-explanation and source-evaluation have their benefits and their limitations; however, both need to be explored as strategies that can be leveraged to improve comprehension and integration. Self-explanation is intended to support readers production of causal connections between events (Allen, Jacovina, & McNamara, 2016). Within a text, creating connections is facilitated when the text is written cohesively. However, between texts information can be unrelated or contradictory such that any connection (causal, semantic, temporal, or other) may be difficult to infer. The contradictory nature between some texts may impede the development of a coherent representation of the text set, even with the support of self-explanation. Sourcing supports the identification of different sources and as a result helps resolve inconsistencies within a mental model; yet sourcing alone may not specifically support inference generation within or between texts. Both strategies seem to offer different benefits, prompting the question regarding the adequacy of either strategy for supporting inferencing and integration within and across texts. Is sourcing a sufficiently adequate strategy for initiating coherence-building processes and is self-explanation sufficient for intertextual inferencing?

**The Current Study**

The current study examines the extent to which strategy use (i.e., self-explanation, source-evaluation, and think-aloud) affects comprehension accuracy and integration as a function of different types of comprehension questions (i.e., textbase, intra-textual, and
inter-textual). Textbase questions target comprehension of individual sentences or ideas within the texts; intra-textual questions target readers’ understanding of relations within the texts; and inter-textual questions target comprehension of relations between texts.

Research on multiple text comprehension has stemmed from two slightly contrasting theoretical perspectives: a) an Inference model, and b) a Document model. Inference models attribute significant importance to the role of knowledge activation during comprehension, specifically positing that this activation permits inference generation across sections of a text and potentially across texts (e.g., McNamara & Magliano, 2009; Kintsch, 1988). The Document model invites a hierarchical perspective to inferencing such that knowledge activation is best categorized within the document level with the potential for resolving inconsistencies (e.g., contrasting or contradictory perspectives) across documents if the document or source information is activated in tandem (e.g., Perfetti, Rouet, & Britt, 1999).

The hypotheses for this experiment emanate from two different theoretical accounts but this study is not intended to test the validity of either theory over and above the other. Rather, the goal of this study is to gain a better understanding of the integration process in comprehension that can be supported by different strategies. In turn, the predominance of particular strategies can be associated with contrasting theoretical perspectives.

**Comprehension Accuracy**

Comprehension accuracy of four global warming texts will be assessed using a 12-question open-ended assessment. The assessment targets student's sentence-level comprehension using textbase questions, within-text inferencing skill using intra-textual
inferencing questions, and between-text inferencing skill using inter-textual inferencing questions. There is one of each question type in a question set, and each set of three questions focus on content from one text. Only the inter-textual questions in each set are designed to include information from other texts. This measure allows for an understanding of the reader's superficial comprehension as well as their deeper comprehension and ability to form connections between text content.

Main effects

H1 Reading skill: Reading skill is expected to positively correlate with comprehension accuracy because more skilled readers generally better understand text. All analyses will include reading skill as a covariate to account for variance associated with general reading skill prior to reading the texts.

H2 Prior knowledge: Prior domain knowledge is expected to positively correlate with comprehension accuracy. All analyses will include prior knowledge as a covariate to account for variance associated with knowledge prior to reading the texts.

H3. Strategy Condition

H3a: In line with the Inference model, a main effect of strategy condition is expected such that those in the self-explanation condition are expected to perform better than participants in the source-evaluation and think-aloud conditions. Self-explanation provides support for reading comprehension by encouraging the use of strategies during the reading process, thus allowing for deeper processing of textual material and increased inference generation. Source-evaluation is a strategy that directs reader’s attention to source information without necessarily requiring inference generation between concepts of a text. Think-aloud is a strategy that does not encourage the use of any specific reading
strategies within the constructed responses. Therefore, self-explanation is expected to better support comprehension across all question types.

![Figure 1. H3a: Inference Model: Comprehension accuracy as a function of strategy use](image)

H3b: An alternative null hypothesis in line with the Documents model predicts that there would be no difference between self-explanation and source-evaluation. This would be hypothesized if both strategies were insufficiently adequate to support all question types. Self-explanation has been developed and tested with single texts and has thus been most successful for textbase and intra-textual inferencing; however, there is little empirical support indicating that self-explanation enhances inter-textual inferencing. Similarly, source-evaluation is specific to inter-textual tasks, and therefore may offer minimal advantages for textbase and intra-textual questions.
H4 Question Type:

H4a: In line with the Inference model, a main effect of question type is expected in which participants are expected to perform best on textbase questions and worst on inter-textual questions. Both types of inference questions require a deeper processing of textual content, which is challenging for many readers, with the challenges increasing as coherence between concepts decreases (as is the case for concepts located in separate texts). Therefore, when averaged across conditions, performance on inter-textual questions is expected to be lower than on intra-textual questions.
Figure 3. H4a: Inference Model: Comprehension Accuracy as a Function of Question Type

H4b: The Document model would suggest a contrasting effect. Textbase question performance would again be expected to be the highest, however, the performance on the inference questions will be different such that performance on inter-textual questions will be better than intra-textual question performance. Inter-textual comprehension can be supported by the reliance on the inter-text node within the Document model. The inter-text node uses the reliance of source-information to make accurate inferences between texts.
Interaction Effects

H5 Interactions between Condition and Question Type:

H5a: A two-way interaction is expected between question type and strategy condition. Textbase question accuracy is expected to be highest for participants in the self-explanation condition, with no difference between inference questions. Participants who self-explain are expected to achieve similar levels of comprehension accuracy on both intra-textual and inter-textual questions because self-explanation is expected to similarly support inference generation for both types of inferential questions. The focus on evaluating source information may come at the expense of inference generation across challenging concepts that span multiple texts; therefore, participants who evaluate sources may perform worse on inference questions, particularly inter-textual questions. Think-aloud does not provide any inferencing or reading strategies, therefore, participants are expected to perform worse than both other strategies across all question types, but especially on the inferencing questions in which there is no expectation of a difference.
between intra-textual and inter-textual since all inference questions would be receive similar support within the constructed responses.

Figure 5. H5a: Inference Model: Comprehension Accuracy as a Function of Strategy Use and Question Type

H5b: In line with the Documents model, research suggests that attending to sources while reading supports inter-textual comprehension. As such, an alternative two-way interaction would be expected. Students who self-explain are still expected to perform best on textbase questions and show no difference between inference questions. However, participants in the source-evaluation condition are expected to perform better on inter-textual questions and worse on intra-textual questions compared to students who self-explain. Think-aloud is not expected to present a different outcome than in Hypothesis 5a.
Inter-textual Integration

Inter-textual integration is measured using the comprehension questions, which are also used for assessing comprehension accuracy. Inter-textual integration will be a count score of the number of times an individual used information from another text to answer each question. Overall score is totaled across all 12 comprehension questions, and question type total scores are calculated from the four responses of each question type. This measure assesses the extent to which participants are integrating text content from separate texts within their responses to comprehension questions. Further information regarding the coding method is provided in the Method section.

Main effects

H6 Reading skill: Reading skill is expected to positively correlate with intertextual integration. All analyses will include reading skill as a covariate to account for variance associated with reading skill level prior to reading the texts.
H7 Prior knowledge: Consistent with previous literature on prior knowledge and inferencing, prior knowledge is expected to significantly correlate with inter-textual integration count scores. All analyses will include prior knowledge as a covariate.

H8 Strategy Condition:

H8a: Consistent with the Inference model, a main effect of strategy condition is expected such that participants in the self-explanation condition will produce more inter-textual integrations than participants in the source-evaluation condition. Self-explanations offer more opportunities for inference generation, which is likely to be associated with an increase in inter-textual integration. Think-aloud does not prompt participants to integrate information, thus is expected to produce the fewest integrations.

Figure 7. H8a: Inference Model: Inter-textual Integration as a Function of Strategy Use

H8b: Contrastingly, and in line with the Documents model, an alternative null hypothesis would suggest the lack of a main effect of strategy condition because each strategy would benefit integration at different question types. Think-aloud is not expected to differ from Hypothesis 8a.
H9 *Question Type*: Both the Inference and the Document model would suggest that a main effect of question type is expected, such that participants will produce the fewest integrations for textbase questions, and the most for inter-textual questions. This is a function of the nature of the questions, in which inter-textual questions require integrations across texts, whereas textbase questions are isolated to single locations in a text. Intra-textual questions are expected to present some inter-textual integrations because they are inference questions and readers are not explicitly informed within the question as to which text each question refers.
Figure 9. H9: Inter-textual integration as a function of question type

Interaction Effects

H10 Interactions between Condition and Question Type:

H10a: The Inference model would suggest that greater inference generation is best supported by a strategy that supports deeper processing; thus, regardless of question type, self-explanation is expected to outperform both source-evaluation and think-aloud, and produce no interaction between question type and strategy use.

Figure 10. H10a: Inference Model: inter-textual integration as a function of strategy use and question type
H10b: Contrasting, a Document model would support a two-way interaction between strategy conditions and question type. In line with the sourcing literature suggesting that sourcing supports a greater number of integrations, fewer integrations are expected in textbase questions and more are expected for inter-textual questions for conditions in which participants source-evaluate as opposed to self-explain. The intertext model proposed by the document model would be expected to support students’ activation of concepts from different texts, decreasing unnecessary integrations in textbase questions while supporting integrations in inter-textual questions. On the other hand, self-explanation supports inferencing at all levels, but is potentially less specific at the inter-textual question level.

Figure 11. H10b: Document Model: Inter-textual integration as a function of strategy use and question type

Method

Participants
Participants (n=80) were recruited at a large southwestern university in the United States in exchange for credit within their introductory psychology course.

**Design**

The experimental design included one predictor variable, the strategy conditions (self-explanation, source-evaluation, and think-aloud). Additionally, each condition had two possible text sequences (i.e., original and reverse) as a means of accounting for effects of text order. Reading skill and prior knowledge were also assessed and were included as covariates in all analyses. Both dependent variables, comprehension score and total inter-textual integration, were examined as within-subjects variables thus allowing for comparisons between the three question types (text-base, intra-textual, and inter-textual).

**Materials**

**Demographics.** The demographics questionnaire included questions regarding students’ gender, ethnicity, college grade level, GPA, and first language. Second language questions were included for students that indicated that English is not their first language (see Appendix A).

**Prior Knowledge Questionnaires.** All students received an assessment of their domain knowledge in history and science (see Appendix B). The assessment was composed of 10 history and 14 science multiple-choice questions obtained from an original larger set of 30 questions that tested for students’ knowledge in history, science, and literature. The assessment omitted the original questions on literature since they were not relevant to the current study. An example science question is, “The poisons produced by some bacteria are called (a) antibiotics, (b) toxins, (c) pathogens, (d) oncogenes.”
The original 30 questions were developed in prior work for college and high school students and have been used in previous research on reading comprehension, writing skill, and strategy acquisition skill (Allen, Snow, & McNamara, 2016; Roscoe, Crossley, Snow, Varner, & McNamara, 2014). This test was reduced from an original set of 55 questions which has demonstrated a high reliability ranging from .72 to .81 and have been validated with over 4,000 students over multiple studies with high school and college students (McNamara, O’Reilly, Best, & Ozuru, 2006; O’Reilly, Best, & McNamara, 2004; O’Reilly & McNamara, 2007; O’Reilly, Taylor, & McNamara, 2006; See Appendix B). The original 55 questions (i.e., 18 science, 18 history, and 19 literature) were piloted with 15 undergraduate students. Results from this pilot yielded the 30 questions in which none of the items produced ceiling or floor effects.

In addition to domain knowledge questions, readers will also be asked to answer 15 prior knowledge questions on the topic of climate change (see Appendix C). These questions are carefully selected to ensure that they do not contain any information that can be derived from the texts or the comprehension questions, but at the same time are useful for producing textual inferences.

**Reading Skill Measure.** Students completed the Gates-MacGinitie (4th ed.) reading skill test (Form S, level 10/12; MacGinitie & MacGinitie, 1989). This is a standardized 48-item multiple-choice test wherein students were asked to read short passages and answer two to six questions for each passage. The test has been used widely and is well established as a measure of general reading skill ($\alpha = .85–.92$; Phillips, Norris, Osmond, & Maynard, 2002). This test was designed to obtain an overall measure of students reading ability, including surface-level comprehension and deep-level comprehension.
After receiving instructions and two practice questions, students were given 20 minutes to complete the test.

**Texts.** The texts that were used in this study originated from a study with Norwegian students to assess how source evaluation supports integration across texts (Bråten, Strømsø, & Britt, 2009; see Appendix D). The original set included seven texts that varied in their degree of trustworthiness. For the purpose of this study, only four texts were included due to time constraints (see Table 1 for details of each text). These texts are representative of the types of texts to which individuals are exposed on a daily basis (i.e., news articles, opinion pieces, and non-fiction books) and have been used extensively in previous studies to assess source-evaluation (Bråten, Strømsø, & Britt, 2009; Bråten, Strømsø, & Salmerón, 2011), epistemic beliefs (Strømsø, Bråten, & Britt, 2011) and comprehension skills (Hagen, Braasch, & Bråten, 2014).

An important consideration of using real world texts is that they vary highly in difficulty level; thus, it is important to consider how the aspects of text difficulty may impact comprehension of subsequent texts. Five main textual components can be used to summarize text difficulty levels: narrativity, syntactic simplicity, word concreteness, referential cohesion, and deep cohesion. Each of these measures provide a proportional score that describes one aspect of text easability; where a higher score indicates greater ease of comprehension. A narrativity score indicates the degree to which a passage is story-like. Syntactic simplicity demonstrates how simple the syntax is, specifically identifying how many clauses exist in a sentence or how many words appear before the main verb. Word concreteness measures the degree to which words have high imageability. Referential cohesion measures how many words and concepts overlap in
the text, and deep cohesion measures how events and ideas are related throughout the text (Jackson, Allen, & McNamara, 2016; McNamara, Graesser, McCarthy, & Cai, 2014).

Table 1. Descriptions of the four texts read by participants

<table>
<thead>
<tr>
<th>Text</th>
<th>Title</th>
<th>Author</th>
<th>Source</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text-1</td>
<td>Natural and Manmade Global Warming Causes</td>
<td>Patrick Heskestad, Kevin Lerstad, and Hanna Liebich</td>
<td>Text obtained from a High School textbook for nature studies: Cosmos; Routledge</td>
<td>5/4/2004</td>
</tr>
<tr>
<td>Text-2</td>
<td>Greenhouse Gases: Manmade Causes</td>
<td>Professor Martha Olsen</td>
<td>Center for International Climate and Environmental Research - Vanderbilt University</td>
<td>2/8/2005</td>
</tr>
</tbody>
</table>

Each of the four texts that were used in this study vary in text difficulty level across each of the five component scores; the quantitative descriptive summaries for each text are presented in Table 2. In general, these scores confirm that they are informational (non-narrative) text, with moderate syntactic complexity. Texts 1 and 2 are relatively cohesive, whereas texts 3 and 4 have relatively low local cohesion, but high deep cohesion (which indicates that they include more explicit connectives).

Table 2. Characteristics of the four texts read by participants

<table>
<thead>
<tr>
<th>Text</th>
<th>Number of Words</th>
<th>Grade Level</th>
<th>Narrativity</th>
<th>Syntactic Simplicity</th>
<th>Word Concreteness</th>
<th>Referential Cohesion</th>
<th>Deep Cohesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text 1</td>
<td>391</td>
<td>8</td>
<td>20.61</td>
<td>50.00</td>
<td>61.03</td>
<td>58.71</td>
<td>35.57</td>
</tr>
<tr>
<td>Text 2</td>
<td>290</td>
<td>14</td>
<td>18.41</td>
<td>14.46</td>
<td>34.83</td>
<td>62.93</td>
<td>63.31</td>
</tr>
<tr>
<td>Text 3</td>
<td>345</td>
<td>11</td>
<td>12.51</td>
<td>50.00</td>
<td>32.28</td>
<td>12.71</td>
<td>84.38</td>
</tr>
<tr>
<td>-------</td>
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<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Text 4</td>
<td>263</td>
<td>12</td>
<td>3.44</td>
<td>62.55</td>
<td>50.80</td>
<td>10.93</td>
<td>62.55</td>
</tr>
</tbody>
</table>

*Note. Text characteristic scores were acquired through Coh-Metrix Common Core Text Ease and Readability Assessor (T.E.R.A.) (Jackson, Allen, & McNamara, 2016).*

**Constructed Responses.** Students were prompted to either type a self-explanation or a source-evaluation after reading specific target sentences. Sentences that support or require inference generation for comprehension are candidate target sentences (Ozuru, Briner, Best, & McNamara, 2010). Target sentences were presented every two to four sentences selected based on the following criteria: (1) the sentence discussed critical information important for understanding surrounding sentences, and (2) contained inferential information relevant for one to four of the comprehension questions (see Appendix E).

Constructed response tasks in all three conditions (i.e., self-explanation, source-evaluation, think-aloud) are identical in structure and instruction delivery. Both include instructions on the task, explanation of the prompt, and examples of good responses to either strategy (see Appendix E). Self-explanation instruction focuses on explaining the meaning of the text and elaborating beyond the reader’s initial understanding of the text. Source-evaluation instructions prompt the reader to report their thoughts regarding how the source impacts the meaning of the text. Think-aloud instructions prompted the reader to simply report what they were thinking, regardless of the relation to the text. After receiving instructions and an example of the constructed response, participants read the text and were prompted to write constructed responses at various target sentences throughout the texts. Participants were given the opportunity to view a shortened set of supplemental instructions through a pdf link for their specific condition strategy in case they needed a refresher.
**Comprehension Assessment.** The comprehension assessment includes 12 questions, comprised of 4 textbase questions, 4 intra-textual inference questions, and 4 inter-textual inference questions (see Appendix G). The questions cover four topics (corresponding to the main focus of each of the four texts) with three questions per topic including each question type. Each topic centers around a concept presented in one of the four texts, but that can be linked to information in the other three texts.

Each of the three questions within each topic is designed in a hierarchical fashion; meaning that each subsequent question is related to the previous one within the topic. Typically, the first question is the easiest (text-base), the second question is of medium difficulty level (involving intra-textual bridging or some inter-textual bridging), and the third question is the most difficult (requiring inter-textual bridging). Each question within a topic is a precursor to each subsequent question, meaning that students’ success on the following questions is often dependent on their understanding of concepts presented in the previous questions. This procedure was adopted to facilitate students’ inter-textual inference generation and allow them to reason about concepts from separate texts. As these texts are not directly related to each other and each one lacks discourse markers to refer to the other texts, the questions are designed to provide cues for potential connections. Below is an example set of hierarchical questions stemming from Text 3:

1. *Text-base: What happens to temperature when the circulation of the Atlantic is disturbed?*

2. *Intra-textual: Explain why and how global warming can cause dramatic effects on farming and forestry?*
3. *Inter-textual:* Explain how negative effects on forestry potentially affect the climate system's natural cycle?

**Memory for Sources Assessment.** Students completed a memory for sources task: a 32-item multiple-choice task (see Appendix H) that assessed how accurately students could determine where textual information originated. Each item was a sentence from one of the texts, and given the source information, students were asked to identify from which text the sentence originated. Of the 32 items, half were from target sentences, and half were non-target sentences. The sentences were distributed relatively evenly across the texts; however, because Text 2 had the fewest number of sentences (only five target sentences) only three target sentences were selected for that text. Contrastively, Text 1 was the longest text with the most target sentences (n = 9), therefore five target sentences were selected for the measure. All other texts were represented with four target and four non-target sentences. The 32-item test was then reordered into three different random orders to which each participant was randomly assigned to one of them.

**Procedure**

Participants were tested individually in a controlled laboratory setting among other participants during a two-and-a-half-hour session. Students initially completed a demographics survey and were then presented with the reading task composed of the four texts. Students were then informed that they would be reading four texts on the topic of global warming followed by a set of open-ended comprehension questions on the reading. Once they receive these instructions they proceeded to the first text. As they read, students were prompted to write a constructed response for five to nine target sentences per text. Participants had the option to view a short version of instructions in
case they needed a reminder (see Appendix F for an example). The type of constructed response (self-explanations, source-evaluation, or think-aloud) depended on the condition to which each participant was randomly assigned.

After reading all four texts, students were asked to answer the comprehension questions. While the order of the texts varied across participants, the order of the questions in the assessment remained constant. Each question was presented one at a time, and students did not have the opportunity to return to previous questions. After completing the comprehension task, students were given the option of taking a 10-minute break after which they completed the memory for source task. Finally, students completed the individual difference measures to assess their reading skill and their prior knowledge. None of the text content was directly related to the prior knowledge test or to the reading skill test. Individual difference measures were presented after completing the comprehension task to avoid any potential knowledge priming during the experimental task (McNamara & Kintsch, 1996; O’Reilly & McNamara, 2007).

Coding

**Comprehension Score.** Each of the 12 questions were assigned a score of 0 to 1.0. A question was given a partial score of .5 if the question requires two independent responses, or when the idea units of the response (as determined by the rubric) needed to be segmented into two parts. An example of a question whose score was segmented into two different parts is, *Name 2 resources that are being found in the Northern Regions as a result of global warming.* Students needed to provide two example resources discussed in the text, with each correctly mentioned resource receiving a .5 score.
**Text Integration Score.** In addition to comprehension scores, each question was coded for inter-textual integration. This count is calculated by coding for the number of additional texts whose information was employed in the response. Since the purpose of this score was to determine the total “inter-textual integrations” a unit score of 1 is only given when students use a text in addition to another (i.e., if a student uses zero texts or only one text in a response, then this student’s response will be coded as a 0 because they do not produce any inter-textual integrations).

The purpose of this code is to assess whether students who integrate information across more texts perform better than those that integrate fewer texts. When integrating information from a single text, students can either pull from specific locations within a text (text-base), produce an inference about an intra-textual concept identified between two adjacent sentences (local bridging), or produce an inference between more distal concepts (global bridging) (Ozuru, Briner, Kurby, & McNamara, 2013). Information was coded as originating from specific texts based on the response idea units that relate to the singular location (text-base) or the distance of intra-textual inferences (local, or global) of concepts in the text. This was done to avoid giving an inflated score to students that might make multiple connections to a single text or a lower score to students that make fewer connections to each individual text, but still use multiple texts in their responses.

Coding for inter-textual integration was done after completing comprehension coding, and was done blind to the comprehension score. For both coding schemes, each question was coded independently of all others and was then summed as a function of each question’s predetermined “question type”: text-base, intra-textual, and inter-textual (see Appendix I for the rubric and assigned category of each question). The
comprehension scores were then transformed into proportional scores, while the inter-textual count remained a count score.

Two raters trained on a minimum of 20% of responses to achieve reliability on scores for both comprehension and integration. Both coders reached a minimum kappa of .75 and 83 percent exact agreement per question for the comprehension score after which one of the two raters coded all the remaining responses. Variability was very low for the integration count outcome as most responses received a zero. Therefore, after training on approximately 20% of the responses, both raters coded all items and reached a minimum exact 84 percent exact agreement on each question and resolved any disagreement through discussions. Individual reliability scores for each question can be found in Appendix J.

Results

Preliminary Analyses. Preliminary analyses were conducted on the individual difference measures (prior knowledge and Gates reading skill) as well as with the exploratory outcome measure, memory for sources (see Table 3 for means and standard deviations). Prior knowledge was composed of two different prior knowledge sets; a general set composed of general knowledge questions about history and science, and a topic knowledge set with questions on climate change. The two sets were strongly correlated ($r = .666, p < .001$).

Three different versions of the memory for sources measure were used in the study to control for any order effects of the questions (all participants answered the same questions). The three versions were similar in their distributions with means of .61, .71, and .60 and standard deviations of .24, .30, and .26, respectively. The memory for source
task was presented after the optional 10-minute break, therefore a t-test was used to assess any differences between students that elected to take a break compared to those that did not. The t-test indicated that the 10-minute break had a significant effect on performance on the memory for source task ($t(79) = 2.135, p = .036$), such that the participants who did take a break ($n = 29$) performed slightly better than participants who did not ($n = 52$). A subsequent regression did not indicate a significant effect of a break or task version on performance on the memory for source task ($F(2, 80) = 2.314, p = .106$). Responses on the Gates MacGinitie Reading Test (GMRT) displayed a heavily platykurtic distribution. A Shapiro-Wilk normality test indicates that the reading questionnaire is not normally distributed ($W = 0.961, p < .05$).

Correlations were calculated between individual difference revealed that the measures were significantly correlated. Prior knowledge and the Gates reading skill were all significantly correlated with the outcome variables (see Table 3 and Appendix K). Prior Knowledge was most strongly correlated with Gates reading skill ($r = .653, p < .001$) and significantly correlated with memory for sources ($r = .364, p < .001$). Gates reading skill and memory for sources were also strongly correlated ($r = .553, p < .001$). Table 3 illustrates the correlations between the individual difference measures and the total scores of the dependent variables. Table 3 presents these correlations as a function of question type.
### Table 3. Descriptive statistics and correlations for dependent and independent variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prior Knowledge</td>
<td>0.587</td>
<td>0.156</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Gates reading skill</td>
<td>0.607</td>
<td>0.219</td>
<td>.653**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Memory for Source</td>
<td>0.533</td>
<td>0.234</td>
<td>.364**</td>
<td>.553**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Total Comprehension Score</td>
<td>0.491</td>
<td>0.192</td>
<td>.582**</td>
<td>.602**</td>
<td>.564**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Textbase Comprehension</td>
<td>0.705</td>
<td>0.219</td>
<td>.491**</td>
<td>.535**</td>
<td>.437**</td>
<td>.795**</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>6. Intratextual Comprehension</td>
<td>0.381</td>
<td>0.228</td>
<td>.509**</td>
<td>.413**</td>
<td>.472**</td>
<td>.879**</td>
<td>.555**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Intertextual Comprehension</td>
<td>0.387</td>
<td>0.235</td>
<td>.473**</td>
<td>.574**</td>
<td>.515**</td>
<td>.852**</td>
<td>.474**</td>
<td>.662**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Total Integration Count</td>
<td>1.148</td>
<td>0.950</td>
<td>.308**</td>
<td>.311**</td>
<td>.0715</td>
<td>.368**</td>
<td>.326**</td>
<td>.234*</td>
<td>.369**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Text-based Integration</td>
<td>0.370</td>
<td>0.511</td>
<td>.181</td>
<td>.051</td>
<td>.038</td>
<td>.071</td>
<td>.108</td>
<td>.101</td>
<td>-.026</td>
<td>.323**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Intra-textual Integration</td>
<td>0.124</td>
<td>0.367</td>
<td>.003</td>
<td>-.063</td>
<td>-.108</td>
<td>-.118</td>
<td>-.067</td>
<td>-.065</td>
<td>-.163</td>
<td>.341**</td>
<td>-.18</td>
<td></td>
</tr>
<tr>
<td>11. Inter-textual Integration</td>
<td>0.654</td>
<td>0.824</td>
<td>.241*</td>
<td>.355**</td>
<td>.107</td>
<td>.433**</td>
<td>.338**</td>
<td>.236*</td>
<td>.514**</td>
<td>.801**</td>
<td>-.167</td>
<td>.060</td>
</tr>
</tbody>
</table>

Note: SD = Standard Deviation

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).
Two text orders were used to control for text order effects, the originally designed text order (1,2,3,4) and a reverse order (4,3,2,1). An independent samples t-test was conducted to examine the effect of text order on comprehension. The t-test revealed that there was no significant effect of text order on comprehension scores ($t(79) = 0.067, p = .947$). The integration scores are not normally distributed, and instead presented as a Poisson distribution. Because a Poisson distribution would violate the assumption of a normal distribution for a t-test, a Poisson regression was used to examine the effect of text order on the integration count outcome. Dummy codes were used with Order 1 (1,2,3,4) as the reference level to which Order 2 compares. Results indicated that text order did not significantly predict integration ($F(1, 79) = 0.005, p = .947$). As such, text order is not further considered in the analyses.

Because there was an important range of total survey time it was important to analyze any potential effects of time on the outcome measures. However, analyses did not reveal a significant effect of time on comprehension score, nor on integration counts, and there were no significant interactions as a function of question type. Hence, survey time is not further considered in the analyses.

**Data Preparation**

Linear Mixed Models (LMM) were conducted to examine the effects of strategy condition, prior knowledge and memory for source as a function of question type, including a LMM for the comprehension outcome, and a generalized linear mixed model (GLMM) for the inter-textual integration outcome. The LMM was the appropriate modeling approach for two reasons: 1) the model considered both fixed effects of the four predictors as well as the random effects of individual participants, and 2) accounted for
the question type nested within each subject. The GLMM was the appropriate modeling approach for the inter-textual integration dependent variable for similar reasons, but with the added consideration that a Poisson distribution is appropriate for count data. Analyses for both mixed effects models were conducted using the \textit{lme4} package (Bates, Maechler, Bolker, & Walker, 2015) within the R statistical software (R Core Team, 2013).

All individual difference measures (prior knowledge, Gates reading skill, and memory for sources) were centered in order to facilitate interpretation of the analyses. **Variable Coding.** Both categorical variables – the between-subjects strategy condition and the within-subjects question types – were recoded with contrast codes for both the LMM and the GLM analyses of both dependent variables. The following structure was selected for the contrast codes assigned to the strategy condition variable:

Contrasts for the three levels of the strategy condition were selected based on planned analyses for this study. The current research primarily addresses how self-explanation and source-evaluation strategies differentially affect comprehension and integration. Think-aloud was included primarily as a control variable. To examine these differences, think-aloud was compared to the average of self-explanation and source-evaluation strategies in Contrast 1, whilst self-explanation and source-evaluation were compared to one another while disregarding think-aloud in Contrast 2. Importantly, because think-aloud is expected to produce lower scores, Contrast 1 has a negative value for think-aloud whereas the two other strategies are positive. These two contrasts are listed in Table 4.

<table>
<thead>
<tr>
<th>Table 4. Contrast codes for strategy condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contrasts</td>
</tr>
<tr>
<td>Think-aloud</td>
</tr>
<tr>
<td>Self-explanation</td>
</tr>
</tbody>
</table>
Contrasts for question type followed a similar structure as the one for strategy condition, with one difference described below. The current research seeks to determine how textbase questions can differ from both inference questions (intra-textual and inter-textual) as well as how both inference questions differ from one another. As such, Contrast 1 compares textbase questions to the mean of both inference questions, and Contrast 2 specifically addresses the comparison between intra-textual and inter-textual questions, while omitting textbase questions.

In our hypotheses, we predicted different results for each outcome variable; specifically, we predicted a high comprehension performance on textbase questions and low generation of integrations within that same question type. Therefore, the contrasts needed to reflect this difference in the direction of the predicted effects, which are specifically reflected in Contrast 1 (the contrast that compares the textbase questions to both inference questions) as the predictions did not affect Contrast 2 (since textbase questions are not compared in this contrast). Thus, we determined that a positive direction for the textbase questions and a negative direction for the inference questions would be most appropriate for the comprehension outcome (see Table 5).

| Table 5. Comprehension contrast codes for question type |
|-----------------------------------------------|----------------|----------------|
| Contrasts 1                                   | Contrasts 2   |
| Textbase                                     | 0.50          | 0.00           |
| Intra-textual                                | -0.25         | 0.50           |
| Inter-textual                                | -0.25         | -0.50          |

Regarding integration scores, we predicted that textbase questions would produce the fewest integrations in comparison to either inference questions, as such a negative
direction was applied to textbase questions, and a positive direction was applied to the inference questions for the integration count outcome (see Table 6).

| Table 6. Integration contrast codes for question type |
|---------------------------------|---|---|
| Textbase                        | -0.50 | 0.00 |
| Intra-textual                   | 0.25  | 0.50 |
| Inter-textual                   | 0.25  | -0.50 |

Model Variables. Model construction followed the general steps for both dependent variables. In each case, a baseline model was fit that included prior knowledge as a covariate and an intercept term for each participant. Both sets of models (the LMM and GLMM) included the same predictor variables (prior knowledge, Gates reading skill, question type, and strategy condition). All predictors were entered as fixed effects with subjects entered as random intercepts. Level 1 models included a random intercept term for each participant and question type. The fixed effects for prior knowledge scores, Gates reading skill, and strategy condition are entered at Level 2.

Model predicting comprehension scores. Comprehension score was analyzed as a function of question type within Level 1. Level 1 effects are described first, followed by Level 2 effects and interactions, and finally, cross-level interactions. To develop the LMM model, we began with a baseline model and a random intercept for each individual. For Model 1 in Level 1, question type significantly improved model fit ($F(2, 80) = 123.63, p < .001$), with only Contrast 1 between textbase and the average of the two inference questions being significant ($\beta = .428, t = 15.722, p < .001$). In other words, performance was significantly higher in the textbase questions than for the two other
questions. There was no significant difference between intra-textual and inter-textual comprehension ($\beta = -.006, t = -0.262, p = .794$). See below for the modeling process:

$$m_0 = \text{lmer}(\text{Score}_Q \sim 1 + (1|\text{idnumber}), \text{data}=\text{mal})$$

$$m_1 = \text{lmer}(\text{Score}_Q \sim \text{Qtype} + (1|\text{idnumber}), \text{data}=\text{mal})$$

$$m_2 = \text{lmer}(\text{Score}_Q \sim \text{Qtype} + \text{Prop_PKGCC} + (1|\text{idnumber}), \text{data}=\text{mal})$$

$$m_3 = \text{lmer}(\text{Score}_Q \sim \text{Qtype} + \text{Prop_PKGCC} + \text{Prop_Gates} + (1|\text{idnumber}), \text{data}=\text{mal})$$

$$m_4 = \text{lmer}(\text{Score}_Q \sim \text{Qtype} + \text{Prop_PKGCC} + \text{Prop_Gates} + \text{ConditionName} + (1|\text{idnumber}), \text{data}=\text{mal})$$

At Level 2, prior knowledge significantly predicted comprehension score ($F(1, 79) = 40.581, p > .001$). Next, we included Gates reading skill which also significantly predicted comprehension score ($F(1, 78) = 11.53.47, p < .001$). Finally, condition was added but did not add to model fit, ($F(2, 76) = 2.36, p = .101$), with neither contrasts demonstrating significant effects: Contrast 1 ($\beta = -0.063, t = -1.540, p = .128$), Contrast 2 ($\beta = 0.064, t = 1.416, p = .161$). Cross-level interactions of question type with condition, prior knowledge, and gates reading skill were sequentially added, but none of these interaction terms improved model fit. Means and standard deviations of the two outcomes measures as a function of condition and question type are provided in Tables 7.

Results for the comprehension scores are presented in Figure 12.

Table 7. Descriptive measures for comprehension scores as a function of question type.

<table>
<thead>
<tr>
<th>Source</th>
<th>Self-explanation Mean</th>
<th>Self-explanation SD</th>
<th>Source-evaluation Mean</th>
<th>Source-evaluation SD</th>
<th>Think-Aloud Mean</th>
<th>Think-Aloud SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbase</td>
<td>0.733</td>
<td>0.240</td>
<td>0.728</td>
<td>0.198</td>
<td>0.659483</td>
<td>0.211</td>
</tr>
<tr>
<td>Intra-textual</td>
<td>0.457</td>
<td>0.242</td>
<td>0.364</td>
<td>0.244</td>
<td>0.318966</td>
<td>0.182</td>
</tr>
<tr>
<td>Inter-textual</td>
<td>0.444</td>
<td>0.233</td>
<td>0.413</td>
<td>0.278</td>
<td>0.310345</td>
<td>0.182</td>
</tr>
</tbody>
</table>

Note: SD = Standard Deviation
There may be insufficient power to include both individual difference measures in the multi-level model analysis above, resulting in unstable effects. When investigating the data further without the individual difference measures, the condition still produces a marginally significant effect on condition ($F(2, 78) = 2.780, p = .068$), in which Contrast 1 was significant, indicating that students in the think-aloud condition performed worse than those in the self-explanation and source-evaluation conditions ($\beta = 0.125, t = 2.15, p = .035$), whereas Contrast 2 was not significant, indicating that there was no difference between self-explanation and source-evaluation ($\beta = -0.043, t = -0.817, p = .417$). When subsequently testing the model with only one individual difference measure at a time, we discover unstable results. First, the inclusion of only prior knowledge as a covariate produced the similar results as the previous analysis without any individual difference measures. However, the inclusion of just Gates Reading skill generated contrasting results: Condition again marginally significantly contributed to the model ($F(2, 77) = 3.111, p = .050$), but Contrast 1 between think-aloud and the two other strategies was not significant ($\beta = 0.076, t = 1.616, p = 0.110$), whereas Contrast 2 between self-explanation and source-evaluation was marginally significant ($\beta = -0.074, t = -1.755, p = 0.083$).

---

Figure 12. Comprehension as a function of question type and strategy condition. Figure 12A represents the interactions between question type and strategy condition, whereas Figures 12B and 12C illustrate the main effects for question type and strategy condition, respectively.
Model predicting integration counts. Counts of inter-textual integrations were also analyzed as a function of question type within the Level 1 model. Initial Level 1 effects are described first, followed by Level 2 effects. Similar to the LMM model for comprehension, the baseline model for the GLMM only included a random intercept for each individual. See below for the modeling process:

\[
m_0 = \text{glmer}(\text{Int}_Q \sim 1 + (1|\text{idnumber}), \text{family='poisson'} \text{ data=mal})
\]

\[
m_1 = \text{glmer}(\text{Int}_Q \sim \text{Qtype} + (1|\text{idnumber}), \text{family='poisson'} \text{ data=mal})
\]

\[
m_2 = \text{glmer}(\text{Int}_Q \sim \text{Qtype} + \text{Prop_PKGCC} + (1|\text{idnumber}), \text{family='poisson'} \text{ data=mal})
\]

\[
m_3 = \text{glmer}(\text{Int}_Q \sim \text{Qtype} + \text{Prop_PKGCC} + \text{ConditionName} + (1|\text{idnumber}), \text{family='poisson'} \text{ data=mal})
\]

Within Level 1, question type significantly improved model fit, \(\chi^2(2) = 32.253, p < .001\); specifically, within Contrast 2 comparing intra-textual question to inter-textual questions, there were significantly fewer inter-textual integrations for intra-textual questions \(\beta = -1.668, z = -4.837, p < .001\) than for inter-textual questions (See Figure 13). There was no significant difference between the textbase and the average of the inference questions \(\beta = -0.353, z = -1.054, p = .292\).

At Level 2, prior knowledge significantly accounted for the model variance, \(\chi^2(1) = 6.21, p < .05\), however, Gates Reading Skill did not \(\chi^2(1) = 1.304, p = 0.254\), and therefore was omitted from the rest of the analyses for the integration dependent variable. Finally, condition was added to the model, but did not significantly contributed to model fit, \(\chi^2(2) = 0.795, p = .672\), with neither contrast demonstrating significant effects: Contrast 1 \(\beta = -0.231, t = -0.885, p = .376\), Contrast 2 \(\beta = -0.032, t = -0.104, p = .917\).
Models for interactions between question type and condition, prior knowledge, and reading skill were tested for increase in model fit, none significantly contributed to model fit. Means and standard deviations of the two outcomes measures as a function of condition and question type are provided in Tables 8.

Table 8. Descriptive measures for integration count as a function of question type.

<table>
<thead>
<tr>
<th>Question Type</th>
<th>Self-explanation</th>
<th>Source-evaluation</th>
<th>Think-Aloud</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Textbase</td>
<td>0.414</td>
<td>0.568</td>
<td>0.348</td>
</tr>
<tr>
<td>Intra-textual</td>
<td>0.172</td>
<td>0.384</td>
<td>0.043</td>
</tr>
<tr>
<td>Inter-textual</td>
<td>0.724</td>
<td>0.841</td>
<td>0.652</td>
</tr>
</tbody>
</table>

Note: SD = Standard Deviation

Figure 13. Integration counts as a function of question type and strategy condition. Figure 13A represents the interactions between question type and strategy condition, whereas
Figures 13B and 13C illustrate the main effects for question type and strategy condition, respectively.

**Analysis of Memory for Source Outcome**

Descriptive statistics for the memory for source outcome are available in Table 9. Initial analyses of text order effects on memory for source were important because participants’ potential memory for source information could be a result of the order in which they saw the texts. Text order did significantly predict memory for source ($\beta = -0.107, t = -2.55, p = 0.013$), such that those that read the texts in their original order (text order: 1234) performed better than those that read the texts in their reverse order (text order: 4321) (See Figure 14). As a result, text order was included in the following models.

A stepwise multiple regression was conducted on memory for source including text-order, the decision to take a 10-minute break, the individual difference measures (prior knowledge and Gates reading skill), as well as strategy condition as predictors. Whereas the break did not significantly predict memory for source ($\beta = 0.013, t = 0.245, p = .807$), text order did ($\beta = -0.106, t = -2.07, p = .041$). Prior knowledge alone had significantly accounted for model variance ($F(1, 77) = 17.91, p < .001$), until Gates reading skill was subsequently included in the model, accounting for a significant amount of variance ($F(1, 76) = 18.717, p < .001$), and in which case prior knowledge was no longer significant ($\beta = 0.145, t = 0.780, p = .438$). As such, prior knowledge was not included in the subsequent models. Condition was then added to the model and significantly accounted for the variance, ($F(1, 75) = 8.169, p < .01$). The analysis revealed that the contrast between self-explanation and source-evaluation was not
significant ($\beta = .082, t = 1.595, p = .115$). However, the contrast between the cognitive strategies (the average of self-explanation and source-evaluation) and think-aloud was significant ($\beta = .148, t = 2.618, p < .05$), with both cognitive strategies outperforming participants in the think-aloud condition (see Figure 15).

An interaction term between condition and Gates reading skill was then entered in the model, but the results were not significant ($F(2, 75) = 1.059, p = .352$). An additional interaction term for text-order and condition was also entered, but also did not reveal any significant results ($F(2, 75) = .011, p = .989$).

Table 9. Descriptive statistics of memory for source

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-min Break</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>29</td>
<td>0.676</td>
<td>0.117</td>
</tr>
<tr>
<td>No</td>
<td>52</td>
<td>0.583</td>
<td>0.161</td>
</tr>
<tr>
<td>Text Order</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1234</td>
<td>40</td>
<td>0.587</td>
<td>0.240</td>
</tr>
<tr>
<td>4321</td>
<td>41</td>
<td>0.481</td>
<td>0.218</td>
</tr>
<tr>
<td>Strategy Condition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-explanation</td>
<td>29</td>
<td>0.524</td>
<td>0.242</td>
</tr>
<tr>
<td>Source-evaluation</td>
<td>23</td>
<td>0.647</td>
<td>0.223</td>
</tr>
<tr>
<td>Think-aloud</td>
<td>29</td>
<td>0.452</td>
<td>0.202</td>
</tr>
</tbody>
</table>

Figure 14. Memory for source as a function of text order
Figure 15. Memory for source as a function of strategy condition.

Discussion

The present study examined the effects of three different strategies—self-explanation, source-evaluation, and think-aloud—on multiple-document comprehension and inter-textual integration. The purpose of this study was to understand the differential benefits of either strategy at various levels of comprehension assessed through three different question types: text-base, intra-textual inference, and inter-textual inference questions. Two of the three strategies (self-explanation and source-evaluation) were expected to support comprehension and integration whereas think-aloud was included as a control condition. However, the extent to which the two experimental strategies (self-explanation and source-evaluation) might support comprehension and integration was unclear.

There are different theoretical perspectives that would more strongly support the use of one strategy over the other. The Inference model strongly aligns with the benefits of self-explanation for increasing deep connections between text content through the use of prior knowledge. The Document model suggests a strong benefit of source-evaluation such that relevant knowledge is activated when source information is used to distinguish
texts and resolve inconsistencies across texts. The planned multilevel model analyses were conducted to determine which strategy best supports comprehension and integration at each question type.

Self-explanation was expected to best benefit comprehension accuracy for textbase and intra-textual inferencing questions. Further predictions differ as a function of the two theoretical perspectives. The Inference model would suggest greater comprehension for inter-textual questions when readers self-explain as opposed to source-evaluate because readers were prompted to generate inferences and develop deeper comprehension. The Document model, however, would posit that source-evaluation better supports inter-textual comprehension compared to self-explanation because attention to sources helps distinguish text content, which supports the activation of relevant knowledge. Inter-textual integrations were expected to increase at each question type with the lowest number for textbase questions and the highest for inter-textual questions. The Inference model would suggest that individuals that self-explain should consistently produce more integrations across all question types. The Document model would suggest that both self-explanation and source-evaluation perform similarly on intra-textual questions, but that students that source-evaluate will produce more integrations for inter-textual questions.

Neither hypotheses emanating from the two comprehension models (Inference model and Document model) were supported. Performance on textbase questions was higher overall; however, there was no significant interaction between the strategy conditions as a function of question type. The effect of question type only highlighted the difference between performance on textbase question versus the two inference questions.
The literature has repeatedly shown that performance is higher on textbase questions as these types of questions only require information from a single sentence and do not require integrating information across sentences or across texts resulting in greater ease of processing. Regardless, the results are surprising in that there was no effect of condition. This is surprising because of the lack of difference between the two inference questions and the think-aloud condition (which was applied as control condition). Think-aloud does not inherently encourage any specific comprehension or sourcing strategy, hence it was expected that performance on the questions would be especially low for the think-aloud condition.

Furthermore, a lack of power may explain the lack of significant effects of condition, the marginal effect without the individual differences, as well as the opposite effects on the contrasts with the inclusion or exclusion of reading skill. An additional study would need to be conducted with a greater sample to determine whether there is truly a difference between the conditions and if reading skill moderates these effect of condition.

With regards to the integration outcome, neither the hypothesis for the Document model nor the Inference model were supported by the results. Whereas inter-textual questions did present the most integrations across all conditions as expected, the results for textbase and intra-textual questions was more surprising. Participants produced significantly more inter-textual integrations in the inter-textual questions than the intra-textual questions. While these results are expected, the degree of intertextual integration between intra-textual questions and textbase questions did not align with the hypotheses. The hypotheses predicted that textbase questions would have the fewest integrations.
because they only require information from single sentences, whereas intra-textual questions are expected to have some inter-textual integrations as a function of their inferential nature, which require integrating information within a text, potentially prompting students to integrate across texts. The results of this study, however, indicated that participants produced more inter-textual integrations for textbase questions than for intra-textual questions. These results may be partially due to how students’ process textbase questions within the context of a multiple document task with highly related texts. Textbase questions include information from single sentences within a text, but the presence of multiple texts that are highly semantically related could support activation of semantically related information from other texts. An analysis of the texts through a document set analysis revealed that a few cross-text relations exist for the sentences used for text-based questions.

Results relating to the memory for source outcome revealed that both cognitive strategies, self-explanation and source-evaluation, similarly supported memory for sources, above and beyond the think-aloud condition. These results in conjunction with the results for comprehension accuracy and intertextual integration suggest that processing of source information and textual information may be similar for both source-evaluation and self-explanation. Both strategies may tap into similar or related cognitive processes.

**Limitations.** An important limitation to this study may be a lack of sufficient power to detect a significant effect of condition considering that there was a marginal effect of condition on comprehension score when both individual difference measures were included. A subsequent study would need to include more participants in order to
determine the presence of a significant effect when both prior knowledge and Gates reading skill are included.

One potential limitation to this study was due to experimenter error: the supplemental example for the sourcing strategy was incorrectly replaced with the supplemental example for the thinking-aloud strategy. The original and detailed instructions and examples for all three strategies were correct, but the additional example for sourcing that was incorrect. However, these additional examples were only presented in hyperlinked pdfs, thus, it is unclear how many participants viewed these and if this error had a significant impact on participants’ responses.

An additional limitation stems from challenges in coding the integration counts. The comprehension questions from which the comprehension score and integration counts were derived revealed some design limitations during coding. One particular limitation regarding integration was the imperfect attribution of content origin, or the attribution of question response idea units to a specific source. Often, when concepts were more general and lacking in specific keywords uniquely identifiable to one source, then the concepts were grouped as coming from potentially more than one text. As a result, integrations are identified less frequently than they may occur. The coders attempted to isolate the integrations by applying the context of the sentence, however, this still would not fully recognize the extent of integration that may occur. A remedy to this problem would be use texts with zero or minimal overlap and with unique words.

Upon observing individual constructed responses, we identified several similarities between the constructed responses of students in the source-evaluation and self-explanation conditions. Particularly that source-evaluations often included some type
of self-explanation strategy whether in the form of a paraphrase or even more advanced strategies such as bridging (combining information across sentences) as well as elaborations (linking textual information to prior knowledge). As such, source-evaluation evidently invited some self-explanation; hence the two may not have been sufficiently distinct strategies, rendering it difficult to assess which strategy best supported comprehension and integration. Previous research with source-evaluations have also included some form of reasoning or strategy similar to self-explanations; therefore, it is possible that the results here may suggest that the presence of self-explanation strategies are most beneficial. However, further research would need to be conducted to compare self-explanation source-evaluation as presented in this study, and a source-evaluation condition absent of any self-explanation or reasoning strategies in order to determine what aspect of source-evaluation or self-explanation best supports comprehension and integration.

**Conclusion.** The two theoretical perspectives were not applied here in a competing manner, but instead were used to invite a deeper understanding of the integration and comprehension process involved in reading multiple texts. There are strong societal demands for comprehending information from multiple sources, integrating information, and developing coherent representations of combined sources. Individuals need to be able to read and integrate information from multiple sources in several aspects of life; including success in education and careers, as well as for daily activities such as making sense of a social media feed. Multiple document comprehension is challenging for readers and as such is an aspect of literacy addressed in education. Researchers continually endeavor to understand the processes involved in multiple
document comprehension as well as explore ways that readers can improve their comprehension. While the results supported neither of the models, this study still has important implications for education and comprehension research. Recognizing that there is no significant difference between self-explanation and source-evaluation suggests that both strategies are likely similar in structure and in cognitive impact. Future analyses and studies could assess in depth the type of strategies applied in each condition during reading. This could further inform on the structure of constructed responses as well as the type of content that students prioritize in their constructed responses. Such analysis may reveal why self-explanation and source-evaluation yielded such similar results.
References


Bråten, I., Anmarkrud, Ø., Brandmo, C., & Strømsø, H. I. (2014). Developing and testing a model of direct and indirect relationships between individual differences, processing, and multiple-text comprehension. Learning and Instruction, 30, 9-24.


Bråten, I., Strømsø, H. I., & Salmerón, L. (2011). Trust and mistrust when students read multiple information sources about climate change. Learning and Instruction, 21(2), 180-192.


1. Please enter the subject number given to you by the experimenter.

Please answer the following questions as completely and honestly as possible. All of your responses will be confidential.

2. I am a ...
   a) Male
   b) Female

3. What is your ethnicity?
   a) African American
   b) Caucasian
   c) Hispanic (Latin American)
   d) Asian
   e) Other

4. Is English your first language?
   a) Yes
   b) No

Skip To: Question 11 If “Is English your first language? = Yes”

5. What is your native language?

6. How many years have you been studying English?
   a) less than 1 year
   b) 1 year
   c) 2 years
   d) 3 years
   e) 4 years
   f) 5 years
   g) 6 years
   h) 7 or more years

7. Please list the languages you have studied. (enter N/A for unneeded answer spaces)
   1
   2
   3
   4
   5

8. Please list the languages that you speak. (enter N/A for unneeded answer spaces)
   1
   2
9. What types of texts do you generally write in English?
Please check all that apply.
☐ E-mails
☐ Letters
☐ Notes
☐ Essays
☐ Research Papers
☐ Reports
☐ Creative Writing
☐ Other ________________________________________________

10. Do you like writing in English?
   a) I don't like it at all
   b) I don't like it
   c) I have no feelings about it
   d) I like it
   e) I like it a lot

11. I am in my _______ year of college.
    a) 1
    b) 2
    c) 3
    d) 4+

12. My GPA is ...
    a) 1.0(65%) or below
    b) 1.1(66%) - 1.5 (70%)
    c) 1.6 (71%) - 2.0 (75%)
    d) 2.1 (76%) - 2.5 (80%)
    e) 2.6 (81%) - 3.0 (85%)
    f) 3.1 (86%) - 3.5 (90%)
    g) 3.6 (91%) or above
APPENDIX B

GENERAL SCIENCE AND HISTORY PRIOR KNOWLEDGE QUESTIONNAIRE
1. The edible part of the sweet potato is the
   a. stem tissue.
   b. root tissue.
   c. fruit.
   d. seed.
   
   Correct answer B (science 1)

2. The ancient Romans’ most significant contribution to Europe has been in the area of
   a. economics.
   b. poetry.
   c. drama.
   d. law.
   
   Correct answer D (History 1)

3. Which represents a chemical change in matter?
   a. a metal beginning to rust
   b. water dissolving salt to form a solution
   c. water undergoing evaporation
   d. carbon dioxide undergoing sublimation
   
  Correct answer A (science 2)

4. The poisons produced by some bacteria are called
   a. antibiotics.
   b. toxins.
   c. pathogens.
   d. oncogenes.
   
   Correct answer B (science 3)
5. The writers and philosophers of the Enlightenment believed the government decisions should be based on

   a. fundamental religious beliefs.
   b. the concept of divine right of kings.
   c. laws of nature and reason.
   d. traditional values.

   Correct answer C (History 2)

6. An acidic solution could have a pH of

   a. 7.
   b. 10.
   c. 3.
   d. 14.

   Correct answer C (Science 4)

7. In the Soviet Union, a negative aspect of the Cold War Era was the

   a. attempt to preserve democratic ideals.
   b. development of peaceful uses for modern technology.
   c. development of effective means of international cooperation.
   d. high cost of maintaining the arms race.

   Correct answer D (History 3)

8. Which of the following tissues produces voluntary body movements?

   a. skeletal muscle
   b. cardiac muscle
   c. smooth muscle
   d. fibrous connective tissue

   Correct answer A (Science 5)

9. Which statement best describes a characteristic of the Renaissance in Europe?

   a. The social structure became very rigid.
   b. Creativity in the arts was encouraged.
   c. The political structure was similar to that of the Roman Empire.
   d. Humanism decreased in importance.

   Correct answer B (History 4)
10. Which of these causes ocean tides on Earth?
   a. the gravitational pull of the moon
   b. the revolution of the Earth around the sun
   c. differences in wind speed around the Earth
   d. the tilt of the Earth’s axis

   Correct answer A (Science 6)

11. Which of these is a compound?
   a. oxygen in the air
   b. liquid nitrogen
   c. neon in lights
   d. carbon dioxide gas

   Correct answer D (Science 7)

12. The American Revolution was primarily motivated by
   a. land disputes between France and England.
   b. taxation without representation.
   c. the confrontation at the Alamo.
   d. a decline in the price of cotton.

   Correct answer B (History 5)

13. A painter who was also knowledgeable about mathematics, geology, music, and engineering was
   a. Michelangelo.
   b. Cellini.
   c. Titian.
   d. da Vinci.

   Correct answer D (History 6)

14. Blood is supplied to the heart wall by the
   a. hepatic portal vein.
   b. coronary arteries.
   c. auricular artery.
   d. coronary veins.

   Correct answer B (Science 8)
15. One important result of the French Revolution was that

a. France enjoyed a lengthy period of peace and prosperity.
b. the church was restored to its former role and power in the French government.
c. political power shifted to the bourgeoisie.
d. France lost its spirit of nationalism.

Correct answer C (History 7)

16. From the following lists of states, which state was the last state to join the union?

a. Tennessee
b. Florida
c. New York
d. Missouri

Correct answer B (History 8)

17. According to the protoplanet hypothesis, the solar system began as which of the following?

a. a star
b. a vacuum
c. a huge cloud of dust and gas
d. a group of comets

Correct answer C (Science 9)

18. The first successful colonial settlement in the United States was located in

a. Salem, Massachusetts.
b. Roanoke, North Carolina.
c. Plymouth, Massachusetts.
d. Jamestown, Virginia.

Correct answer D (History 9)

19. Which of these has a positive charge and is found in the nucleus of an atom?

a. neutrons
b. protons
c. electrons
d. elements

Correct answer B (Science 10)
20. In the 1920’s and 1930’s, the rise of totalitarian governments in Germany, Italy, and Spain was largely the result of

a. the success of the Communists in establishing a command economy in the Soviet Union.
b. severe economic and social problems that arose in Europe after World War I.
c. the active support of the United States.
d. movements demanding the return of the old monarchies.

Correct answer B (History 10)

21. Both plants and animals need water to live. What common purpose does water serve for plants and animals?
   a. Both use water for cooling
   b. Both get their energy from water
   c. Both use water to transport nutrients
   d. Both extract hydrogen and oxygen from water

Correct answer C (Science 11)

22. Ants are in the same order as wasps, but not in the same order as butterflies because ants are ___.
   a. Comparable in size to wasps
   b. Able to eat the same things as wasps
   c. Related structurally to wasps
   d. Found in the same environments as wasps

Correct answer C (Science 12)

23. Which biomes are similar in temperatures?
   a. Tundra and desert
   b. Boreal forest and tundra
   c. Desert and grassland
   d. Grassland and deciduous forest

Correct answer D (Science 13)

24. A part of a neuron that carries nerve impulses toward the cell body is called:
   a. a nerve.
   b. a neurotransmitter.
   c. a dendrite.
   d. an axon.

Correct answer C (Science 14)
APPENDIX C

CLIMATE CHANGE TOPIC KNOWLEDGE QUESTIONNAIRE
1. What was agreed to in the “Paris Agreement” that came out of COP-21, held in Paris in 2015?
   a. to protect biodiversity and end the deforestation of the world’s rainforests
   b. to keep global temperature rise well below 2°C pre-industrial levels and to pursue a path to limit warming to 1.5°C
   c. to limit sea level rise to 3 feet above current levels
   d. to pursue a goal of 100% clean, renewable energy

Correct Answer B (External 1)

2. Which of these countries emits the most carbon dioxide?
   a. China
   b. USA
   c. UK
   d. Russia

Correct Answer A (External 2)

3. What percentage of the global greenhouse gas emissions does the transportation sector emit?
   a. 1%
   b. 14%
   c. 33%
   d. 70%

Correct Answer B (External 3)

4. Globally, which of the following economic sectors emits the largest percentage of greenhouse gas emissions?
   a. transportation
   b. buildings
   c. industry
   d. electricity and heat production

Correct Answer D (External 4)

5. What is the biggest source of greenhouse gas emissions in the United States?
   a. farming logging and manufacturing
   b. heating and cooling buildings
   c. producing electricity
   d. using transportation

Correct Answer C (External 5)

6. Which state has the highest energy-related carbon dioxide emissions per capita?
   a. Florida
b. North Dakota
c. Wyoming
d. California

Correct Answer C (External 6)

7. During the 2015 United Nations Climate Change Conference in Paris, how many countries committed to doubling clean energy research and development?
   a. 76
   b. 195
   c. 20
   d. 12

Correct Answer C (External 7)

8. What does carbon intensity measure?
   a. carbon dioxide produced per dollar of gross domestic product
   b. carbon dioxide produced per electrical charge
   c. carbon dioxide produced per kilowatt hour
   d. carbon dioxide produced per british thermal unit of energy

Correct Answer A (External 8)

9. The Kyoto Protocol deals with
   a. trade agreements between rich and poor countries
   b. reduction in the discharge of climate gases
   c. the pollution of the Pacific Ocean
   d. protection of the ozone layer

Correct Answer B (Braasch 1)

10. The earth’s climate has changed
    a. due to astronomical conditions
    b. primarily due to increased discharges of ozone gas
    c. due to reduced discharges of ozone gas
    d. because the ocean currents have increased in intensity

Correct Answer A (Braasch 2)

11. The concentration of carbon dioxide (CO₂) in the atmosphere
    a. varies very little from place to place
    b. is greatest in industrialized parts of the world
    c. is greatest in the polar regions
    d. varies a lot from place to place
Correct Answer A (Braasch 3)

12. Global climate change can
   a. lead to a lowering of ocean levels
   b. lead to less extreme weather on the entire earth
   c. influence ocean currents
   d. lead to more solar energy escaping from the atmosphere

Correct Answer C (Braasch 4)

13. Mankind’s discharges of carbon dioxide (CO₂)
   a. can lead to an increase in the ozone layer
   b. are necessary for the life on the earth
   c. can change the heat balance of the earth
   d. introduce into the atmosphere the largest part of the climate gases

Correct Answer C (Braasch 5)

14. The Kyoto Protocol is
   a. a binding agreement between USA and EU
   b. a binding international agreement managed by the UN
   c. ratified by all the large industrialised countries
   d. an important agreement about the storing of radioactive waste

Correct Answer B (Braasch 6)

15. Global climate change can lead to
   a. more cultivable land in desert areas
   b. smaller differences in farm production between different areas of the world
   c. more stable conditions for farming in exposed coastal areas
   d. larger differences in farm production between different areas of the world

Correct Answer D (Braasch 7)
The earth’s climate has always changed over time. Such climate changes have until recently had natural causes such as changes in the strength of the sun, changes in the earth’s orbit around the sun, and volcanic eruptions. It now appears that for the first time mankind is facing a global climate change caused by its own activities.

The greenhouse effect is primarily a natural and necessary process. The sun has a surface temperature of approximately 6,000 °C and emits various kinds of radiation. Half of the sunrays that hit the earth’s atmosphere penetrate down to the surface of the earth, the rest are reflected by clouds and other gases. Most of the sunrays that reach the earth have short wavelengths. They warm the surface of the earth, which sends back long wavelength streams of heat. A large proportion of these streams returned from the earth are absorbed by the clouds and the gases in the atmosphere, which then send the radiated heat back to us.

Some of these gases in the atmosphere are called climate gases. The most important climate gases are water vapour, carbon dioxide and methane. They form a heat shield that slows down the radiation of heat from the earth. This results in the surface of the earth and the air layer being heated up. This is the same that takes place in a greenhouse where sunlight penetrates the glass panes, but radiated heat is restrained on its way out. The result is that the greenhouse is warmer than its surroundings. Without this natural greenhouse effect the average temperature on earth would be -18 °C instead of the 15 °C it is today.

In recent times, climate researchers have found that the earth’s average temperature rose by approximately 0.5 °C between 1850 and 2004. From around 1900 until the present day the level of carbon dioxide in the air has increased from less than 0.03% to almost 0.04%, and it appears that this increase is continuing. This is due to the fact that we have increased our discharges of CO2 into the atmosphere through the burning of large quantities of oil, gas and coal.

Human activities have also resulted in increased discharges of other climate gases. This can result in more of the heat being stopped from escaping from the earth and the average temperature rising even more.
The UN’s climate panel concludes in its third main report from 2001 that it is highly probable that manmade discharges of climate gases have contributed significantly to the climate changes observed in the last 30 to 50 years.

Since pre-industrial times (around 1750) the concentration of carbon dioxide (CO2) has increased by around 31 per cent, the concentration of methane (CH4) has increased by around 151 percent and the concentration of nitrogen oxide (N2O) has increased by around 17 percent. These increases are due to manmade discharges and have resulted in a stronger greenhouse effect. Human activities have also introduced into the atmosphere smaller quantities of a number of climate gases that do not exist in the atmosphere naturally.

The increase in the concentration of CO2 in the atmosphere forms the primary constituent (around 60%) of the strengthening of the greenhouse effect for which mankind is responsible. These manmade discharges of CO2 are first and foremost due to the consumption of fossil fuels (coal, oil and gas) and the deforestation of tropical regions.

Mankind’s discharges amount to only a small part of the quantity of climate gases released into the atmosphere and the effect is minor in relation to, for example, the effect of naturally occurring water vapour. The problem is that the climate system is very complex and sensitive, and even small changes in the system can trigger major consequences. Nature’s own discharges of climate gases form part of a cycle in which, for example, rotting trees release CO2 and living trees absorb CO2 through photosynthesis. Our CO2 discharges from, among other things, the burning of fossil fuels do not form part of this cycle and result in surplus CO2 which remains in the atmosphere for a long time.
Stronger storms, more hurricanes and increasingly tumultuous weather are just a few of the negative consequences we can expect in the next few years. Global warming may also weaken the Gulf Stream and result in serious cooling in Northern Europe.

A number of oceanographers fear highly uncomfortable side effects due to global warming. It may weaken the ocean currents in the North Atlantic to such a degree that there is a genuine risk of serious and long-term cooling both in the Nordic Region and large parts of Europe and North America. The Nordic Region would be significantly colder without the Gulf Stream.

Oceanographers know all to well that the warnings will cause surprise because we are reminded almost daily of the opposite, namely that global warming will raise the earth’s average temperature. However, paradoxically, both things could well occur at the same time. If the circulation of the Atlantic is disturbed, we could have a fall in the average temperature of 3-5 °C. This will have a dramatic effect on farming and forestry, while at the same time there will be a greater need for heating.

And there is much that indicates that the disturbances are well underway. More ice is melting due to global warming and more precipitation is falling over Russia, among other places. This is resulting in greater outward flows of freshwater from the major Russian rivers into the Arctic Ocean. At the same time, we risk losing the Western Arctic ice and Greenland ice.

When the ice surrounding the poles melts, this will not just result in an increased mass of water, it will also result in increased evaporation from the oceans. This will provide hurricanes with energy. Time magazine reports that hurricanes have increased in both number and intensity since 1995.

According to the UN’s climate panel, an increased greenhouse effect resulted in water levels rising between 10 and 20 cm in the last century and by 2100 ocean levels will rise by between 9 and 88 cm. This will be catastrophic for many coastal communities – especially in developing countries.
Regions that are now becoming accessible due to global warming conceal enormous riches. The melting of the ice permits the exploitation of resources in the northerly regions.

Temperatures around the North Pole are increasing at double the rate of other places around the globe according to UN experts. The Arctic ice is melting so quickly that a sea passage between the Atlantic Ocean and the Pacific Ocean may be accessible to ordinary ships during the summer by 2050. The route through the Northwest Passage to Asia will reduce the journey distance between London and Tokyo from 21,000 to 16,000 kilometres.

The northerly regions that are becoming accessible also conceal enormous riches. The oil and gas deposits that are concealed there are estimated to amount to 30 per cent of the earth’s deposits.

And there is more to be found in the northerly regions than petroleum. There is also gold, diamonds, copper and zinc. There will be a lot of traffic due to such exploration says Frederic Lasserre, a geographer at Laval University in Quebec in Canada who is a specialist in Arctic regions.

The director of the Nansen Environmental and Remote Sensing Center, also points out positive consequences of global warming, which occurs in the Arctic in particular: A warmer climate could result in better growing conditions and lower heating costs. The ice in the Barents Sea will be pushed northwards and eastwards due to increasing south-westerly winds and warmer weather. This will expand winter fishing grounds and make it easier for the gas and oil industry to operate during the winter season.
APPENDIX E

PROMPTS FOR CONSTRUCTED RESPONSES
<table>
<thead>
<tr>
<th>Think-Aloud</th>
<th>Self-Explain</th>
<th>Source Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>You will now be asked to read these texts. After you read, your understanding will be assessed with comprehension questions. One way to help us learn how you read is to think-aloud. To help you with this task, we would like you to report your thoughts about the text while you read. Please report your thoughts that immediately come to mind regarding how you understand the meaning of the text. After some sentences, which are bolded, there is a blank box. In the space provided below the bolded segment, please read the text, and then write any thoughts that immediately come to mind. Please note that there are no &quot;right&quot; or &quot;wrong&quot; thoughts.</td>
<td>You will now be asked to read these texts. After you read, your understanding will be assessed with comprehension questions. One way to improve your comprehension is to self-explain. To help you with this task, we would like you to provide your own self-explanations of the text while you read. Please explain the meaning of the text, elaborating beyond your initial understanding of the text. After some sentences, which are bolded, there is a blank box. In the space provided below the bolded segment, please read the text, and then write your explanation for the meaning of the text. Please note that there are no &quot;right&quot; or &quot;wrong&quot; self-explanations.</td>
<td>You will now be asked to read these texts. After you read, your understanding will be assessed with comprehension questions. One way to improve your comprehension is to evaluate sources. To help you with this task, we would like you to reflect on the source (i.e., author, publication date/location, audience) of the text while you read. Please report your thoughts regarding how the source impacts the meaning of the text. After some sentences, which are bolded, there is a blank box. In the space provided below the bolded segment, please read the text, and then write your evaluation of the source. Please note that there are no &quot;right&quot; or &quot;wrong&quot; evaluations.</td>
</tr>
<tr>
<td>Here is an example from a student:</td>
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</tr>
<tr>
<td>Text Segment: Because long-distance food shipments promote fuel use and the exploitation of cheap labor, shifting back to a more locally sourced food economy is often touted as a fairly straightforward way to cut externalities, restore some measure of equity between producers and consumers, and put the food economy on a more sustainable footing.</td>
<td></td>
<td>Text Segment: Because long-distance food shipments promote fuel use and the exploitation of cheap labor, shifting back to a more locally sourced food economy is often touted as a fairly straightforward way to cut externalities, restore some measure of equity between producers and consumers, and put the food economy on a more sustainable footing.</td>
</tr>
<tr>
<td>Self-Explanation:</td>
<td></td>
<td>Source-Evaluation:</td>
</tr>
<tr>
<td>Think-Aloud:</td>
<td>&quot;This sentence is saying eating food that is not produced locally is more expensive and that eating locally might actually reduce some costs and make the economy more sustainable. This makes sense since we spend so much money to get food shipped halfway around the world, when we could try to rely on closer food sources.&quot;</td>
<td>&quot;This sentence argues that eating food that comes from far away is problematic and that eating locally sourced is better, but the title of the book is The End of Food, so maybe the author is just being sarcastic or preparing an argument against eating local.&quot;</td>
</tr>
</tbody>
</table>

You can see that a think-aloud doesn’t just restate the passage. It includes everything that comes to your mind. You can type anything that you think about the sentence as you read.

You can see that an self-explanation doesn’t just restate the passage. It explains what the passage means. You can use anything you know about the information in the sentence to explain it.

You can see that a source evaluation doesn’t just restate the passage. It considers how the source might impact what the passage means. You can use anything you know about the source and the sentence to evaluate it.

Example 2

<table>
<thead>
<tr>
<th>Source Information:</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Title: On My Mind: The Locavore Myth Author(s): James E. McWilliams, PhD History Source: Article published in Forbes Magazine Date: July 15, 2009</td>
<td>Title: On My Mind: The Locavore Myth Author(s): James E. McWilliams, PhD History Source: Article published in Forbes Magazine Date: July 15, 2009</td>
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<td>Text Segment: Buy local, shrink the distance food travels, save the planet. But by focusing on transportation, people overlook other energy-hogging factors in food production. Take lamb. A 2006 academic study discovered that it made more environmental sense for a Londoner to buy lamb shipped from New Zealand than to buy lamb raised in the U.K.</td>
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</tr>
<tr>
<td>Think-Aloud: &quot;I like this study, I wouldn’t think it would be cheaper to ship from New Zealand than purchase closer to home.&quot;</td>
<td>Self-Explanation: &quot;If someone lives in London it makes more sense for them to buy lamb shipped from New Zealand than produced in the UK. This might be because</td>
<td>Source-Evaluation: &quot;Both the article and study were published 10 years ago, but the article might still provide accurate information on the topic.&quot;</td>
</tr>
</tbody>
</table>
You can see that a think-aloud doesn’t just restate the passage. This student is evaluating and reasoning about what the sentence means.

You can see that a self-explanation doesn’t just restate the passage. This example is considering the information from the study in order to make a connection to transportation costs.

You can see that a source evaluation doesn’t just restate the passage. It considers how the source, in this case the article’s date, might impact the information in the passage.

### Example 3

<table>
<thead>
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</tr>
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<tbody>
<tr>
<td><strong>Title:</strong> 10 Reasons to Eat Local Food.</td>
</tr>
<tr>
<td><strong>Author(s):</strong> Jennifer Maiser, advocate for local food</td>
</tr>
<tr>
<td><strong>Source:</strong> A weblog called Eat Local Challenge</td>
</tr>
<tr>
<td><strong>Date:</strong> December 16, 2009</td>
</tr>
</tbody>
</table>

<table>
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<th>Text Segment:</th>
</tr>
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<tbody>
<tr>
<td>Locally grown produce is fresher. While produce that is purchased in the supermarket or a big-box store has been in transit or cold-stored for days or weeks, produce that you purchase at your local farmer’s market has often been picked within 24 hours of your purchase. This freshness not only affects the taste of your food, but the nutritional value, which declines with time.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Think-Aloud:</th>
</tr>
</thead>
<tbody>
<tr>
<td>“I always try to eat my produce while it’s fresh. That’s why I shop two or three times a week.”</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Self-Explanation:</th>
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</thead>
<tbody>
<tr>
<td>“This is trying to say that produce with the most nutritional value is the kind that was harvested the most recently, which you can get at a farmer’s market, but maybe not at a local supermarket. This makes sense since the food I’ve gotten has always seemed more fresh than when I buy it at the store.”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source-Evaluation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>“This is a weblog, so I'm not sure if the information was verified as accurate. I am not sure how truthful this information can be.”</td>
</tr>
</tbody>
</table>
You can see that a think-aloud doesn’t just restate the passage. In this one, the student is thinking about what they normally do as it relates to the sentence.

Source Information:
Title: Plenty: One Man, One Woman, and a Raucous Year of Eating Locally
Author(s): creators of 100-mile diet: Alisa Smith and J. B. MacKinnon
Source: Book published in New York by Harmony
Date: 2007

Text Segment:
Food begins to lose nutrition as soon as it is harvested. Fruit and vegetables that travel shorter distances are therefore likely to be closer to a maximum of nutrition.

Yet when I called to confirm these facts with Marion Nestle, a professor and former chair of nutrition, food studies, and public health at New York University, she waved away the nutrition issue as a red herring. Yes, she said, our 100-mile diet—even in winter—was almost certainly more nutritious than what the average American was eating.

Think-Aloud:
"A 100-mile diet sounds interesting, could be fun to try to eat only local food."

You can see that an self-explanation doesn’t just restate the passage. In this one, the student is connecting ideas in the text while also connecting the information to their own experiences.

Source Information:
Title: Plenty: One Man, One Woman, and a Raucous Year of Eating Locally
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Self-Explanation:
"So this is trying to say that eating local might be more nutritious, but the professor treated the nutrition issue as a red herring, meaning it shouldn’t really matter. So maybe this means the difference is negligible."

You can see that a source evaluation doesn’t just restate the passage. It considers how the publication venue might impact how trustworthy the passage is.

Source Information:
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Source-Evaluation:
"This is a book written by the creators of the 100-mile diet, which means this article might try to advertise their dieting style."
<table>
<thead>
<tr>
<th>You can see that a think-aloud doesn’t just restate the passage. This example includes a thought about trying something the text talks about. Remember, you can type anything that you think about the sentence as you read.</th>
<th>You can see that an self-explanation doesn’t just restate the passage. This example is trying to connect information to come to an understanding about what the text actually means. Remember, you can use anything you know about the information in the sentence to explain it.</th>
<th>You can see that a source evaluation doesn’t just restate the passage. It considers how the author’s goal might impact how the passage is written. Remember, you can use anything you know about the source and the sentence to evaluate it.</th>
</tr>
</thead>
<tbody>
<tr>
<td>You will now be asked to write your own think-aloud statements for each of the target segments within the text. Please respond to the text segments in the order in which they are presented.</td>
<td>You will now be asked to write your own self-explanations for each of the target segments within the text. Please respond to the text segments in the order in which they are presented.</td>
<td>You will now be asked to write your own source evaluations for each of the target segments within the text. Please respond to the text segments in the order in which they are presented.</td>
</tr>
</tbody>
</table>
APPENDIX F

CLIMATE CHANGE COMPREHENSION QUESTIONS
Questions Text 1: Natural and Manmade Causes
1) Textbase Question:
   Name 2 specific climate gases that exist in the atmosphere.

2) Intra-textual Question:
   Explain how climate gases form a heat shield to slow down the radiation of heat from earth?

3) Inter-textual Question:
   Describe how the climate gases have changed since pre-industrial times?

Questions Text 2: Manmade Causes
1) Textbase Question:
   What have manmade discharges done to the greenhouse effect?

2) Intra-textual Question:
   How do nature’s discharges of CO2 and manmade discharges CO2 differ in how they are produced?

3) Inter-textual Question:
   Explain how a stronger greenhouse effect can trigger major negative weather consequences?

Questions Text 3: Cooling in the Atlantic
1) Textbase Question:
   What happens to temperature when the circulation of the Atlantic is disturbed?

2) Intra-textual Question:
   Explain why and how global warming can cause dramatic effects on farming and forestry?

3) Inter-textual Question:
   Explain how negative effects on forestry potentially affect the climate system’s natural cycle.

Questions Text 4: Natural Resources of the North
1) Textbase Question
   Name 2 resources that are being found in the Northern Regions as a result of global warming?

2) Intra-textual Question:
   Name 2 reasons why the oil industries are benefiting from global warming.

3) Inter-textual Question:
   Explain how increased operations of oil industries in the Arctic could be problematic for Northern Europe’s climate.
APPENDIX G

SHORTENED INSTRUCTIONS FOR CONSTRUCTED RESPONSES
Instructions for writing self-explanations

We would like you to provide your own self-explanations of the text while you read. Please explain the meaning of the text, elaborating beyond your initial understanding of the text. After some sentences, which are bolded, there is a blank box. In the space provided below the bolded segment, please read the text, and then write your explanation for the meaning of the text. Please note that there are no "right" or "wrong" self-explanations.

Here is an example from a student:

Source Information:
Title: The End of Food
Author(s): Paul Roberts, Writer of resource economics and politics
Source: Book about the food industry published by Houghton Mifflin Harcourt in New York.
Date: January 13, 2009

Text Segment:

Because long-distance food shipments promote fuel use and the exploitation of cheap labor, shifting back to a more locally sourced food economy is often touted as a fairly straightforward way to cut externalities, restore some measure of equity between producers and consumers, and put the food economy on a more sustainable footing.

Self-Explanation:

"This sentence is saying eating food that is not produced locally is more expensive and that eating locally might actually reduce some costs and make the economy more sustainable. This makes sense since we spend so much money to get food shipped halfway around the world, when we could try to rely on closer food sources."

You can see that an self-explanation doesn’t just restate the passage. It explains what the passage means. You can use anything you know about the information in the sentence to explain it.
APPENDIX H
MEMORY FOR SOURCE ITEMS
<table>
<thead>
<tr>
<th>Item name</th>
<th>Text</th>
<th>Sentence</th>
<th>Target Sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS1</td>
<td>4</td>
<td>The director of the Nansen Environmental and Remote Sensing Center, also points out positive consequences of global warming, which occurs in the Arctic in particular: A warmer climate could result in better growing conditions and lower heating costs.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS2</td>
<td>1</td>
<td>They form a heat shield that slows down the radiation of heat from the earth.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS3</td>
<td>3</td>
<td>Oceanographers know all to well that the warnings will cause surprise because we are reminded almost daily of the opposite, namely that global warming will raise the earth’s average temperature.</td>
<td>No</td>
</tr>
<tr>
<td>MS4</td>
<td>1</td>
<td>Some of these gases in the atmosphere are called climate gases.</td>
<td>No</td>
</tr>
<tr>
<td>MS5</td>
<td>1</td>
<td>The result is that the greenhouse is warmer than its surroundings.</td>
<td>No</td>
</tr>
<tr>
<td>MS6</td>
<td>2</td>
<td>Nature’s own discharges of climate gases form part of a cycle in which, for example, rotting trees release CO$_2$ and living trees absorb CO$_2$ through photosynthesis.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS7</td>
<td>4</td>
<td>There will be a lot of traffic due to such exploration says Frederic Lasserre, a geographer at Laval University in Quebec in Canada who is a specialist in Arctic regions.</td>
<td>No</td>
</tr>
<tr>
<td>MS8</td>
<td>1</td>
<td>The most important climate gases are water vapour, carbon dioxide and methane.</td>
<td>No</td>
</tr>
<tr>
<td>MS9</td>
<td>1</td>
<td>The sun has a surface temperature of approx. 6,000 °C and emits various kinds of radiation.</td>
<td>No</td>
</tr>
<tr>
<td>MS10</td>
<td>1</td>
<td>This can result in more of the heat being stopped from escaping from the earth and the average temperature rising even more.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS11</td>
<td>3</td>
<td>When the ice surrounding the poles melts, this will not just result in an increased mass of water, it will also result in increased evaporation from the oceans.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS12</td>
<td>2</td>
<td>These increases are due to manmade discharges and have resulted in a stronger greenhouse effect.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS13</td>
<td>1</td>
<td>This is due to the fact that we have increased our discharges of CO$_2$ into the atmosphere through the burning of large quantities of oil, gas and coal.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS14</td>
<td>2</td>
<td>Human activities have also introduced into the atmosphere smaller quantities of a number of climate gases that do not exist in the atmosphere naturally.</td>
<td>No</td>
</tr>
<tr>
<td>MS15</td>
<td>1</td>
<td>Half of the sunrays that hit the earth’s atmosphere penetrate down to the surface of the earth, the rest are reflected by clouds and other gases.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS16</td>
<td>3</td>
<td>Stronger storms, more hurricanes and increasingly tumultuous weather are just a few of the negative consequences we can expect in the next few years.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS17</td>
<td>2</td>
<td>These manmade discharges of CO₂ are first and foremost due to the consumption of fossil fuels (coal, oil and gas) and the deforestation of tropical regions.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS18</td>
<td>4</td>
<td>There is also gold, diamonds, copper and zinc.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS19</td>
<td>4</td>
<td>The northerly regions that are becoming accessible also conceal enormous riches.</td>
<td>No</td>
</tr>
<tr>
<td>MS20</td>
<td>4</td>
<td>Temperatures around the North Pole are increasing at double the rate of other places around the globe according to UN experts.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS21</td>
<td>4</td>
<td>The melting of the ice permits the exploitation of resources in the northerly regions.</td>
<td>No</td>
</tr>
<tr>
<td>MS22</td>
<td>4</td>
<td>The route through the Northwest Passage to Asia will reduce the journey distance between London and Tokyo from 21,000 to 16,000 kilometres.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS23</td>
<td>3</td>
<td>Global warming may also weaken the Gulf Stream and result in serious cooling in Northern Europe.</td>
<td>No</td>
</tr>
<tr>
<td>MS24</td>
<td>2</td>
<td>Mankind’s discharges amount to only a small part of the quantity of climate gases released into the atmosphere and the effect is minor in relation to, for example, the effect of naturally occurring water vapour.</td>
<td>No</td>
</tr>
<tr>
<td>MS25</td>
<td>3</td>
<td>If the circulation of the Atlantic is disturbed, we could have a fall in the average temperature of 3-5 °C.</td>
<td>No</td>
</tr>
<tr>
<td>MS26</td>
<td>2</td>
<td>The increase in the concentration of CO₂ in the atmosphere forms the primary constituent (around 60%) of the strengthening of the greenhouse effect for which mankind is responsible.</td>
<td>No</td>
</tr>
<tr>
<td>MS27</td>
<td>3</td>
<td>However, paradoxically, both things could well occur at the same time.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS28</td>
<td>1</td>
<td>A large proportion of these streams returned from the earth are absorbed by the clouds and the gases in the atmosphere, which then send the radiated heat back to us.</td>
<td>Yes</td>
</tr>
<tr>
<td>MS29</td>
<td>3</td>
<td>A number of oceanographers fear highly uncomfortable side effects due to global warming.</td>
<td>No</td>
</tr>
<tr>
<td>MS30</td>
<td>4</td>
<td>The Arctic ice is melting so quickly that a sea passage between the Atlantic Ocean and the Pacific Ocean may be accessible to ordinary ships during the summer by 2050.</td>
<td>No</td>
</tr>
<tr>
<td>MS31</td>
<td>2</td>
<td>The problem is that the climate system is very complex and sensitive, and even small changes in the system can trigger major consequences.</td>
<td>No</td>
</tr>
<tr>
<td>MS32</td>
<td>3</td>
<td>According to the UN’s climate panel, an increased greenhouse effect resulted in water levels rising between 10 and 20 cm in the last century and by 2100 ocean levels will rise by between 9 and 88 cm.</td>
<td>Yes</td>
</tr>
</tbody>
</table>
APPENDIX I

RUBRIC: CLIMATE CHANGE COMPREHENSION QUESTIONS
<table>
<thead>
<tr>
<th>Question</th>
<th>Scoring</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1_Q1: Name 2 specific climate gases that exist in the atmosphere.</td>
<td>1</td>
<td>Provides 2 of the 3: water vapor (H2O), carbon dioxide (CO2) and methane (CH4). &gt; Give points for other greenhouse gases not listed in the texts: Nitrous oxide (N2O), Ozone (O3), Chlorofluorocarbons (CFCs), and Hydrofluorocarbons (includes HCFCs and HFCs).</td>
</tr>
<tr>
<td>Text-base</td>
<td>0.5</td>
<td>Only provides 1 climate gas.</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Provides no answer, is nonsensical, or unrelated.</td>
</tr>
<tr>
<td>T1_Q2: Explain how climate gases form a heat shield to slow down the</td>
<td>1</td>
<td>Response must mention &quot;waves&quot; and how the climate gases absorb/capture the sunrays rebounding from earth, which in turn sends radiated heat back to earth.</td>
</tr>
<tr>
<td>radiation of heat from the earth?</td>
<td></td>
<td>OR must provide a detailed explanation of the process: &gt; Mentions &quot;bounce off the earth&quot;, &quot;trapped under the shield&quot;, &quot;heats the atmosphere&quot;. OR Makes a clear and relevant distinction between long and short wavelengths.</td>
</tr>
<tr>
<td>Intra-textual</td>
<td>0.5</td>
<td>Mentions how a heat shield stops, slows or prevents the escape of &quot;sunrays&quot; or &quot;heat&quot; from the earth's surface: &gt; Captures/traps heat/heat radiation/sunrays in the atmosphere. When the direction of the radiation is not specified, give the benefit of the doubt.</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Provides no answer, is nonsensical, or unrelated. OR just states &quot;it's like a greenhouse&quot;. OR clearly states the opposite: That the heat shield would prevent rays from reaching the earth's surface.</td>
</tr>
<tr>
<td>T1_Q3: Describe how the climate gases have changed since pre-industrial</td>
<td>1</td>
<td>Answer needs to state that 1) the climate gases have increased and 2) due to increased burning of fossil fuels/oil, gas, and coal OR 2) give specific approximations of how much gases have increased OR 2) states that these gases are in excess of what the natural cycle can handle.</td>
</tr>
<tr>
<td>times?</td>
<td>0.5</td>
<td>Only states that gases have increased. Mentions that gas levels have increased because of human activities, or nonrenewable resources (these responses are too vague) Only mentions that industrial burning of fossil fuels is a new thing.</td>
</tr>
<tr>
<td>Inter-textual</td>
<td>0</td>
<td>Provides no answer, is nonsensical, or unrelated.</td>
</tr>
<tr>
<td>T2_Q1: What have manmade discharges done to the greenhouse effect?</td>
<td>1</td>
<td>Mentions that manmade discharges have made the greenhouse effect stronger. Any synonym for &quot;stronger&quot; such as &quot;rigid&quot;, &quot;effective&quot;, &quot;heightened&quot;, &quot;made worse&quot;, etc. is acceptable.</td>
</tr>
<tr>
<td>Text-base</td>
<td>0.5</td>
<td>Only mentions that manmade discharges have added more gases to the atmosphere without stating that the effect is now stronger. OR simply describes the greenhouse effect.</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Does not discuss manmade discharges, or denies them. OR does not discuss anything about an &quot;increase&quot;. Provides no answer, is nonsensical, or unrelated.</td>
</tr>
<tr>
<td>T2_Q2: How do nature's discharges of carbon dioxide (CO2) and manmade</td>
<td>1</td>
<td>Must explain both how 1) manmade discharges are produced, and 2) how nature's discharges are produced.</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>Only provides one of the requirements above. Answer can be vague.</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Answer is not about how either discharge is made. Provides no answer, is nonsensical, or unrelated.</td>
</tr>
</tbody>
</table>
discharges CO2 differ in how they are produced?

<table>
<thead>
<tr>
<th>Intra-textual</th>
<th>Inter-textual</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2_Q3: Explain how a stronger greenhouse effect can trigger major negative weather consequences?</td>
<td>1</td>
</tr>
<tr>
<td>Needs to provide one of the following ideas explaining how greenhouse heats the earth: a) there is stronger heat shield, b) more sunrays are trapped, c) less heat escapes the atmosphere, d) temperature increases. AND Needs to provide two points on how storms are triggered: a) melting ice adds water (rising ocean levels), b) gulf stream is weakened, c) more or warmer water means more evaporation.</td>
<td>0.5</td>
</tr>
<tr>
<td>Only focuses on one side: either greenhouse heating the air or on how storms are triggered, but must include at least 2 ideas. OR Only provides 1 idea from each category.</td>
<td>0</td>
</tr>
</tbody>
</table>

| T3_Q1: What happens to temperature when the circulation of the Atlantic is disturbed? | 1 |
| Provides a response related to cooling. Ideal textbase answer: "fall in the average temperature of 3-5 °C." | 0.5 |
| Explains the process of the gulf stream without explicitly stating that the temperature decreases. Due to lack of question specificity, water temperature responses receive a 0.5. | 0 |
| States that the temperature would increase. Provides no answer, is nonsensical, or unrelated. | 0 |

| T3_Q2: Explain why and how global warming can cause dramatic effects on farming and forestry? | 1 |
| Must also explain that 1) global warming affects/disrupts the Gulf stream, OR melting ice slows the currents down (so warm water doesn't reach the poles), 2) leading to long term cooling and therefore making it difficult for plants to grow. | 0.5 |
| Mentions only one of the items above: >Plants can't grow because there will long term cooling. >Mention both increasing and decreasing temperatures but in different places but explains what the results are due to this. | 0 |
| Provides no answer, is nonsensical, or unrelated. Respond with "plants can't grow because it gets too hot". Hedge too much between increasing and decreasing temperatures. | 0 |

| T3_Q3: Explain how negative effects on forestry potentially affect the climate | 1 |
| Main Point: deforestation means fewer trees to reabsorb CO2, which means more greenhouse gases or CO2 surplus that can't be regulated by nature's cycle, thus increasing temperatures. Must include information about 1) deforestation reducing the number of trees that can reabsorb CO2, 2) which causes a surplus of gases (or there are more gases that can't be regulated). OR (can combine with either response above) 1) There is a surplus 2) that cannot be accounted for by nature's |
Inter-textual cycle or 2) that increases temperatures because "greenhouse gases", or strengthens greenhouse effect.

<table>
<thead>
<tr>
<th>T4_Q1: Name 2 resources that are being found in the Northern Regions as a result of global warming.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lists at least 2 different resources: oil (Petroleum), gas, gold, diamonds, copper, and zinc</td>
</tr>
<tr>
<td>0.5. Lists only 1 of the resources listed above.</td>
</tr>
<tr>
<td>0. Provides no answer, is nonsensical, or unrelated.</td>
</tr>
</tbody>
</table>

**Text-base**

<table>
<thead>
<tr>
<th>T4_Q2: Name 2 reasons why the oil industries are benefiting from global warming.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Needs to mention two of the following reasons: 1) warmer climate melts ice for better passage 2) warmer climate allows for operation during the winter seasons, 3) there is access to oil and gas, which was not previously accessible, 4) Arctic contains (30% of earth's) oil and gas deposits.</td>
</tr>
<tr>
<td>0.5. Only mentions or describes one of the aspects above.</td>
</tr>
<tr>
<td>0. Provides no answer, is nonsensical, or unrelated.</td>
</tr>
</tbody>
</table>

**Intra-textual**

<table>
<thead>
<tr>
<th>T4_Q3: Explain how increased operations of oil industries in the Arctic could be problematic for Northern Europe's climate.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Response needs to mention 1) the burning of fossil fuels OR more CO2 emissions, and 2) the exacerbation or increase in the greenhouse effect or climate change (or explains the process of fluctuating temperature in Europe).</td>
</tr>
<tr>
<td>0.5. Only mentions or describes one of the aspects above.</td>
</tr>
<tr>
<td>0. Provides no answer, is nonsensical, or unrelated.</td>
</tr>
</tbody>
</table>
APPENDIX J

COMPREHENSION QUESTION RELIABILITY
<table>
<thead>
<tr>
<th>Question</th>
<th>Comprehension Score</th>
<th>Integration Count</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%Agreement</td>
<td>Kappa</td>
</tr>
<tr>
<td>T1Q1</td>
<td>0.95</td>
<td>0.91</td>
</tr>
<tr>
<td>T1Q2</td>
<td>0.87</td>
<td>0.78</td>
</tr>
<tr>
<td>T1Q3</td>
<td>0.85</td>
<td>0.77</td>
</tr>
<tr>
<td>T2Q1</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>T2Q2</td>
<td>0.83</td>
<td>0.76</td>
</tr>
<tr>
<td>T2Q3</td>
<td>0.95</td>
<td>0.90</td>
</tr>
<tr>
<td>T3Q1</td>
<td>0.90</td>
<td>0.81</td>
</tr>
<tr>
<td>T3Q2</td>
<td>0.93</td>
<td>0.80</td>
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<tr>
<td>T3Q3</td>
<td>0.93</td>
<td>0.88</td>
</tr>
<tr>
<td>T4Q1</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>T4Q2</td>
<td>0.87</td>
<td>0.80</td>
</tr>
<tr>
<td>T4Q3</td>
<td>0.86</td>
<td>0.75</td>
</tr>
</tbody>
</table>

*Note: There were zero integrations for question T1Q1.
APPENDIX K

CORRELATION MATRIX

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>0.5</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>B</td>
<td>0.5</td>
<td>1</td>
<td>0.7</td>
<td>0.4</td>
</tr>
<tr>
<td>C</td>
<td>0.3</td>
<td>0.7</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>D</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
<td>1</td>
</tr>
</tbody>
</table>
APPENDIX L

IRB HUMAN SUBJECTS RESEARCH APPROVAL/EXEMPTION
EXEMPTION GRANTED

Danielle McNamara
Psychology
480/727-5690
Danielle.McNamara@asu.edu

Dear Danielle McNamara:

On 3/13/2019 the ASU IRB reviewed the following protocol:

<table>
<thead>
<tr>
<th>Type of Review:</th>
<th>Initial Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title:</td>
<td>Developing a Deeper Understanding of Cognitive Processes Driving Multiple Document Comprehension</td>
</tr>
<tr>
<td>Investigator:</td>
<td>Danielle McNamara</td>
</tr>
<tr>
<td>IRB ID:</td>
<td>STUDY00009493</td>
</tr>
<tr>
<td>Funding: Name:</td>
<td>DOEd: Institute of Education Sciences (IES), Grant Office ID: FP00012432</td>
</tr>
<tr>
<td>Grant ID:</td>
<td>FP00012432;</td>
</tr>
<tr>
<td>Documents Reviewed:</td>
<td>Multi-Doc Appendix A Question Examples.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);</td>
</tr>
<tr>
<td></td>
<td>MD proposal 8-15-17 final4.docx, Category: Sponsor Attachment;</td>
</tr>
<tr>
<td></td>
<td>SONA Posting.pdf, Category: Recruitment Materials;</td>
</tr>
<tr>
<td></td>
<td>Multi-Doc IRB Adult Studies.docx, Category: IRB Protocol;</td>
</tr>
<tr>
<td></td>
<td>Informed Consent_MTurk.pdf, Category: Consent Form;</td>
</tr>
<tr>
<td></td>
<td>Informed Consent College.pdf, Category: Consent Form;</td>
</tr>
</tbody>
</table>

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 3/13/2019.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).
Sincerely,

IRB Administrator

cc: Micah Watanabe
    Cecile Perret
    Rod Roscoe
    Renu Balyan
    Danielle McNamara
    Micah Watanabe
    Jianmin Dai
    Carson Flood
    Farhan Khera