What Have We Been Missing?  
The Role of General World Knowledge in Discourse Processing

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In recent years, memory-based and explanation-based theories have dominated the discourse processing literature. Numerous studies have been conducted to show support for each of the two views. Most of these studies have manipulated factors in the episodic memory trace of texts, without a great deal of focus on how general world knowledge impacts processing. We describe several studies from the reading comprehension literature that show strong effects of general world knowledge. We also present a framework that can account for both episodic and general world knowledge effects, and that may be used to reconcile the memory-based and explanation-based views.

Currently, the two most prominent positions within the research literature on text processing are the memory-based processing view (e.g., Gerrig & McKoon, 1998; Myers & O’Brien, 1998; O’Brien & Myers, 1999) and the explanation-based view (e.g., Graesser, Singer, & Trabasso, 1994; Singer, Graesser, & Trabasso, 1994). Although the two views have frequently been portrayed as conflicting, the combined results from both perspectives have led to a considerable advancement in our understanding of the comprehension process. Both views readily acknowledge the role that general world knowledge plays in the comprehension process, although explanation-based theories (e.g., Graesser et al., 1994; Zwaan & Radvansky, 1998) have more readily appealed to the influence that general world knowledge has on...
comprehension. The goal of this article is to provide a framework that can account for general world knowledge effects in reading that are due to both memory-based and explanation-based processes. In this article, we show that the influence of general world knowledge is often greater than acknowledged, independent of theoretical perspective.

Within the memory-based view of text processing, the goal has been to explain as much of comprehension as possible, relying only on low-level automatic memory retrieval processes such as resonance (Myers & O'Brien, 1998; O'Brien, 1995; O'Brien & Myers, 1999). According to the resonance model, when new concepts are encoded into working memory, a signal is sent from these concepts to all of long-term memory in parallel (both the episodic memory trace and general world knowledge). Concepts in long-term memory that share features in common with the contents of working memory will “resonate” in response (cf. Ratcliff, 1978), and those concepts that resonate the most are also most likely to be incorporated into working memory. Factors that have been found to influence this passive reactivation process include elaboration (e.g., O'Brien, 1987; O'Brien, Albrecht, Hakala, & Rizzella, 1995; O'Brien, Plewes, & Albrecht, 1990), distance (e.g., O'Brien, 1987), featural overlap (e.g., Albrecht & Myers, 1998; Albrecht & O'Brien, 1993; O'Brien & Albrecht, 1991), and causal connections (e.g., O'Brien & Myers, 1987; Rizzella & O'Brien, 1996).

The role of higher order processes in reading has been more directly addressed by proponents of the explanation-based approach. According to this view, both automatic and controlled strategic processes interact to influence on-line processing. When new information is encoded, readers search long-term memory for any meaningful information that is relevant to the concepts in working memory to develop a rich and complete representation of the situation described by the text. This search may involve bottom-up retrieval processes, such as those described by memory-based researchers, as well as more active higher order processing on the part of the reader. For example, explanation-based researchers argued that readers of narratives track the causes of events (e.g., Trabasso & Sperry, 1995; Trabasso & van den Broek, 1985), attend to goal information (e.g., Lutz & Radvansky, 1997; Singer & Halldorson, 1996; Suh & Trabasso, 1993; van den Broek, 1990), and may engage in different strategies or hold different standards of coherence, depending on the context and/or purpose of the reading situation (e.g., van den Broek, Lorch, Linderholm, & Gustafson, 2001; van den Broek, Risden, & Husebye-Hartman, 1995).

A FRAMEWORK FOR RECONCILING MEMORY-BASED AND EXPLANATION-BASED VIEWS

The memory-based and explanation-based views are often presented as conflicting with one another, in part because memory-based theories focus primarily on the
bottom-up components involved in reading and explanation-based theories take into account top-down components. Cook and Myers (2004) recently proposed a framework derived from research used to support memory-based processing that may also be used to explain the more strategic processes described by explanation-based researchers. The framework, which operates via a bottom-up reactivation process (e.g., resonance), is a modified version of the bonding and resolution model proposed by Garrod and Sanford (1999; see also Garrod & Terras, 2000; Sanford & Garrod, this issue). The first stage involves linking the contents of active memory with the first information reactivated from long-term memory via an automatic retrieval mechanism—semantic or episodic information. Which type of information, if either, dominates this initial processing stage depends on the degree of featural overlap between the concepts in active memory and long-term memory and the types of episodic manipulations used. According to this view, both episodic and semantic information may be reactivated and may interact to influence early stages of processing (e.g., Myers, Cook, Kambe, Mason, & O'Brien, 2000; Rizzella & O'Brien, 2002; Sereno, Brewer, & O'Donnell, 2003; Wiley & Rayner, 2000). The second stage of the Cook and Myers (2004) framework describes processing as information continues to be reactivated and integrated with the contents of active memory, even after the reader has moved on in the text. That is, “slower” information may not show its influences until later downstream (e.g., spillover sentences, posttarget regions, regressions, second pass reading times, etc.).

What this framework leaves out is any description of when more active processes on the part of the reader come into play. O'Brien and Myers (1999) suggested that when resonance fails to reactivate sufficient information for comprehension to proceed, readers may refocus on the contents of active memory and thus “reboot” the resonance process or they may engage in active problem-solving processes such as those described by explanation-based theorists (Graesser et al., 1994; Singer et al., 1994; van den Broek, 1990; van den Broek et al., 1995). Considering that automatic processes have been shown to influence priming at an earlier stage than controlled processes (e.g., Kintsch, Welsch, Schmalhofer, & Zinny, 1990; Neely, 1977), it may be that the first stage in the framework described by Cook and Myers (2004) is dominated by memory-based processes, whereas explanation-based processes do not show their influences until the second, slower stage. Therefore, this framework can explain both memory-based and explanation-based processes, as well as effects due to episodic and semantic variables.

Much of the evidence for the memory-based and explanation-based views has come from studies in which variables in the episodic memory trace of a text have been manipulated. This has often involved investigating how the relation between information presented early in a passage influenced processing time on text presented later (e.g., a target sentence) or affected the availability of a specific concept (e.g., a probe word). Studies of this nature often attempted to minimize semantic influences on processing by holding general world knowledge constant. This is es-
especially true for studies conducted within the memory-based framework (although see Rizzella & O'Brien, 2002, for an exception). For example, following an anaphoric phrase, the availability of an antecedent is influenced by contextual factors such as distance (e.g., O'Brien, 1987; O'Brien & Myers, 1987), elaboration (e.g., O'Brien et al., 1995; O'Brien et al., 1990), causal relations (e.g., O'Brien & Myers, 1987; Rizzella & O'Brien, 1996), and distractors (e.g., O'Brien et al., 1995).

However, because an anaphor and its antecedent are not always lexically identical, the process of reactivating or accessing an antecedent in response to an anaphor must be mediated by their pre-existing relation to one another in general world knowledge; that is, antecedent retrieval processes must involve both general world knowledge and episodic information (Cook, 2000; Duffy & Rayner, 1990; Garrod & Sanford, 1977; O'Brien & Albrecht, 1991).

Even in those studies that assume that general world knowledge is activated, semantic influences on processing are assumed to be held constant. This is especially true in examinations of predictive inferencing (e.g., Cook, Limber, & O'Brien, 2001; Keefe & McDaniel, 1993; Klin, Guzman, & Levine, 1999; McKoon & Ratcliff, 1986; Murray, Klin, & Myers, 1993). For example, Cook et al. presented readers with passage contexts (e.g., a person is standing on a scaffolding at the 15th story of a building and then loses his balance and falls) and tested for the activation of a predictive inference (e.g., dead). Although they held semantic factors (e.g., lexical associations) constant, the context was only supportive of the predictive inference because readers' general world knowledge contained the information that something terrible usually happens to a person when he falls from great heights, and that information was available to the reader and influenced comprehension. In the next section, we describe several studies that show the influence of semantic variables in reading.

GENERAL WORLD KNOWLEDGE INFLUENCES IN READING

Given that general world knowledge can have a strong influence on the accessibility of information contained in the episodic memory trace, it is important to understand how these two sources of information interact in determining what information ultimately becomes available to the reader (see O'Brien, Cook, & Derpentigny, 2001, for a discussion of the importance of understanding the interaction between general world knowledge and information contained in the episodic memory trace). O'Brien et al. provided considerable evidence that information from earlier portions of a text are reactivated when the reader encounters related information; this occurs independent of whether that reactivated information facilitates or hinders the processing of current information (e.g., Albrecht &
O’Brien, 1993; Myers & O’Brien, Albrecht, & Mason, 1994; O’Brien, Rizzella, Albrecht, & Halleran, 1998). Because the same activation mechanism is assumed to operate on the episodic memory trace and general world knowledge in parallel, similar effects ought to occur as the result of the reactivation of information in general world knowledge; that is, there should be conditions in which activated general world knowledge facilitates comprehension and conditions in which it hinders comprehension.

However, it is difficult to draw direct comparisons between the influences of the two types of information. Reactivated episodic information appears to have its greatest influence at the level of the text base or situation model, whereas general world knowledge appears to influence processing at a much wider variety of levels. For example, general world knowledge has been found to influence processing at the lexical level (e.g., Binder & Rayner, 1998; Duffy, Morris, & Rayner, 1988; Kambe, Rayner, & Duffy, 2001; Rayner & Frazier, 1989; Rayner, Pacht, & Duffy, 1994), the featural level (e.g., Albrecht & Myers, 1995, 1998; Cook, 2000; Guéraud, 2003; Guéraud & Tapiero, 2003; O’Brien & Albrecht, 1991), and the scenario or script level (e.g., Bower, Black, & Turner, 1979; Cook & Myers, 2004; Garrod & Terras, 2000; Rizzella & O’Brien, 2002). This is certainly not an exhaustive list, but it highlights some of the major ways that general world knowledge impacts comprehension. In what follows, we discuss a select set of findings that demonstrate the impact of general world knowledge at each of these levels, how it interacts with information contained in the episodic memory trace, and how the framework proposed earlier can account for these effects.

Lexical Knowledge

A considerable number of studies have been conducted on lexically ambiguous words (e.g., Binder & Rayner, 1998; Duffy et al., 1988; Kambe et al., 2001; Rayner & Frazier, 1989; Rayner et al., 1994). One major finding from this research is the subordinate bias effect, which is clearly influenced by both general world knowledge and the episodic memory trace. This effect refers to the finding that, for biased ambiguous words (i.e., ambiguous words for which one meaning is more dominant than the other meaning, e.g., “bank”), when the prior episodic context supports the dominant meaning of the word (e.g., money), fixation times on that word are shorter than in a control condition. But, when the episodic context supports the subordinate meaning of that word (e.g., river), fixation times on that word are longer than in a control condition. The subordinate bias effect is good evidence for the interaction of information from general world knowledge with information in the episodic memory trace. However, it also shows that although disambiguating context in the episodic memory trace may speed access of the subordinate meaning of a word, it does not completely override general world knowledge (see also Binder & Rayner, 1998; Kambe et al., 2001).
Wiley and Rayner (2000) investigated the subordinate bias effect by manipulating the episodic memory trace in a way that was different from the manipulations used in previous studies. They compared reading times on lexically ambiguous words containing more than two meanings (e.g., fly) and matched control words, which were embedded in texts that were preceded by titles (e.g., “Worries of a Baseball Manager”) that disambiguated the words toward a particular meaning. Contrary to studies on the subordinate bias effect, Wiley and Rayner found that titles that disambiguated words toward their more frequent subordinate meanings were sufficient to eliminate the effect. Consistent with previous lexical access theories (e.g., Duffy et al., 1988), they concluded that context can interact with lexical information about a word to influence the speed of access of a particular meaning. The impact of context in this interaction may depend on such factors as the difficulty level of the texts (Rayner & Pollatsek, 1989), the strength (i.e., frequency) of the subordinate meanings, and the type of context used. This finding demonstrates that when the information coming from the episodic memory trace is sufficient, it can override a strong general world knowledge effect very early in the reading process. Thus, according to the framework that we have proposed, at the lexical level, meaning activation is determined by an interaction of information coming from both general world knowledge and the episodic memory trace (see also Sereno et al., 2003).

Featural Knowledge

In addition to lexical information, featural information is also stored in general world knowledge. Although “features” have never been specifically defined in the discourse processing literature, many theorists agree that they are an important element in reading (e.g., construction–integration [CI] model, Kintsch, 1988; resonance model, Myers & O’Brien, 1998; O’Brien & Myers, 1999). Features involve more basic units of meaning than can be captured by propositions (e.g., Kintsch, 1998; Kintsch & van Dijk, 1978) or lexical items. That is, concepts are made up of clusters of features and features can overlap among concepts. For example, the concept, “cat” contains the feature “fur,” which is also a feature of the concept “dog”; however, it is important to note that each feature may also be composed of additional features.

One example from the memory literature in which featural information from general world knowledge can influence processing is the Moses Illusion. Erickson and Mattson (1981) asked participants questions such as, “How many animals of each kind did Moses take on the Ark?” and found that over 80% answered, “Two,” even though they knew that it was actually Noah who sailed the biblical ark. However, when the question referred to Nixon instead of Moses, error rates decreased dramatically. Erickson and Mattson argued that although Moses and Noah represent two distinct individuals, the figures share several features in common (e.g.,
Old Testament figures, received messages from God, stories involved water), which may lead them to be easily mistaken for one another. These features in common do not exist in the episodic memory trace, but instead are a part of general world knowledge; and that these two figures share features in common can lead to interference in the comprehension of a question about one of them (see also van Oostendorp & de Mul, 1990; van Oostendorp & Kok, 1990). Although the Moses Illusion can be mediated by manipulating the amount of information contained in the episodic memory trace (and by strategic factors), the effect has never been completely eliminated (e.g., Bredart & Docquier, 1989; Bredart & Modolo, 1988; Hannon & Daneman, 2001; Kamas, Reder, & Ayers, 1996; Reder & Cleeremans, 1990).

O’Brien and his colleagues have provided evidence for the role of featural information during reading with their inconsistency paradigm (Albrecht & O’Brien, 1993; Cook, Halleran, & O’Brien, 1998; Hakala & O’Brien, 1995; Myers et al., 1994; O’Brien & Albrecht, 1992; O’Brien et al., 1998). In several studies, they demonstrated that readers exhibit longer reading times on a target sentence (e.g., “Mary ordered a cheeseburger and fries”) that is inconsistent with previous text (e.g., “Mary was a health nut and a strict vegetarian”), compared to a control condition. It is important to point out that the target sentence and the previous text do not create a direct contradiction (e.g., Mary eats meat. Mary does not eat meat). The two portions of text are inconsistent because they conflict with information already stored in general world knowledge (e.g., vegetarians do not eat meat). That is, when readers encode the information that Mary is a vegetarian, the knowledge that vegetarians don’t eat meat is likely activated and may or may not be integrated as part of the episodic representation of the text in memory. When the target sentence is encountered, it too would activate the information about meat from either the episodic memory trace or from general world knowledge. In either case, it is the activation of this information from general world knowledge that creates the conflict between the target sentence and previous text (see also, Cook et al., 1998; Long & Chong, 2001; O’Brien et al., 1998; O’Brien, Cook, & Peracchi, 2004).

Additional evidence for the role of featural information in reading comes from studies investigating anaphoric resolution processes. Although general world knowledge effects have been found with both nominal and pronominal anaphors (see Garnham, 2001, for a review), this discussion is limited to investigations of nominal anaphoric references. Duffy and Rayner (1990; see also Garrod & Sanford, 1977) manipulated the typicality of an antecedent (e.g., robin/goose) and distance (close versus distant). Using eye tracking methodology to measure fixation times on the categorical anaphor (e.g., bird), they found interacting effects of typicality and distance, with the shortest fixation times on anaphors in the close, high-typical condition. In addition, typicality (but not distance) continued to influence processing times after the eye moved away from
the anaphor. These studies demonstrate that the underlying semantic relation in general world knowledge between an anaphor and an antecedent is an important factor in anaphor resolution and that this relation may have stronger and longer lasting effects than some episodic relations (e.g., distance between concepts in the discourse).

O'Brien and Albrecht (1991) found that concepts that were highly related to an anaphor in general world knowledge, but not present in a text, can also impact anaphor resolution processes. They used passages containing statements that shared several features in common with an unmentioned concept, "skunk" (e.g., terrific odor, small black animal, had a white stripe down its back, etc.). They used naming probe methodology to demonstrate that "skunk" was activated in response to an anaphoric phrase, even though it had never been mentioned and the correct antecedent, "cat," had been explicitly mentioned in the text. They also found that if the passage contained highly supportive context for the unstated concept, and if the unstated concept had sufficient featural overlap with the anaphoric phrase, the unstated concept could even be instantiated in place of the correct antecedent.

Cook (2000) also showed that when there are strong pre-existing associations between anaphors and potential antecedents, they can have strong effects on the resolution process. She presented readers with passages containing an object (e.g., "cello") that was referenced later in the text with an anaphor. The anaphor was either a correct reference for the antecedent (e.g., "cello"), an incorrect but highly related anaphor (e.g., "violin"), or incorrect and not highly related anaphor (e.g., "oboe"). Reading times for the sentence containing the anaphor decreased as a function of the pre-existing relation in general world knowledge between the anaphor and the antecedent. The correct anaphor condition (e.g., "cello") yielded faster reading times than the incorrect-high related condition (e.g., "violin"), which yielded faster reading times than the incorrect-low related condition (e.g., "oboe"). This effect persisted despite several attempts to override it with manipulations that were designed to increase the availability of the episodic memory trace of the antecedent (e.g., describing and elaborating on distinctive characteristics of the antecedent, syntactic focus, and distance). It was only reduced when all featural information about the antecedent was removed from the text. The results of this study, in combination with those described earlier, provide support for the proposed framework by demonstrating that anaphor resolution processes are affected by semantic factors (i.e., general world knowledge) to the same degree, if not more than, episodic factors (e.g., elaboration or distance). This is especially important, given that most of the focus in research on anaphoric resolution has focused on factors governing the episodic memory trace (e.g., O'Brien, 1987; O'Brien & Myers, 1987; O'Brien et al., 1990; O'Brien et al., 1995).
Script/Scenario Knowledge

A final level of general world knowledge that we discuss refers to knowledge about scripts and scenarios. For example, when reading a narrative about a common activity or situation (e.g., writing a letter, going to a rock concert, going to a restaurant, etc.), readers quickly reactivate information in general world knowledge related to the situation being described (e.g., Bower et al., 1979; Rizzolla & O'Brien, 2002). Several theorists (e.g., Garrod & Sanford, 1999; Kintsch, 1988) argued that this semantic information may even be reactivated more quickly than episodic information (i.e., information explicitly stated in the text).

Garrod and Terras (2000) investigated whether effects of general world knowledge on comprehension processes are immediate or delayed and how general world knowledge effects are influenced by episodic factors. They tracked readers' eye movements for texts in which the first sentence contained common verbs (e.g., writing) in specific scenarios (e.g., writing a letter, writing on a blackboard). The next sentence referenced a role filler for the verb that was: either explicitly stated or implied in the first sentence; either dominant (e.g., pen) or nondominant (e.g., chalk) with respect to the verb; and either appropriate (e.g., writing a letter with a pen) or inappropriate (e.g., writing on the blackboard with a pen) with respect to the scenario described. They tested for effects of general world knowledge by comparing explicit conditions to implicit conditions. If “pen” is a dominant role filler for “write,” it should be easy to process regardless of whether it had been explicitly stated or not. However, if “chalk” is a nondominant role filler for “write,” it should be easier to process when it was explicitly stated than when it was only implied. Context effects were examined by comparing the appropriate conditions (e.g., write a letter with a pen, write on the blackboard with chalk) to the inappropriate conditions (e.g., write a letter with chalk, write on the blackboard with a pen). They found that initial processing times (i.e., first pass reading times) on the role filler were influenced by general world knowledge and that information in the episodic memory trace did not influence processing until later downstream (e.g., second pass reading times). Garrod and Terras argued that their results supported a two-stage process. In the first stage, bonding, a role filler is linked with its verb via a bottom-up memory retrieval process that is dominated by general world knowledge. Once this link is formed, it is resolved with respect to the discourse (i.e., the episodic memory trace) in a second, resolution stage (see Sanford & Garrod, 1999, this issue).

Cook and Myers (2004) investigated whether bonding and resolution would extend beyond verbs to more general scripted actions. Their passages were script-based stories (e.g., about a rock concert) in which individuals (e.g., guitarist) performed actions that were either appropriate or inappropriate with respect to readers’ general world knowledge about scripts (e.g., played a slow and heart-
felt love song vs. handled publicity and finances). In addition, in half of their passages, the individuals’ inappropriate actions were supported by previous passage context. Like Garrod and Terras (2000), Cook and Myers tracked readers’ eye movements and found that when a character’s action was not previously supported by information in the episodic memory trace, general world knowledge influenced first pass reading times on the role filler (e.g., guitarist)—fixation durations were longer when the action was inappropriate than when it was appropriate. However, when the action was previously supported, information in the episodic memory trace appeared to dominate initial processing times on the role filler—there was no disadvantage for the inappropriate condition in first pass reading times, but inappropriateness effects did appear later downstream (i.e., in second pass reading times). Cook and Myers argued that although general world knowledge will often become available more quickly than episodic information to influence the initial linkage stage, these results show that in some situations, strong episodic information may be reactivated quickly enough to influence early processing. As information (semantic or episodic) continues to be reactivated and integrated with the incoming text, those effects appear in the second, slower verification stage. To explain these results, Cook and Myers presented a modified version of bonding and resolution—the framework presented earlier in this article.

CONCLUSIONS

Although much of the research in discourse processing has focused on the role of episodic variables in reading, it is clear from the research described here that general world knowledge also has a strong influence on reading processes. The framework presented in the introduction provides a mechanism that can explain both the passive and strategic reactivation of episodic and semantic information. This framework allows for the possibility that early stages of reading are dominated by memory-based processes, whereas later stages of reading are controlled by explanation-based processes. Because many of the studies that support either the memory-based view or the explanation-based view have used methodologies that do not provide a window into the time course of processing (e.g., line-by-line reading, single-SOA probe methodologies, talk aloud protocols, etc.), this question remains open. Eye tracking methodology, such as that used by Garrod and Terras (2000) and Cook and Myers (2004), is one possibility for investigating this issue because it allows for a more fine-grained analysis of on-line reading processes (see Rayner & Pollatsek, 1989). Future research should make use of eye tracking and other on-line methodologies to examine how and when memory-based and explanation-based processes influence reading.
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REFERENCES


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