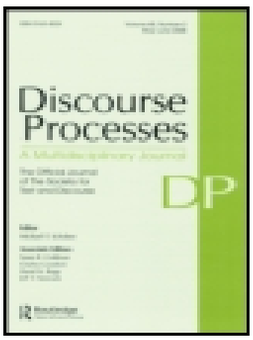

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If Integration Is the Keystone of Comprehension: Inferencing Is the Key

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ABSTRACT

This article provides a commentary within the special issue, Integration: The Keystone of Comprehension. According to most contemporary frameworks, a driving force in comprehension is the reader's ability to generate the links among the words and sentences (ideas) in the texts and between the ideas in the text and what the readers already know. As such, the key to successful comprehension is generating inferences: inferences about what a word means, inferences to integrate ideas within the sentences, and inferences to integrate ideas within and outside the text. Accordingly, inferences provide the glue to hold it all together. While there is general agreement in this regard, the factors reported to be key to comprehension also depend on the focus of the research. Some studies focus on surface level and relatively brief measures of reading comprehension. These studies might conclude that comparable measures are the key to comprehension. Other studies use inference-level questions with a focus on comprehension and learning in the context of informational text, even multiple documents. These studies point toward the crucial importance of inference generation. The four articles in this special issue each tackle the question of how readers comprehend text from different angles, using different types of dependent measures, and with foci on different individual differences. Each of these studies provides a glimpse into different experimental paradigms used to investigate comprehension processes as well differing questions that are currently faced by discourse processes researchers.

Introduction

One foundational question that researchers in discourse processes have tackled is how do readers comprehend text? How does a child read and understand *Cat in the Hat*? How does a developing reader comprehend a text about mammals, or heart disease? How do readers understand narratives, informational text, and poems, and how do they learn new information from text? And, what aspects of the reader drive those processes?

From one point of view, reading is relatively serial. The child reads the words, accesses the meaning of the words, links the words together by processing the syntactic relations, all the while holding in working memory as much content from the text as possible. Accordingly, knowledge of words and their meanings and sufficient working memory capacity to "put it all together" are the driving forces of comprehension. Indeed, these simple factors often account for significant amounts of variance in reading comprehension, particularly if those factors are being measured (i.e., memory for the words in the text).

From another point of view, there is more to it. Reading is not serial; the reader engages in multiple, parallel processes, with multiple areas of the brain activated in parallel, processing the letters, words, word meanings, word features, relevant and irrelevant associations to the words, images, syntactic relations, and unrelated thoughts, all at the same time.

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Many theoretical frameworks for text and discourse comprehension fall somewhere in the middle, wherein some sets of processes are serial and some are parallel; some are earlier and some later; some are automatic and some conscious. Most recognize that comprehension depends on a host of factors, including prior experience of reading, reading skill, knowledge of the words and the domain, and motivation, just to name a few skills that contribute to successful comprehension. Sifting through the array of potential skills at play has motivated a good deal of research on comprehension.

According to the construction-integration model (Kintsch, 1998; see also McNamara & Magliano, 2009), a driving force in comprehension is the reader's ability to generate the links amongst the words and sentences (ideas) in the texts and between the ideas in the text and what the readers already know. Readers activate relevant and irrelevant concepts during reading based on the text and prior knowledge. These concepts are *integrated* within a connectionist framework driven by constraint satisfaction principles. In such a system, concepts (represented by nodes) that are related to other concepts are essentially fed activation from those concepts. Those with fewer links drop out, and those with more links are retained in the network of concepts, or *mental representation*. When there are more concepts activated and when the concepts are related to each other, then the mental representation is said to be more *coherent* (McNamara & McDaniel, 2004). Through *dumb* activation, coherence, and, in turn, comprehension and memory for the text depend largely on prior knowledge. It also depends on deliberate inferences to make connections between ideas in the text, to what the reader already knows, and potentially to other texts or sources. As such, the key to successful comprehension is generating inferences: inferences about what a word means, inferences to integrate ideas within the sentences, and inferences to integrate ideas within and outside the text. Accordingly, *inferences provide the glue to hold it all together*.

While there is general agreement in this regard, the factors that are reported to be *key* to comprehension also depend on the focus of the research. Some studies focus on surface-level and relatively cursory measures of reading comprehension. These studies might conclude that comparable measures, such as measures of working memory and vocabulary, are the key to comprehension. On the other side of the continuum, other studies use inference-level questions with a focus on comprehension and learning in the context of informational text, even multiple documents. These studies tell a different story. Perhaps no one is right or wrong, but the answers intrinsically depend on both the nature of the experimental manipulations and dependent variables (e.g., the nature of the text, how comprehension is measured) as well as which individual differences are measured and how.

My own research has been largely motivated by the assumption that inferences are key to transferable and longer lasting comprehension of and learning from text, and in turn, discovering methods to enhance readers' ability to generate inferences is an important, if not crucial application of discourse comprehension research. As such, the *archway* that I have been constructing represents *deep* comprehension, and this archway is intended to provide a portal to students' academic and lifetime success. Others' archways and thus their keystones are not the same.

A key to discovering the keystone of comprehension depends on which archway the researchers are attempting to construct. If the research is focused on "lower level" comprehension and the measures are related to lower level processes related to memory for the words and sentences, then the keystone is more likely to entail memory for words. If the research is focused on more "higher level" processes, including readers' understanding of relations between sentences and documents, then the keystone is more likely to entail comprehension processes related to readers' ability to generate those connections. This interdependence of methodology and theoretical framework is often ignored in the interpretation of research in the realm of discourse processes.

The four studies in this special issue provide prototypical examples of this interdependence as well as the range of perspectives within discourse processes. Each of these studies provides a glimpse into different experimental paradigms used to investigate comprehension processes, as well differing questions that are currently faced by discourse processes researchers. Each tackles the question of how readers comprehend text but from different angles, using different types of dependent measures, and with foci on different individual differences. The differences between the studies weave a complex

story, but the differing theoretical frameworks, objectives, methods, and results must be interpreted in light of which archway the researchers are attempting to construct.

Let's first summarize each of these articles in turn

Spencer and Cutting (2020) approach questions regarding comprehension by investigating the relations between children's (ages 6–8; n = 298) reading comprehension (i.e., as measured by a cloze comprehension task within the Woodcock Johnson-IV, WJ-IV), decoding (i.e., as measured by word attack in WJ-IV), and executive functioning (as measured by teacher ratings of students' working memory, shifting, and inhibition, using the BRIEF-2). As such, this study represents an investigation of factors related to one side of the equation, early reading, surface level comprehension (i.e., using a cloze task), word decoding, and executive functioning estimates. As expected, they found moderate relations between word decoding and cloze-task performance on the WJ-IV (r = ~.61). In turn, the relations between executive functioning and decoding were not significant. While executive functioning was weakly related to cloze-task performance (r = −.13 to −.30), this relation emerged solely for females. Otherwise, there were few differences as a function of gender.

In sum, Spencer and Cutting's (2020) study is indicative of relatively weak correlations between executive functioning and lower-level comprehension processes. These relations may be slightly accentuated for females in their sample, but the cause of these differences might be attributed to any number of factors given the caveat that executive functioning was assessed via teachers' ratings (who might be the subject of gender biases). Nonetheless, the results of this study align with other studies that have shown that the relation between executive functioning (e.g., working memory) and reading comprehension is generally weak to moderate and has been reported primarily for lower level comprehension tasks (narrative passages, cloze tasks, multiple-choice tasks).

Perfetti and Helder (2020) similarly focus on comprehension of narrative passages and how word meanings enable connections within the text. According to Perfetti and Helder, a skilled reader achieves an understanding of a text incrementally, using discrete linguistic units (i.e., words, phrases, clauses sentences) to build and update a mental representation of the messages conveyed in a text. This theoretical model inherently drives their methodological focus on incremental word reading processes as revealed by event-related potential, eye-tracking, and behavioral reading time measures. In particular, they focus on processes associated with word meaning prediction and integration, and the relative influence of global (distal) and local information within a text. They measure processes at sentence beginnings (as opposed to sentence endings) following the assumption that the effects of word-to-text integration can be separated from word-to-sentence integration solely at the beginning of the sentence.

Across several studies reviewed by Perfetti and Helder (2020), prediction (i.e., the use of word probability as a function of context) is not a major factor in lexical inference processes at sentence beginnings. Additionally, they have not found relations between the presence of distal information (e.g., a title) or thematic centrality and the N400 (i.e., as an indicator of meaning congruence). However, a reduction in the N400 signature (i.e., indicative of inferential processes) tends to be accentuated when the reader's task is more globally oriented (e.g., choosing a better passage title). Likewise, there is an N400 reduction when an antecedent occurs nine words before the word being read, suggestive of textual or global integration processes. As such, the degree and type of integrative processes varies as a function of the task and context. Readers may be minimalists in some contexts, generating inferences only locally and rarely globally. In other contexts, readers may be more likely to generate inferences using local and global information in the passage. As such, Perfetti and Helder's findings are aligned with comprehension theories that emphasize multilevel integrative processes in concert with serial, incremental reading processes.

Van Moort et al. (2020) move beyond lexical processing, using eye-tracking to detect the extent to which readers detect and repair inconsistencies in text. Specifically, young adults (n = 47) read 80

passages about relatively familiar historical topics. Each passage contained a target sentence that was consistent or not with prior text in the passage and either true (e.g., the Statue of Liberty was delivered from France to the United States) or false (e.g., the Statue of Liberty was not delivered to the United States) relative to historical accuracy. As expected, texts containing target sentences with historical inaccuracies increased early (i.e., first-pass reading times) and later processing (i.e., regressions, rereading). Inconsistent contexts generally increased later processing and increased early processing when combined with historical inaccuracies. These results suggest that readers monitored comprehension while reading and attempted to repair their understanding.

Like Spencer and Cutting (2020), this study also examined the relations between executive functioning and reading. Van Moort et al. (2020) found that performance on working memory capacity tasks was not associated with early processing (i.e., first-pass reading times) but was positively associated with shorter regressions and a lower propensity to reread. They assume that eye movements after the first pass are more sensitive to reader-initiated repair processes. Assumedly, those with a larger working memory had more resources during reading and thus did not need to reread or reprocess the text because they had more relevant information activated in the first pass to construct a coherent mental representation. Nonetheless, readers were not differentially affected by inconsistencies in the passages as a function of working memory capacity. As such, readers with better working memory task performance read more quickly and processed information more efficiently, but their reading patterns did not reveal different patterns in inference processes rising from inaccuracies in text.

Rouet et al. (2020) explored factors influencing readers' attention to and memory for character attributes and credibility. Studies to investigate attention to and memory for source attributes is increasingly important in this internet age, wherein the credibility of source and information vary widely. Readers must generate inferences to connect text contents to source credibility and in turn, remember and *value* more credible information.

To further investigate issues related to the source credibility, Rouet et al. (2020) conducted two experiments wherein undergraduate students read 16 (unrelated) four-sentence *newsflash* reports in which two characters issued statements (consistent vs. discrepant) about a relatively familiar situation. In this study, the manipulation of source was represented within the same four-sentence passage but by different characters (i.e., wherein a person is a source of information). Across two experiments, participants tended to notice discrepant information and consider the characters to be more knowledgeable sources of information when the passages included action-based statements about how the characters obtained the information. Participants' source evaluations were highest when the passages included the action statement and they evaluated the character's competence. They also found that asking a question after reading about the character (regardless of question type) enhanced both source-feature integration and source-content integration in comparison with a baseline.

Their results further support the notion that text content that is tagged in terms of source information is more likely to be remembered and integrated. Accordingly, providing more information or increasing attention to *relevant* source information has potential to enhance comprehension. In this case, a relatively simple prompt asking about the knowledge level of a character increased the likelihood that readers recognized the connections between the character (i.e., source) and ideas in the passages and potentially integrated the information within the passages.

Conclusions

A relatively simple view of reading holds that comprehension is constrained by two main factors: the ability to understand the words and sentences (i.e., decoding) and the ability to understand the relations between ideas in the text and the relations between the text and prior knowledge (i.e., inferencing). The result of these processes is a more or less integrated mental representation of a text. Theoretically, comprehension is further constrained by resources available to attend to information, shift between one idea and another, and suppress irrelevant concepts. These abilities might be constrained by executive functioning or by other factors related to knowledge and skill, such as

vocabulary knowledge, prior domain knowledge, comprehension strategies, motivation, or a host of other individual and contextual differences (McNamara et al., 2007).

Collectively, the studies presented in this issue represent a continuum of theoretical frameworks and methodological approaches to spotlight various reading processes and disentangle factors that might influence integration while reading. While there are certainly weaknesses and gaps in each of these studies, no one study can provide the full picture, just as no one theory (to date) provides a comprehensive account for comprehension. Putting together the pieces of the puzzle is challenging in the field of text and discourse because the particular question, population, paradigm, measures, variables, and tasks vary so widely. The spotlights move from one area of this multidimensional puzzle to another. It is important to interpret the results of all discourse processing studies in that light.

It is also important to interpret paradigms, measures, and constructs with appropriate caution. This is particularly critical as we often rely on correlational variables in our search to better understand the factors that underlie comprehension. Correlations can be misleading, particularly if they are misinterpreted in a causal light. For example, tasks within the same measure (such as the WJ-IV) are administered in similar ways and have similar underlying cognitive and social requisites, which may artificially inflate correlations. Moreover, tasks that tap into the same underlying processes (e.g., lexical and lower-level processing) will tend to be correlated. For example, decoding ability, particularly for young readers, tends to correlated with cloze-task performance because both primarily tap into lexical processing. One should not conclude from those correlations, however, that comprehension occurs primarily at the lexical level or that lexical processing causes comprehension. In sum, it is important to not conflate task with construct and attribute causal relations to correlational data, particularly weak correlations.

Some theorists have been focused on understanding the role of executive functioning in comprehension (e.g., Spencer & Cutting, 2020; Van Moort et al., 2020). In such studies, working memory can appear to provide a keystone within the archway. Notably, the strength of this keystone varies across studies. The strength of these relations varies widely across studies, depending on the population, tasks, measures, and context. Across studies, relations between executive functioning and comprehension tend to be weak and have not been well established for informational texts and inference tasks, the signatures of integrative processing. As such, validation of theoretical models that assume that executive functioning is a driving force in comprehension calls for additional research on those relations for both narrative and informational texts, with studies that include comprehension measures that require inferencing, measures of readers' prior knowledge, as well as multiple measures of executive functioning.

Finally, in our quest to understand comprehension, it is important to not get lost in one's own method, measures, and definition of constructs. If your spotlight is on, for example, the words in the text or on attention mechanisms, it is important to remember that other mechanisms may be at work. Similarly, for those who focus on text-level integration processes, it is important to not forget the words and lower level processes. By doing so, we will be more likely to fill in the gaps in the puzzle. Integration is a complex process of combining multiple sources of information, in multiple ways—understanding those processes requires examining them from multiple angles, building multiple archways, and considering multiple keystones.

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