Writing for Human Performance: Relating Reading Research to Document Design

Jan H. Spyridakis
University of Washington

Michael J. Wenger
State University of New York, Binghamton

Summary
This paper briefly reviews a few models of reading performance as a point of departure and as an organizing framework for understanding findings from empirical studies of text and reader factors. It then reviews numerous empirical studies of text design and reader variables and their effects on comprehension. Its goal is to help readers understand this research and identify the implications of such research in document design decisions.

Technical communicators are well aware of the critical role that audience plays in decisions about document design. We carefully consider our intended readers' knowledge, experience, situation, and culture; we then seek to match the style, content, and design of a document to the tasks, needs, and desires of various readers. But on the whole, our conception of the members of our audiences is often superficial: our "readers" or "users" are somewhat faceless, amorphous, idealized beings.

Our intent here is to get under the skin of those beings or, more accurately, to try to look inside their heads to gain insight into what happens between the time they look at a document and the time they do something with the information. Insight into these hidden processes should powerfully inform our document-design decisions.

For the majority of us, the principles of document design (regarding style, organization, etc.) are handed to us as time-tested prescriptions. As the discussion that follows illustrates, many of these prescriptions find empirical support in studies conducted by psychologists, linguists, educators, and, increasingly in recent years, technical communicators. However, perhaps as a consequence of this increasing body of information (and the formal and informal rules that tend to separate workers in scholarly disciplines), there is no coherent organizing framework for the information. Technical communicators, if they are willing to consult the empirical experimental literature for guidance, are left to their own resources in synthesizing the information and drawing conclusions for application.

This article has been peer reviewed.
We begin this article by reviewing a few models that explain and predict reading performance. We then review some empirical studies of text and reader variables and discuss the impact of these variables on document-design decisions. We close by giving a short set of recommendations for those interested in further exploring and applying the experimental literature.

**MODELS OF READING AND COMPREHENSION**

"Theories are fun"—so concludes B. F. Skinner in a critique on the evolution of scientific psychology over the past four decades [1, 522]. Such a conclusion seems to be borne out when we examine some of the existing models of reading and comprehension. While we might conclude that there are as many models of reading as there are modelers, we must remember that reading is one of the most heavily researched of all human cognitive behaviors. Indeed, it is a favorite research topic because it involves nearly all the processes that interest cognitive scientists: perception; recognition; encoding, storing, and retrieving information from memory; use of the rules of language; and complex forms of reasoning and problem-solving [2; 3].

Reviewing the types of models that have been employed by reading researchers is useful because a working knowledge of the assumptions that underlie these models helps us place in perspective the data and conclusions presented in research articles. Our review, almost by necessity, does not do full justice to the logical rigor with which the models we present were originally developed. Our intent in reviewing these models is to acquaint you with the intellectual context for the research findings that we review later in this paper.

"Bottom-up" or "feature-driven" models of reading take as their starting points the most basic elements of a text—such as the strokes of each individual letter—and work their way up through cognitive processing to conscious experience [4]. These models hold that comprehension is the end product of a process that begins with the perception of basic features on the page. In contrast to the bottom-up or feature-driven models of reading are the "top-down" or "context-driven" models. These models take as their starting points the background knowledge that readers bring to the text and the context for the document [5]. These models hold that comprehension begins with readers laying a foundation of prior knowledge and further develops with readers mapping incoming information onto that foundation [6].

The bottom-up and the top-down models of reading differ in their starting points but share the notion that reading is a linear process. The "interactive-compensatory" model of reading [7; 8], a hybrid of bottom-up and top-down models, holds that readers can work from the bottom up (beginning with basic features), from the top down (beginning with pre-existing knowledge), or from the middle out in either direction. Given a particular combination of readers and texts, interactions and cross-overs could occur at any point. Readers with strengths at one level could compensate for weaknesses at other levels; for example, readers who possess a great deal of knowledge about a topic would not have to decode the text from basic features, since they could rely on information in memory to guide inferences about incoming information.

**While we might conclude that there are as many models of reading as there are modelers, we must remember that reading is one of the most heavily researched of all human cognitive behaviors.**

Another set of models represents the processes of reading and comprehension as a set of procedures or productions akin to a structured computer program [2; 10; 11]. The "if-then" rules can operate on information represented in the words and phrases in a text, the low- and high-level semantic content of a text, or the situation described in a text. These surface, propositional, and situational elements of a text interact in readers' memory representations, and the nature of these interactions influences comprehension and the application of textual information [12].

In summarizing these reading models, we must realize that each model was developed to account for a set of available data, and each has its strengths and weaknesses. We have presented these models to give you a flavor for the working assumptions behind the studies we review later in this paper. However, before leaving the topic of reading models, we must make two final points.

First, each model relies on different text or reader features for its unit of analysis. For example, many bottom-up models start with words or word features as their unit of analysis, whereas many top-down models focus on readers' prior knowledge and larger
units of analysis such as phrases, clauses, or sentences. The question of unit of analysis becomes important in interpreting the findings in the studies we review.

Second, while each of these models focuses on different aspects of reading, they all acknowledge that various aspects of the text and reader greatly influence a reader's performance. In the sections that follow, we present data derived from studies that followed one or more of the models just presented, but we do it outside the implications for any of the models. Instead, we focus on the effects on reader performance.

TEXT VARIABLES AND READING

Given the multitude of steps involved in reading and comprehending information, well-informed writers should be aware of what research has revealed about text factors that facilitate reading. Summarizing all empirical studies that investigate the effect of different text factors on comprehension is beyond the scope of this article; therefore, we review just a few well-known studies that cover a spectrum of document-design issues. (Unfortunately, issues of graphic design are outside the domain of this paper.)

For a complete review of research on document design through 1979, readers should consult an excellent source published in 1980—Document Design: A Review of the Relevant Research [13]. Here, we review recent studies that have examined the effect of physical and semantic features of words, negation, syntactic manipulations, and organization and content variations.

Physical and Semantic Features of Words

Authors are often advised to value short and familiar words and reserve the use of long and less familiar words for technical concepts that require such terminology. Fortunately, such advice is supported by numerous studies that have examined the physical and semantic features of words to determine what features facilitate word recognition and comprehension.

High-frequency words (words that occur frequently in our language), short words, and structurally simple words are much easier for readers to recognize and comprehend than their low-frequency or longer counterparts, a phenomenon generally referred to as Zipf's law [14; 15; 16]. Specifically, readers decide that words are in fact words much faster when they occur often in the language [17]. Further, both high-frequency and short words are easier to discriminate than low-frequency and long words, but long words are harder to discriminate than low-frequency words [18]. Interestingly, shorter words usually have higher frequency ratings.

Examining the effect of articulatory surface features of language (loosely speaking, prounciability), Naveh-Benjamin and Ayres tested and confirmed two hypotheses: (1) Languages with greater average word length reduce a reader's memory span, and (2) immediate recall is a constant for humans, independent of the speaker's primary language [19]. In other words, although the memory spans of readers of different languages are identical, readers who must hold many long words in immediate memory can retain fewer words than readers who must hold many short words in immediate memory. Naveh-Benjamin and Ayres argue for the use of structurally simple words (fewer syllables) because such words are perceived and processed more quickly than more structurally complex words (more syllables).

Authors are also advised to use concrete and nonambiguous words. Many researchers have studied the semantic features of words (i.e., features of word meaning) to ascertain what features aid readers in acquiring meaning. Kroll and Merves tested the dual-encoding hypothesis for concrete and abstract nouns, a hypothesis that suggests that concrete words are encoded in memory through both visual and verbal channels and are therefore encoded better than abstract words, which are encoded only through a verbal channel [20]. In general, they found only slightly faster reaction times for concrete nouns versus abstract nouns. However, when concrete nouns preceded abstract nouns, reaction times for abstract nouns were faster, suggesting that abstract nouns are processed faster and comprehended better when concrete nouns precede them. Schwanenflugel, Harnishfeger, and Stowe also found faster lexical decision times for abstract nouns residing in concrete contexts [21].

In a similar vein, prior context for ambiguous words has also been shown to facilitate recovery of relevant aspects of meaning and to inhibit recovery of irrelevant aspects [22]. The more the surrounding context constrains the meaning of ambiguous words, the greater the context effect will be, because high-constraint sentences create more restrictions on word features and thus facilitate a reader's recognition of words [23]. From the perspective of the technical
writer, these findings imply that when writers must introduce abstract or ambiguous nouns (representing abstract and perhaps unfamiliar or ambiguous concepts), they could aid their readers by first introducing concrete nouns and contexts.

Further studying the effect of context on word recognition, Duffy, Henderson, and Morris examined word perception with and without context sentences [24]. They found that both the subject and the verb of the context sentence facilitated naming of target words while neither the subject nor the verb alone did. They also noted that the combination of both the content noun and the verb facilitated naming of target words regardless of the syntactic relation of the target word to the content noun or verb. The authors suggest that the automatic combination of content words within the mental lexicon of the reader facilitates word naming rather than the integration of sentence meaning at the message level. These results underscore the importance of using appropriate content words in sentences and considering word choice in context.

**Negation**

A number of semantic studies have examined how readers process negations, though it will become clear that this issue takes on a syntactic cloak as well. Gross, Fischer, and Miller found that antonymous word pairs are processed more quickly when the words are categorical opposites [25]. For example, the word pair alive/dead is processed more quickly than the word pair alive/lifeless. If the word lifeless appears soon after the word alive, the reader will follow a path from lifeless to its synonym dead and then back to the antonym alive. Apparently a reader’s semantic memory for text is organized by bipolar characteristics of antonymy and synonymy. When describing antonymous relationships, writers should select antonyms that are categorical opposites, a particularly valuable suggestion for constructing bipolar rating scales in questionnaires.

Other work on negation has assessed the effect of logical reversals. “We comprehend more rapidly that a particular light should be on than that it should be not off” [26]. Investigating the use of negatives in instructions, Jones found that readers understand and respond to positive instructions (e.g., Choose five items) faster and more efficiently than to instructions containing a qualifying negative such as except (e.g., Choose all except three items) [27]. In this example, the use of the exclusionary class (except) actually miscues readers, forcing them to search for one word class yet respond to another—a positive word class (e.g., choose). A similar scenario would exist in the sentence, “Check to see that the meter needle is not outside allowable range”; readers would recode it into its related positive form of “Check to see that the meter needle is within allowable range.”

Although some empirical studies find no difference between passive and active voice when readers have pragmatic expectations about the subject, verb, and object, it has been noted that active voice facilitates readers’ interpretation when they lack pragmatic expectations.

Also examining readers’ recoding of negative constructions into positive constructions, Just and Carpenter found that many predicate negatives are recoded into positive form [28]. With the sentence, “It is true that a fire isn’t cold,” the reader will recode the content in the predicate negative (“that a fire isn’t cold”) into the positive statement (“that a fire is hot”). Readers are less likely to recode the main or independent clause in “It isn’t true that a fire is cold.” Apparently predicate negatives are recoded at the time of comprehension and hence are recalled as positive constructions. The results of Jones’s and Just and Carpenter’s studies suggest that negatively phrased statements that are actually conveying positive content should be phrased as positive statements.

**Syntactic Manipulations**

Writers are constantly told to use active voice, denominizations (action-based verbs derived from nouns), and simplified syntax. Although some empirical studies find no difference between passive and active voice when readers have pragmatic expectations about the subject, verb, and object, it has been noted that active voice facilitates readers’ interpretation when they lack pragmatic expectations [29]. Pragmatic expectations are caused by the semantic sense of the nouns and the verb in a clause. For example, in the sentence, “The cat attacked the mouse,” readers expect cats to attack mice. These pragmatic expectations will hold and be of use in reading the passive construction, “The mouse was attacked by the cat.” However, if the two nouns had been cat and dog (instead of cat and mouse), a
reader would have had fewer pragmatic expectations to facilitate interpretation of the clause, since cats attack dogs and dogs attack cats. In such a case, active voice would be preferable.

Further examining the passive voice, Coleman constructed prose passages in which he used active-voice verbs to replace all passive-voice constructions and nominalizations [30]. He found improved comprehension for active-voice versions. In a later study, comparing active-voice sentences with passive-voice sentences, Coleman found that readers remember active constructions better than their passive counterparts [31]. He also noted that passive constructions containing the actors in the prepositional phrase are often stored in active form. In other words, the sentence, “The ball was thrown by John,” would be stored in memory as “John threw the ball.”

Although these results emphasize a general preference for active constructions, passive-voice constructions can be effective under certain conditions. When the prepositional phrase containing the actor is omitted from the passive construction, the reader will be forced to store the clause in passive form, thus creating a focus on the grammatical subject of the passive construction. In addition, writers can effectively use passive-voice constructions when readers have pragmatic expectations about the actors, actions, and recipients.

A few researchers have investigated the use of nominalizations and stacked nouns. Coleman examined the effect of denominalizations (changing nominalizations to verbs) on readers’ comprehension and found that denominalizations were easier to learn than the original nominalizations if the denominalization resulted in shorter clauses or the addition of a clause [31]. Murphy compared adjective-noun phrases with noun-noun phrases (stacked nouns) and found that noun-noun phrases took longer to interpret than adjective-noun phrases, if the adjectives were predicating adjectives (adjectives that, in a given context, could logically be moved to the predicate position, e.g., “the religious person” versus “the person is religious”) [32]. He also found that predicating adjectives were understood more quickly than nonpredicating adjectives (in the following context, religious is a nonpredicating adjective: “religious artifact” would sound quite amusing if we moved religious to the predicate position—“the artifact is religious”).

The results from the studies of voice, nominalizations, and noun stacks show that active voice, denominalizations, and adjective-noun phrases are sometimes easier for readers to learn and comprehend than their transformed counterparts. However, they also show that these general recommendations must be tempered by the interacting effects of other variables: in the case of passive voice, pragmatic expectations or the presence of the actor in the prepositional phrase; in the case of denominalizations, the number and length of clauses; and in the case of adjective-noun phrases, the nature of the adjective.

When writers reduce clauses or shorten the clauses, readers process the text more accurately and retain more information. These results suggest that we should restrain our use of embedded clauses and keep such clauses short when used.

Other clausal features have also been examined, specifically the effect of complementary clauses versus direct objects, and embedded clauses. When readers encounter verbs that can take either direct objects or complement clauses (e.g., “I believe the boy” versus “I believe that the boy was telling the truth,” respectively), the clause with the direct object is parsed and understood more quickly than the complementary clause when the conjunction that has been removed and left implicit [33]. When the that conjunction is restored, readers perform equally well with complementary clauses and direct objects. Given these findings, we must question the all too common editorial practice of deleting the word that from such clauses.

Assessing the influence of embedded clauses (clauses inside other clauses—often seen after relative pronouns, e.g., who, which, that), Larkin and Burns tested subjects’ recall and found that embedded clauses place extra demands on short-term memory, particularly when more than two embedded clauses are used together [34]. When writers reduce the number of clauses or shorten the clauses, readers process the text more accurately and retain more information. These results suggest that we should restrain our use of embedded clauses and keep such clauses short when we do use them.

Studies have also found that the presence of conjunctions between clauses and the order of clauses influences a reader’s comprehension. Irwin’s study of the effects of clause manipulations found that reversible causal relationships are understood better if the relationship is made explicit by the use of a con-
junction [35]. She also found that maintaining proper temporal order aids comprehension. If authors want to communicate causal relationships clearly, they should signal the relationship with an explicit conjunction and order the information according to the temporal nature of the content.

One last area of research on syntax focuses on anaphora or incomplete expressions that rely on earlier content for their meaning (e.g., pronouns and elliptical phrases). Clark and Sengul examined the placement of referents for noun phrases and for pronouns [36]. Subjects’ comprehension was better when referents were only one sentence before the noun or pronoun than when referents were two or three sentences back. In fact, a second experiment revealed that the best location for a referent was no more than one clause before the target noun or pronoun.

Additionally, Matthews and Chodorow found that antecedents were most quickly located when they resided late in the preceding clause [37]. Ehrlich examined pronoun antecedents and found that in identifying antecedents, readers follow gender cues first and then linguistic knowledge combined with event knowledge taken from the context [38]. The selection of a single referent from a set of potential referents is based on a set of prioritizing rules that are sensitive to the order and meaning of ideas within a text, and the features of surface syntactic structure.

Additional studies of anaphora have focused on elliptical verb phrases. Garnham and Oakhill experimentally varied the presentation of elliptical verb phrases and found more response errors, longer reading times, and longer question-answering times when antecedents were in less plausible contexts and were greater distances from their related elliptical phrases [39]. The authors argue that readers use both surface plausibility and structure cues to interpret elliptical verb phrases and that plausibility cues are more readily accessed than surface-structure cues.

Murphy also studied readers’ interpretation of elliptical verb phrases and found that long antecedents and syntactically inconsistent antecedents slowed comprehension [40]. As with pronoun antecedents, antecedents for elliptical verb phrases that are located further back than one sentence increase reading times. These results indicate the need for authors to maintain explicit links between referential elements that are critical to their arguments, especially when manipulating referential forms (such as pronouns or elliptical verb phrases).

Content and Organizational Aspects of Text

In the preceding sections, we have focused on relatively small textual units: words, phrases, clauses, and sentences. Here we examine studies of larger text units, specifically those of content and structure. We also discuss a number of studies that have examined the way structure is signalled in text.

Writers seeking advice on organizational strategies are told to group information, order these groups, and then use headings, previews, and topic sentences to reveal the logic for the groups and the order. Many studies have shown that memory is taxed when subjects must retain more than $7 \pm 2$ equivalent information units and that the memory load is reduced when the items are grouped [41]. Others have found the memory limit to be about $5 \pm 2$ items [42; 43]. Chunking (grouping) information decreases the demands on memory and improves content retention. Furthermore, readers organize information in long-term memory in a hierarchical fashion, verifying topical information faster and more accurately than detail information [44; 45].

Writers seeking advice on organizational strategies are told to group information, order these groups, and use headings, previews, and topic sentences to reveal the logic for the groups and the order.

The need to present information in context and in an expected order is explained by Haviland and Clark in their "given-new" theory of comprehension, wherein new information is best comprehended when it is logically and temporally linked to understood (or given) information [46; also see 47]. Needham reached similar conclusions in his study of speakers’ treatment of given versus new information—he identified shifts in a speaker’s strength of accent between given and new information [48].

Haviland and Clark further investigated the given-new theory by examining the effect of direct versus indirect antecedents and repetition of antecedent nouns [46]. They found that direct antecedents explicitly mentioning the existence of a referent to a noun in a subsequent sentence produced the quickest response times (e.g., direct antecedent: "Ed was given an alligator for his birthday. The alligator was his favorite present." versus indirect antecedent: "Ed was given lots of things for his birthday. The alligator was his favorite present.").
A second experiment revealed that subjects’ improved performance with direct antecedents was not due merely to noun repetition in the second sentence, because comprehension was faster for direct antecedents with noun repetition (e.g., “We got some beer out of the trunk. The beer was warm.”) than for indirect antecedents with noun repetition (e.g., “Andrew was especially fond of beer. The beer was warm.”). Haviland and Clark argue that while language may at first glance seem to contain an unnecessary number of redundant cues, these redundancies are necessary for effective communication [46]. Their results emphasize the necessary utility of redundant cueing, particularly the redundant cueing of explicit links between old and new information.

A very different approach to analyzing content selection and order was undertaken by Dixon in his study of context settings in instructions. Specifically, he examined the effect that object sentences (stating the object of the task described by an instruction) would have on the efficacy of written directions [49]. He found that placing an object sentence prior to a component step sentence (a sentence stating instructional steps) produced faster reading times and fewer production errors. Combining the two types of information into one sentence (object and component information), he found that the component steps were still read faster when the object information was presented first. For example, the statement, “To draw an x, do y” would be easier to read than, “Do y, to drawn an x.” Finally, he found that subjects produced significantly more object errors with no difference in component errors when the component information was presented without the object information. These findings argue that directions should be preceded by information on the purpose and structure of the task.

One final and very important aspect of text organization relates to revealing the logic of a text’s organization to readers. Many studies have found improved comprehension for readers of texts that use signals to cue readers about content relationships and topic sentences to announce new topics. Expanding on the research on reading strategies by Walker and Meyer [50], Loman and Mayer assumed that when readers approach unfamiliar or challenging expository text, either they use a rote reading strategy, in which they process information linearly, or they use a meaningful strategy, in which they link text-based information with information already stored in memory and thus impose a meaningful order on the incoming information [51; also see 52].

From this conception, Loman and Mayer hypothesized that readers would recall two types of information from text: conceptual information and detail information [51].

The authors further hypothesized that signals such as previews, headings, or logical connectives would function as cues for selective attention, with subjects recalling more conceptual information from signalled texts and more introductory or concluding information (primacy and recency information) from unsignalled texts. In their study, both good and poor readers of signalled texts recalled significantly more conceptual idea units and generated better answers in problem-solving tests than subjects who read unsignalled texts. Poor readers, when exposed to unsignalled texts, tended to recall more primacy/recency information.

The authors concluded (1) that signals guide selective attention to conceptual information, and (2) that signals encourage readers to build coherent links between information for later transfer to novel situations. Signals then should have great utility in situations where readers would be expected to resort to a rote rather than a meaningful reading strategy (for example, with difficult technical texts).

Headings and previews help readers design the superordinate level of the framework, and logical connectives help readers fill in the lower levels. Headings were of greatest benefit.

Further examining the effect of signals, Spyridakis tested the effects of headings, previews, and logical connectives singularly and in combination in a variety of technical expository texts [53; 54]. She found that when texts are long, unfamiliar, or difficult for even good readers, signals help readers build hierarchical frameworks in memory with which to accept incoming information. Headings and previews appear to help readers design the superordinate level of the framework, and logical connectives appear to help readers fill in the lower levels. Specifically, readers of signalled texts exhibited better comprehension of superordinate and inferential superordinate relationships than readers of unsignalled texts. Headings were of greatest benefit with relatively long passages and with delay tests.

Spyridakis and Standal also found significant effects for logical connectives and previews with less familiar and more difficult texts [55]. Few significant
comprehension effects occurred with easy or familiar passages, indicating that signals may have less effect when the material is relatively easy or familiar. Headings have also been shown to help with search-and-retrieval tasks and to reduce the cognitive load of readers [56; 57]. These findings support the judicious use of signals, especially headings, previews, and logical connectives, in texts where readers can be expected to experience some difficulty.

Some researchers have examined organizational issues at the paragraph level. Kieras investigated the validity of two paragraphing conventions: (1) beginning paragraphs with a topic sentence or a statement of the paragraph’s theme, and (2) linking each sentence to a previous sentence using the “given-new” presentation order [58]. His study revealed that subjects tended to reliably and accurately choose the topic sentence when it was presented in the initial position in the paragraph. He also found that poorly ordered sentences created a high memory load for readers by forcing them to hold unintegrable input in immediate memory; poor sentence order produced longer reading times and decreased recall. Writers should realize they can enhance a reader’s comprehension by placing the topic sentence at the beginning of a paragraph and by ordering a paragraph according to the given-new strategy.

Noting that major shifts in the underlying text structure and the introduction of new and difficult topic sentences both affect readers’ processing times, Lorch and Lorch investigated the effects of advance organizers, topic sentences, and logical organization [59]. They predicted that readers will recall more from a text when more cues are given about the text’s structure. They found that either a well-organized text or advance information about the text’s organization led to better recall of topic information. An informative introductory paragraph also aided recall, even in the absence of a logical ordering of topics. Lorch and Lorch also found that topic recall was best when paragraphs had topic sentences.

These results emphasize the effectiveness of emphasizing the topic structure of written discourse by using advance organizing information, topic sentences, and logical organization.

**READER VARIABLES AND READING COMPREHENSION**

At this point it should be apparent that readers are not passive responders to incoming textual stimuli. One last area of research we review relates to the fact that readers must actively attend to incoming messages while simultaneously accessing old information so they can integrate new information into a general text meaning [60]. Considering the reader’s retrieval of old information takes us to some studies that have investigated the effect of prior knowledge on reading, the area of reader attributes that has received probably the most attention in the reading-research literature. We conclude this section with a short discussion of other reader attributes that can also affect reading and comprehension.

**Prior Knowledge**

Writers are often told to “know their audience,” to know how much their readers know about a topic. Much of the research on the effects of prior knowledge relates to the design of texts and learning materials and has been conducted from the theoretical standpoint associated with David Ausubel, who did some of the original work on advance organizers, or “ideational anchors” [61]. In general, researchers have noted that prior knowledge can affect comprehension in two basic ways: (1) by inadequate activation and use of prior knowledge, and (2) by activation of topic-relevant prior knowledge for learning [62–66].

Pointing out that meaning may not be inherent in text, Anderson, Reynolds, Schallert, and Goetz used the notion of “schemata” to describe the network of knowledge relations that a reader may bring to a text in order to develop meaning [67]. The authors argue three primary points:

1. Readers comprehend a message’s meaning when they construct a correspondence between their relevant schemata and the given propositions in a text.

2. Schemata allow readers to make the inferences necessary to elaborate incompletely explicit texts.

3. These high-level schemata can so strongly impose an interpretation that readers may be unaware of alternative interpretations. Their study indicated that subjects tended to interpret a passage in one distinct way and that these interpretations were consistent with their backgrounds. Few subjects were even aware of alternate interpretations.

Pearson, Hansen, and Gordon investigated readers who possessed strong or weak schemata for a topic and concluded that readers with strong schemata were more able to infer implicit relationships [68].

In a study of discourse recognition and verifica-
tion, Kintsch, Welsch, Schmalhofer, and Zimny noted that readers who had inadequate situational understanding of text meaning made quick judgments based on surface and text-based characteristics of sentences, while readers with more adequate situational understanding used their situation model successfully and required more processing time [11].

Lipson found that readers familiar with textual information were better at acquiring totally new information than correcting inaccurate old information [69]. These findings underscore the need for authors to have a thorough knowledge of their readers’ prior knowledge.

Careful writers will create documents that reduce the demands on readers—allowing readers to allocate effort to document aspects that cannot be simplified. Careful writers also consider the reader’s prior knowledge, cultural background, age, motivation, and reading ability.

Many researchers have noted the profound influence that cultural schemata can exert on a reader’s comprehension. Steffensen, Joag-Dev, and Anderson compared the performance of readers from different countries (India, U.S.) and found a significant interaction of nationality and content, with each cultural group performing best (recalling more idea units and reading more quickly) with a passage from its own culture [70]. When reading passages based on other cultures, each cultural group made more errors in elaborating idea units and constructed inappropriate schemata based on content schemata from its own culture.

Lipson, defining culture in terms of religious affiliation (Catholic, Jewish), found that readers relied on culturally based content schemata appropriate to their religious background [71]. Subjects took less time to read a culturally familiar passage, and recalled more correct, explicit, and inferred information from the culturally familiar passage.

Reynolds, Taylor, Steffensen, Shirey, and Anderson examined the effect of race (black, white) and residence (urban, rural) on content schemata and found that readers interpreted passages on the basis of their own cultural schemata [72].

McClure, Mason, and Williams found that different cultural groups used different strategies for making a narrative coherent and for choosing initial and final sentences in stories [73]. Readers who lacked the schema used in a given story exhibited poorer comprehension because of the mismatch between the reader’s and the story’s structure schemata.

Finally, Pritchard’s study of Palauan versus American readers discovered that with culturally familiar topics, readers use more global processing strategies, make more intrasentential connections, recall more information, and make more elaborations [74]. Readers of culturally unfamiliar topics make more distortions and more pauses while reading. He also noted that readers from different cultures vary in the frequency with which they use different reading strategies.

Some researchers have noted that prior knowledge that conflicts with a text’s intentions can actually impede comprehension. Alvermann, Smith, and Readence addressed this potential for interference by focusing on the differential effect that prior knowledge has when a text is either compatible or incompatible with the prior knowledge [75]. In general, their results support the notion that activated incompatible prior knowledge overrides the text’s intent during comprehension.

Recht and Leslie, grouping subjects by strength of schemata, found that strong prior knowledge overrode text-based information and that when prior knowledge was compatible with the text, there was no facilitatory effect [76]. Lipson found that subjects with no prior knowledge performed better than subjects with inappropiate prior knowledge [69].

These results confirm the notion that authors must be aware of the audience’s prior knowledge and existing beliefs. These results also indicate that when authors present information that is counter to readers’ existing prior knowledge, they must exercise great care.

Age, Motivation, and Reading Ability

A number of other reader variables have been investigated with respect to their effect on reading and comprehension, including age, motivation, and general reading ability. A number of investigators, for example, have noted that older readers may be deficient in the processes associated with storing and retrieving information from memory, and have thus hypothesized that older readers may benefit more from cueing or signals [60]. Zelenski, Light, and Gilewski found that older adults (ages 54–68) recalled less from text than younger adults (ages 20–36) but that both age groups were equally sensitive to passage structure [77; see also 78].
Faas and Schumacher investigated reader motivation, starting with the assumption that a reader's motivation may have an effect when that reader encounters troublesome text [79]. They examined recall for text under the effect of high and low motivation (different levels of payment for performance) and in the presence of a related activity. They found that easy passages and high motivation produced better performance, and high motivation seemed to overcome the effects of low readability. Subjects who were instructed to underline text segments appeared to improve performance only when they were motivated and given a difficult text. These findings again indicate the importance of an author's knowing a great deal about the audience, including some information about its motivation level.

A number of studies have also noted the differences that readers with poorly developed reading skills bring to their interaction with a text. While it has been shown that humans are capable of rapidly shifting the types of behavior they exhibit in response to verbal stimuli [80], good and poor readers may differ in their ability to change their reading behaviors across a variety of texts. Good readers appear to be better able to tailor their responses to the specific stimuli of the text, reading more for meaning; poor readers appear to use a small number of strategies independent of the nature of the stimulus text, reading in a much more linear or rote fashion [50–52; 81–83].

Poor readers also appear to be less able to adjust their general responses to a specified purpose and are more constrained in comprehension by the word-level context [84–86]. Good readers are also better able to differentiate, respond to, and recall text units based on their relative importance with respect to the text as a whole [87–91]. Finally, the eye-movement patterns of good readers show more flexibility across texts, while those of poor readers show more linearity and erraticness [83; 92].

However, while these distinctions might appear to be the result of learning history or biological constraints, at least one study has shown that good readers can be made to perform in patterns similar to poor readers, given difficult and unfamiliar text. Wenger demonstrated that skilled readers of demanding and unfamiliar technical text versus skilled readers of less demanding and more familiar text (1) recalled less information; (2) were more likely to read in a list-wise fashion, ignoring cues as to the importance of idea units and showing primacy/recency effects in their recalls; (3) distorted the meaning of the text in their recalls; and (4) had more difficulty applying the information they had read [93; see also 94].

These observations underscore the importance of considering the difficulty of technical material designed for technical professionals. Readability and usability are issues that have been most publicly associated with information designed for lay or not highly technical audiences. This study points to the need for similar concern for technical information products designed for experienced, technical readers.

**Conclusions**

We have attempted to show the relationship between the published literature on reading and comprehension of text and the design of documents. The studies cited here reveal that numerous textual and reader variables affect how well and how easily readers discern an author's intended meaning. Careful writers will lean toward creating documents that, whenever possible, reduce the demands on readers—thus allowing readers to allocate effort to document aspects that cannot be simplified. Careful writers will also consider the reader's prior knowledge, cultural background, age, motivation, and reading ability.

It is perhaps best to view the findings on text variables as resting on an easy-to-difficult continuum. If writers make all choices from the difficult end of the continuum, they will most certainly overload their readers. A reader-friendly document should exhibit document-design decisions from all parts of the continuum. For example, text sections containing low-frequency words might use simplified syntax to aid the reader. Detailed or complex concepts might be chunked into fewer than six or seven items per chunk. When appropriate, nominalizations might be denormalized to create more verbs and hence more clauses, yet the writer might decide that given an increase in the number of verbs, the reader will be able to tolerate more passive-voice constructions, particularly with verbs that have pragmatic expectations.

These decisions amount to a balancing act—writers should realize when they are taxing their readers with one set of document-design decisions and identify methods to reduce their readers' processing loads with other decisions.

Additionally, a reader-friendly document should be sensitive to given readers' knowledge sets and
abilities, and document designers should make design decisions accordingly.

Finally, document designers should consider the added effect of layout and graphics variables, factors beyond the realm of this paper.

One problem remains, though. Readers of this paper must certainly be wondering how they can find other empirical literature pertinent to document design and how they might synthesize that literature with the information presented here. Thus, we close by offering a small set of recommendations and general encouragement. The reader interested in following the literature should locate the journals cited at the end of this paper. Our recommendation would be to find these journals in your local university library or your company’s technical library and check their tables of contents on a regular basis. You are certain to find articles occasionally that directly or indirectly address the concerns and decisions you face on a daily basis.

Once you have located an article that you think may be of interest, keep a structured set of notes as you read. Write down the central questions posed by the investigators. Note the methods they use to ask those questions and measure the answers. Summarize their results and decide for yourself whether their conclusions make sense. Finally, think how those conclusions might apply to document design.

Keep in mind that, although there may be a difference in the level of analysis applied in the study and the level of analysis that may be pertinent to your work, you may still abstract some application from the work. Most applied professions are built on a solid scientific framework, constructed by researchers who may have little sense of the application of their findings to practical problems. It is the inventive engineer, clinician, or technical communicator who is able to take these findings and see their application and potential advancement.

REFERENCES


57. B. K. Britton, S. M. Glynn, B. J. F. Meyer, and M. F.


89. Priscilla A. Drum, "Prose Recall Responses and Categorizations for Scoring," in P. David Pearson and Jane Han-
The Communicator's Portfolio: The Ideal Saleskit

Barbara McDaniel
CTB/Columbia

Roberta Sheng-Taylor
Vancouver General Hospital

It's 9:30 A.M. on a Monday morning. Big interview for your first job, maybe your next contract, or perhaps a meeting with one of your company's other departments. Sound familiar? Here's your chance to sell your profession and your skills, and make a lasting impression. You've arrived, coat off now and soaking umbrella under your chair.

"Great! Let's get started," says the interviewer. "Show me your writing samples, and tell me what you do."

You lift your loose and unorganized samples from your battered briefcase (or from a tattered manila envelope), and spread them across the interviewer's desk. "Tell me what you do!" you reflect, nervously. A couple of pages fall to the floor. "Come on, get organized," you say to yourself.

Or perhaps you're a little better organized. You have brought along your last manual, so you proudly plop the binder on the desk, heavy with its 500 pages. The interviewer gapes at the formidable tome and grimaces, trying to decide how to evaluate the quality of this monument to the paper god.

If this were a job interview, what kind of impression would the interviewer form of you? If this were an interview for a contract position, what would the potential client think of your company and its writer? Or if this were an internal meeting, what sort of impression of the company's writers would you give your colleagues?

Sometimes it's frustrating to be a communicator. How do you know what to say in such circumstances? How can you hope to remember that great project that the interviewer would be very interested in? (When you're so nervous, it escapes your memory.) How can you prove that you produce consistent, high-quality, professional, cost-effective work? And how can you demonstrate all the skills and abilities that a technical communicator should have, and erase misconceptions, (that you just correct the secretary's work, for example, or just make things "look pretty")?

Answer: The Communicator's Portfolio.

The Ideal Saleskit

The portfolio is the ideal saleskit for communicators. The portfolio does not replace your resume or company literature, but it supplements these other tools. Your resume identifies your skills, talents and experience; your literature describes what you can do; and your portfolio demonstrates. Your portfolio is a self-contained unit that presents your work in an impressive format. Whether it is a large leather