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Is It the Medium or the Message?

Structuring Complex News to Enhance Engagement and Situational Understanding by Nonexperts

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An experimental design, theoretically motivated by cognitive models of text comprehension, investigates effects of structures in complex news on readers (undergraduate non-science majors) who have little or no expertise for the content (science and technology). Text from two *New York Times* stories were modified for a proposed explanatory structure building (ESB) model to enhance reader interest in and comprehension of the content. Dependent variables include self-reported situational interest and a deeper situational understanding of the text as measured by sorting tasks and inference-generating questions. A between-subjects field experiment exposed participants (N = 235) to text on a Web page in either the traditional inverted pyramid or ESB structure. As predicted, when controlling for pretest levels of scientific literacy, the ESB news text significantly enhanced reader interest and understanding of the content, as compared to the original inverted pyramid news stories. Results are interpreted in the context of enhancing the public understanding of complex news issues.

Keywords: *science communication; health and technology; interest; news discourse; news comprehension; situational understanding*

In his book *Understanding Media*, Marshal McLuhan (1964) introduced the world to his enigmatic paradox that "the medium is the message." Congruent with McLuhan's theory, myriad communication studies since the 1960s have sought to explain macro-scale effects of exposure to news by measuring the public's attitude or perceptions or its recall and recognition of news content. We are reminded, however, that the definition of media effects also includes influences of either the form or the content of media (McLeod, Kosicki, & Pan, 1991; McLeod & Reeves, 1980). Accordingly, this study posits that the public's reception of complex news issues is defined not only by mere exposure or attention to content and that exposure

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and attention may not always lead to an understanding of issues or individual action.

This study explores how message structure can affect one's understanding of complex news, such as news about science and technology. This research also investigates the relationship of reader interest and understanding. The implication is that attention to content, and a thorough understanding of it, are fundamental yet crucial antecedents to an individual's subsequent involvement with complex issues. In communicating news about global warming, for example, civic participation is only one of many possible outcomes (Stamm, Clark, & Reynolds-Eblacas, 2000). The supposition is that a reader may also misunderstand or misinterpret the content or be confused by it, all of which could threaten interest and understanding.

News about science and technology is content for which the public generally has interest but only a limited understanding (Miller, 1986, 2004). On one hand, Web users ranked their interest in science in fourth place, behind news about sports, health, and crime (National Science Board, 2004). On other hand, some researchers assert that four out of five Americans cannot read and understand the science section of *The New York Times* (Miller, 2004) and that high school seniors enrolled in at least one science course had difficulty interpreting meaning in science news (Norris, 1994). These data suggest that despite the public's capability to acquire an increasing amount of science and technology news via the Internet, public scientific literacy remains relatively low. For example, between 1997 and 1999, the number of adults who could accurately define a molecule increased marginally from 11% to 13% (National Science Board, 2000).

Why is this so? Although there is much research about the public's limited understanding of science and technology, few studies to date have investigated how the structure of complex news messages can affect processing. To do so, one strategy is to synthesize the rich theoretical history and psychological models of text comprehension with the reading and comprehension of news content.

Therefore, this interdisciplinary study combines theoretical concepts from cognitive psychology, mass communication, and educational psychology to explore a model for more effective communication of complex news issues, such as science and technology.

Investigating effects of complex news content is important because science and technology news is pervasive in the media, and mass media are significant sources of science and technology news for the general public (Wellington, 1991). Not only can the public learn science from the popular media (C. W. Anderson, 1999; Norris & Philips, 2003; Shortland, 1988; Sutman, 1996), science news can influence what people believe and affect broadly based public deliberation about science-related issues (Pellechia, 1997).

According to the National Science Board (2000, 2004), some experts believe that there is no general audience for science and technology news and that such news should be tailored for only the "science attentive public." It is not yet clear, however,

how these messages should be tailored for maximum effectiveness. Accordingly, this study asks

> *Research Question:* How could news about unfamiliar content be better structured to enhance interest and understanding by those with little or no expertise for the content?

To pursue answers, this research measures (a) inferences that nonexperts generate (or fail to generate) when comprehending different structures of science and technology news and (b) the relationships of message structure and a reader's interest in complex content and his or her ability to generate inferences. This study builds on previous studies that measured relationships between journalists and scientists, global strategies for producing news content, and comparisons of learning from the Web versus print (Dunwoody, 1992, 2001; Eveland, Cortese, Park, & Dunwoody, 2002; Eveland & Dunwoody, 2001, 2002).

This reception analysis of micro-level effects could also inform the literature about meso- or macro-level effects of mediated messages.

News Structures

Science journalists define and organize scientific information in certain ways, and that organization can influence thoughts (Einsiedel, 1992). In the second half of the 19th century, however, the so-called inverted pyramid (IP) news structure replaced more commonly used narrative styles in American news reporting (Kaplan, 2002; Mindich, 1998). Because many reporters and editors still consider the most recent story details the most newsworthy, the IP story structure is often used to place the most recent details first.

Many journalism textbooks, such as *Writing for the Mass Media* (Stovall, 2002), continue to endorse the IP structure in print and on the Web. Advocates argue that the IP encourages Web users to slow down and actually read: "Since users tend to scan rather than read, it can be difficult to draw them into a story using the narrative's indirect-lead approach" (Foust, 2005, p. 149).

On the contrary, others believe that arranging news only by importance is something of a dinosaur. They make the case that news production is not a direct representation of events but a form of discourse processing (van Dijk, 1983) and that science journalists, in particular, could structure their messages for more meaningful processing by an audience that possesses low levels of science knowledge (Dunwoody, 1992). Indeed, there is evidence that the IPs of science stories often omit important contextual information (Pellechia, 1997).

Justification for studying potential effects of message structure includes evidence that linear news stories can evoke more suspense than traditional inverted-type

narratives (Knobloch, Patzig, Mende, & Hastall, 2004) and that different news structures can be correlated with differing emotional responses (Bower & Cohen, 1982; Knobloch et al., 2004; Lang, Newhagen, & Reeves, 1996). These data motivate this study's fusion of mass communication with well-researched theory in psychology and models of text comprehension.

Theory of Text Comprehension

Text is not only one of the most important means of conveying information but is central to learning at all levels of education (McNamara, 2001). Because nearly 85% of all college learning still involves reading (Nist & Simpson, 2000; Voss & Silfies, 1996; Woodward, 1993), communication scholars and journalists alike may have much to gain from the rich research history of how individuals process text and the interactions between text structure and reader knowledge (Roller, 1990).

Prominent text comprehension models include the structure-building framework (Gernsbacher, 1990, 1993, 1996) and the construction-integration model (Kintsch & van Dijk, 1978). Both models are based on the fundamental goal for readers to construct a mental representation of the text being read. The structure-building framework states that a reader lays "a foundation" for the initial text, and then, assuming subsequent content is coherent, the reader maps incoming information that relates to the foundation (Gernsbacher, 1996).

Evidence for this foundation-building process is that readers take significantly more time to comprehend the first words, sentences, names, and pictures of a text but significantly less time to recall the same information (Gernsbacher, 1983). As one continues to read, one's mental structure is either enhanced by new information that relates to the previous information or suppressed by less familiar information (Gernsbacher & Faust, 1991a, 1991b).

When unfamiliar content suppresses readers' mental structure, the framework model predicts that readers "shift" to build new substructures**.** Readers with little or no prior knowledge for the content may be forced to shift too often and develop too many substructures (Gernsbacher, Varner, & Faust, 1990). In the context of this study, the structure-building framework predicts that readers who are nonexperts for the textual content are less able to reject contextually inappropriate meanings and ambiguous words, which inhibits understanding (Gernsbacher, 1990).

Particularly applicable to this study is research in psychology that found details placed early in news stories are often associated—in subsequent sentences—with unrelated details of other events without first explaining the primary event (van Dijk, 1985, 1988). Based on Gernsbacher's (1990, 1993, 1996) model, this discontinuity of news events can also threaten a thorough understanding of the content.

Another fundamental but important factor in understanding a situation expressed by a text is the reader's ability to recognize and generate associative links from the

content. The construction-integration model (Kintsch & van Dijk, 1978) states that text coherence is established by the number of associations between a story's lead sentence or paragraph and subsequent sentences. If a reader cannot identify relationships among ideas expressed by a text, he or she may feel that the story lacks coherence.

Again, analyses by van Dijk found that frequent topic changes in news stories contribute to discontinuity. Discontinuity, van Dijk argues, forces readers who are patient enough to continue reading to unscramble "bits and pieces of information" and then fit those bits of information into the appropriate topics and schematic categories (van Dijk, 1985, 1988). All of this suggests that reading news about relatively complex issues, such as those about science and technology, requires substantial cognitive resources.

In contrast to the IP structure, van Dijk (1985, 1988) proposed a global news schema structure to minimize readers' shifting of topics. Instead of always placing the most recent events at the beginning of stories, van Dijk proposed a blending of recent facts with historical and contextual information. Contextual information includes quotations, expectations, and evaluations from those related to the story. This study tests van Dijk's schema structure by applying theoretical concepts of reading comprehension and adding the dimension of explanatory text to see if it increases coherence of news about science and technology for nonscientists.

Explanation in Complex News

Gernsbacher's (1990, 1993, 1996) structure-building framework supports those who also point to the importance of explanation in science discourse (Mayer, 1985b; Ohlsson, 2002). Explanatory text is effective when there is a "partnership" of shared knowledge and skill between a writer's description and the reader's understanding of that description: "Explanations are answers to questions, particularly questions about why an event happened, why something is the case, and how a particular state of affairs came about or why it persists" (Ohlsson, 2002, p. 93).

Content analyses have found only limited explanatory text in science and technology news. As examples, one analysis of science stories in 70 U.S. newspapers discovered that 10% or less of the stories provided explanations of scientific terms (L. Long, 1991, 1995; M. A. Long et al., 1991). A second analysis of 161 science stories revealed that most of the stories included primarily the details about where the research was conducted, the identity and qualifications of the researchers, and the researchers' comments (Zimmerman, Bisanz, Bisanz, Klein, & Klein, 2001). The implication is that news about science and technology often fails to implement Ohlsson's (2002) notion that the writer-reader partnership is an important one.

The explanatory structure building (ESB) model proposed by this study tests the writer-reader partnership by investigating the relationships of coherence and explanation in complex news with readers' interest and understanding. Based on the

cognitive theories discussed, the ESB model posits that readers with little or no expertise in science and technology will express more interest in the content when the content is structured for readers' general world knowledge. In addition, the ESB model attempts to facilitate a deeper understanding of news by applying concepts from the structure-building framework and textual coherence from the Kintsch and van Dyke models.

Operationally, the proposed ESB model prioritizes explanatory content in news and, when possible, places recent details and events into historical context. Theoretically, a reader's understanding of complex news requires the same knowledge structure—or an explanation for that knowledge—as the writer of the story (Ohlsson, 2002). "To learn, one must already know much about what is to be learned" (Kintsch, 1990 p. 93).

Acknowledging that measurements of reader interest and understanding can be challenging, these dependent variables are conceptualized in the context of situations.

Situational Understanding

According to the seminal work by Kintsch (1988), a reader's text-based understanding of content is differentiated from his or her situational understanding. Text-based understanding is used often in communication research to measure recall or recognition of previously read text. Situational understanding, on the other hand, depends more on a combination of explicitly stated information plus the reader's world knowledge and inferences and elaborations generated by the reader. By definition, text-based understanding is not as thorough as situational understanding and may explain why a reader who recalls a phrase from a text may be unable to elaborate on its meaning or context. One psychological explanation is that a reader's well-established situation model provides many of the semantic and contextual features necessary for reactivation of relevant information presented in a text (O'Brien & Myers, 1999).

Situational understanding of a text facilitates a reader's ability to make bridging inferences that associate terms within a text. For example, high-knowledge readers are significantly better at making bridging inferences than are low-knowledge readers (Britton & Gulgoz, 1991; McNamara, 2001). This implies that readers who do not possess the knowledge to make gap-filling inferences require a fully coherent, fully explicit text to understand it (McNamara, Kintsch, Songer, & Kitsch, 1996). It is important to note, however, that because text-based understanding can also contribute to a reader's situational understanding, the distinction between the two levels of understanding is not absolute but a matter of degree.

Not surprisingly, science and technology news includes terminology that requires logical or analytical understanding (Lemke, 1990). Therefore, it is assumed that the public's familiarity with science and technology issues is generally less than its familiarity with more commonly reported news about auto accidents, fires, entertainment, and so on. Unfortunately for producers of news, if a nonexpert is unable to make

inferences while reading a news story and integrate the information with his or her prior knowledge, the potential for situational understanding is reduced (Kintsch, 1988). For that reason, the proposed ESB model predicts that if situational understanding is muted, a reader's situational interest is also reduced.

Situational Interest (Engagement)

Interest in specific content can influence a reader's selective exposure to content (Ettema, Brown, & Luepker, 1983; Genova & Greenberg, 1979; Kwak, 1999; Viswanath, Kahn, Finnegan, Hertog, & Potter, 1993). When a reader becomes disinterested in a news story, he or she is likely to terminate reading (Eveland & Dunwoody, 2001).

Analogous to the distinctions between text-based and situational understanding, theory from the field of educational psychology also differentiates individual interest from situational interest.

Individual interest is uninterrupted interest in a specific content domain that develops slowly over time and tends to have long-lasting effects on a person's knowledge and values (Renninger, Hidi, & Krapp, 1992). Because individual interest in a domain is established a priori, it may be detected prior to exposure to specific content about that domain. To illustrate, a communication scholar would likely exhibit individual interest in reading communication research prior to exposure to a specific communication study.

Conversely, researchers have also explored the extent to which specific content influences cognitive performance across individuals. Situational interest is defined as the influence of characteristics in a specific learning environment (e.g., interestingness of a text) at a given point in time that captures the interest of many individuals (Hidi & Baird, 1986; Hidi & McLaren, 1990). Unlike those with known individual interest, readers with little or no prior interest in a domain may—for a variety of reasons—exhibit situational interest in a specific stimulus, such as a single news story.

In other words, situational interest tends to be evoked suddenly by the environment, usually having only a short-term effect and marginally influencing the knowledge and values of someone who has little or no familiarity with the domain. For the purposes of this study, situational interest is elicited if someone with little or no previous interest in science and technology reads the first words of a science or technology story and wishes to continue reading (Krapp, 1988).

To clarify, individual interest in a domain does not always guarantee that an individual will read a given story. For example, an expert who decides not to read a story related to his or her field can still exhibit high individual interest but low situational interest. Alternatively, a nonscientist who chooses not to read a science story exhibits both low individual and situational interest. Knowing a priori if a reader does or does not have a long-term interest for a specific content can enhance the validity of measurements for situational interest.

Within the uses and gratifications paradigm, research suggests that motivation can also play a role in readers' attending to and learning content. There is, however, evidence that this is not always the case. Eveland and Dunwoody (2001) found that readers who self-reported motivation to learn from news actually learned less from a news story than did readers who did not claim such motivation. Others found that it does not always matter whether one intends to learn but how one processes the presented material (J. R. Anderson, 1980).

These findings remind us that although a reader's motivation can influence processing of information, motivation alone does not guarantee situational understanding of the information. Referencing the text comprehension theory, one possible explanation is that the reader may not possess the prior knowledge to generate appropriate inferences for situational understanding. A second reason is that an ineffective message structure exposed to a motivated reader with insufficient knowledge fails to generate situational interest, prompting the individual to terminate reading. Given these possibilities, the proposed ESB model predicts

Hypothesis 1: Situational understanding will be greater for unfamiliar news in an ESB story than the same news in an IP story when controlling for pretest scientific literacy.

Hypothesis 2: Situational interest in unfamiliar news will be greater for an ESB story than the same news in an IP story.

Hypothesis 3: Situational interest and understanding for unfamiliar news will be positively correlated for an ESB story but not for the same news in the IP story.

Method

Overview

Much previous research assessed learning from news with measures of cued recall and recognition of previously viewed content. Given the evidence of the public's limited understanding of science and technology, this study employs alternate measures to tap readers' deeper understanding and to investigate the relationship of message structure, reader knowledge, and situational interest.

Participants

A total of 235 participants were recruited from an introductory meteorology course open to non-science majors at a large midwestern university. Students earned extra course credit in exchange for their voluntary participation. The mean age was 19.35 years (SD = 1.47), with 54% female participants and 46% male. The majority of the participants (46%) reported that they were sophomores and, with exception of 8 participants, all were either non-science majors or undeclared. Among the 8 students who were not, 1 student majored in biology, 1 in chemistry, and 1 in astronomy, and the

remaining 5 majored in engineering. The mean number of completed high school science courses for the sample was 3.98 courses (SD = 1.14), which exceeded the number of completed college science courses (M = 1.30, SD = 1.47). The sample's mean score on a 12-point pretest measure of civic scientific literacy (described in the materials section that follows) was a relatively high 9.81 (SD = 1.43).

Design

A 2 (story content) × 2 (text structure) factorial design was employed to measure effects of text structure on readers' self-reported situational interest during and immediately following exposure to the news story. Situational understanding was measured after exposure to the entire story. To enhance internal validity of the study, the experiment was conducted in the field (online), with participants accessing one of the two levels of health news or technology news. To enhance external validity, the two levels of text structure (IP vs. ESB) employed actual news stories.

Materials

Two stories were chosen from a total of four stories selected from *The New York Times's* Web site. The four stories were about climate change, the use of MRI scans for breast cancer detection, effects of marijuana use, and the use of viruses in nanotechnology research. As a pretest, the four stories were exposed to a convenience sample of 5 male and 5 female undergraduates who read and then ranked the stories on the dimensions of complexity, perceived importance, and familiarity with the specific content.

On a scale of 1 to 4, a score of 1 represented the least complex, the least important, but the most familiar story, and a score of 4 indicated that the story was judged to be the most complex and most important story but was least familiar. Scores were summed for all four stories. The two stories ranked as the most complex, least familiar, but most important were the health and cancer research and the viruses and nanotechnology stories. The original texts from these stores were used as the control treatments. The experimental treatments were the modified stories as described later in this section.

The health story from July 24, 2003, consisted of 642 words (see Appendix A). The modified (ESB) version of the health story contained 638 words. The selected technology story from February 12, 2004, consisted of 775 words. The modified (ESB) technology story contained 781 words. Both stories were posted online at least 9 months prior to this experiment.

A pretest of familiarity for the original *New York Times* stories was performed using a separate sample of undergraduate non-science majors (N = 274). On a scale of 0 (*no familiarity for the content*) to 5 (*much familiarity*), the mean score for health news was less than 1 (M = 0.77, SD = 1.06) and was even less for the nanotechnology news (M = 0.31, SD = 0.74).

Although most of the original text of both stories remained unchanged, the modified (ESB) texts included a different paragraph order. Guided by van Dijk's (1988) analyses of news, the paragraphs of each story were categorized into three categories by two independent coders. Paragraphs describing the main events of the story were coded as "situation," and paragraphs with historical or explanatory content as "background." Paragraphs coded as "comments" included mainly quotes from observers related to the situation. Intercoder reliability for the health story produced a Cronbach's alpha of .85 ($M = 1.95$, $SD = 0.75$). Reliability for analyses of the technology story revealed a Cronbach's alpha of .87 ($M = 1.88$, $SD = 0.53$).

Paragraphs were then arranged by category to conform to the concepts of coherence and explanation as defined by the text models reviewed. Specifically in the technology story, paragraphs in original text describing the historical, contextual, and explanative, which appeared later in the story, were blended with the lead paragraphs in the modified (ESB) story. In the health story, details about the researchers and their institutions (coded as "credits") were moved to after the "situational" content. This consolidated the number of paragraphs in the health story's ESB version from 15 to 13.

Analyses for relational density and explanation were performed for both stories using a protocol that divides sentences into individual "idea units" (Mayer, 1985a). One idea unit is defined as a word or phase that represents a single event, state, or action.

According to Mayer (1985a), individual idea units can manipulate reading strategy. Dividing text into single idea units can also help to identify scientific terms and processes that could be elucidated with explanatory text for situational understanding by low-knowledge readers.

To illustrate, a numbered list of idea units for the first two sentences of the technology story is presented in Appendix B. Explanatory text (in italics) replaced each underlined term.

The original *New York Times* health story produced 222 idea units that contained 55 scientific terms. Only 2 of the 55 terms were accompanied by explanatory words, indicating that approximately 96% of the unexplained terms in the original health story required readers' prior science knowledge to generate inferences for situational understanding.

To further illustrate the relatively minor modifications to the original text, the following lead paragraph from the technology story includes underlined words to be explained or relocated for the ESB version.

> Living organisms do a fine job of growing crystals, like the ones that make up abalone shells, for example. But there are lots of other inorganic materials, including those that make up semiconductors, that living things haven't gotten around to producing. That may change, though, with some help from a tiny benign virus and a professor at the Massachusetts Institute of Technology.

Here is the modified ESB version of the same paragraph with modifications in bold:

> Living organisms do a fine job of growing crystals, like the ones that make up **some seashells**, for example. But there are lots of **other materials**, including those that make up semiconductors [explained in graf 2], that living things cannot yet produce. That may change, though, with help from a tiny **particle that lives as a parasite in plants and animals**. **The particle is a harmless virus.** [MIT relocated to a subsequent paragraph]

The instrument used to measure the dependent variable of readers' situational interest combined two indicators. First, participants indicated their interest in continuing to read after they read the story's first paragraph. Using a scale of 0 to 4, participants used 0 if they wished to terminate reading and 4 if they were very interested in continuing. After reading the entire story, participants again used a scale of 0 to 4 to indicate how interesting they found the story to be overall. A rating of 0 meant *not at all interesting* and 4 *very interesting* overall.

Measurement for situational understanding employed a battery of questions, including free recall of details and sorting tasks. Previous psychological research found that reading a text changes the way a reader organizes concepts in predictable ways (McNamara et al., 1996). McNamara and her colleagues (1996) showed that the way readers sort concepts after reading is based on a combination of the readers' episodic text memory plus their prior knowledge.

Prior knowledge is assumed to be necessary for the reader to fill contextual gaps within the text and to develop a global understanding or situation model (Kintsch, 1988). Therefore, participants in this study were asked to sort 15 different terms and processes expressed by the story into contextual categories.

In addition, a free recall measure asked participants to write a brief but specific explanation (not just a general description) of the story. Participants were instructed to explain the story as though they were communicating it to a friend, roommate, or family member with little or no expertise for the story content. Theoretically, explaining a story's situation to another individual requires bridging inferences to accurately represent the story's overall situation.

To measure the amount of recalled information, Mayer's (1985a) idea unit protocol (used to analyze the original texts) was used to analyze the explanation generated by each participant. A final measurement of understanding asked participants to answer 12 true-false questions and a detailed multiple-choice question about explicit details contained in the text base.

Procedure

After completing an in-class consent form, participants were randomly assigned to access 1 of 4 unique Web addresses, each containing one version of the story.

Participants could access their assigned story from any computer at a time of their choosing. A sever log verified each participant's start time and site navigation.

Participants were given a 4-day deadline to complete the experiment and were told that they would be disqualified if they (a) accessed the Web site more than once, (b) navigated backward during the experiment, or (c) took an unusually long time to complete the brief study. An hour to read the pages and survey, for instance, would suggest that the participant did not employ reasonable viewing behavior.

After accessing their assigned Web site, participants first completed a survey asking the number of science courses completed in high school and in college, plus their interest in 12 news domains ranging generally from music and sports to the target domains of health and technology. Participants' civic scientific literacy was also assessed using 12 true-false questions implemented by the National Science Foundation as a measure for its *Science and Engineering Indicators* (see_http://www.nsf.gov/sbe/srs/seind04/start.htm). Literacy scores were used as a covariate in subsequent statistical analyses of situational understanding.

Cronbach's (1951) alpha reliability coefficient for the questions on participants with 15 years or less of education is .67 ($M = 5.9$, with a variance of 6.30; Pardo & Calvo, 2004). The true-false questions included items such as (a) "The center of the earth is very hot"; (b) "The oxygen we breathe comes from plants"; and (c) "Lasers work by focusing on sound waves." None of the pretest questions related to the content of the stimulus stories.

After completing the surveys, participants read 1 of 2 text versions (IP or ESB) for 1 of the 2 stories (health or technology). There was no time limit for reading. Participants completed a posttest after reading the story and, after submitting their responses, were exposed to a "thank you" Web page.

Results

ANOVA analysis for homogeneity across participants indicated no significant differences in the number of high school science courses, college science courses, or civic scientific literacy.

The pretest measure of individual interest in general categories using a 0 to 4 scale (0—*no interest*, 1—*not very interested*, 2—*somewhat interested*, 3—*interested*, and 4—*very interested*) produced a comparable mean score for technology news ($M = 2.66$, $SD = 0.98$) and health news ($M = 2.81$, $SD = 0.93$). For comparison, these interest scores were higher than interest in news about biotechnology ($M = 1.38$, $SD = 1.10$) but lower than interest in sports ($M = 3.01$, $SD = 1.17$). Collapsing the science or technology interest scores and the nonscience scores, a paired-samples t test revealed a statistically significant difference in individual interest ($t = 5.276$, $df = 234$, $p < .001$).

Table 1
Comparison of Means: Original Versus Modified Story Structures

	Original (Inverted Pyramid) Text			Modified (Explanatory Structure Building) Text		
	N	*M*	*SD*	*N*	*M*	*SD*
Health story						
Engagement	54	2.96	1.77	58	3.22	1.69
Idea units recalled	54	5.37	5.30	58	7.86	5.68
Situation understanding	54	12.50	3.74	58	14.09	3.11
Technology story						
Engagement	59	1.56	1.30	58	2.44	1.82
Idea units recalled	61	4.97	8.58	61	6.23	5.68
Situation understanding	61	10.87	3.11	60	12.50	2.72

Health Story Interest and Understanding

Table 1 provides a comparison of means across story conditions. Using pretest scientific literacy scores as a covariant, ANCOVA analyses indicated that the modified (ESB) health story produced greater understanding ($M = 14.09$, $SD = 3.26$) than did the original (IP) health story ($M = 12.50$, $SD = 3.374$). Table 2 details the statistically significant main effect of text structure, $F(1, 112) = 5.769$, $p = .018$, $\eta^2 = .05$. Hypothesis 1 is supported.

As a second measure of understanding, participants who read the modified (ESB) health story generated a significantly greater number of idea units in their free recall explanations of the story ($M = 7.86$, $SD = 5.68$) than did those read the original (IP) health story ($M = 5.37$, $SD = 5.31$). One-way ANOVA produced a statistically significant difference in the number of idea units by text structure, $F(1, 110) = 5.733$, $p = .018$, $\eta^2 = .05$.

For self-reported measure of situational interest, participants who read the modified health story found it slightly more interesting during and after reading ($M = 1.62$, $SD = 0.82$) than did those who read the original health story ($M = 1.48$, $SD = 0.89$). The difference, however, was not statistically significant, so Hypothesis 2 is not supported for the health story. As predicted, Pearson correlation of situational interest with situational understanding was significant (Table 3) for the modified health story ($r = .38$, $p = .003$) but also for the original health story ($r = .36$, $p = .008$). Thus, Hypothesis 3 is partially supported.

Technology Story Interest and Understanding

As detailed in Table 1, means for the modified (ESB) technology story surpassed the original (IP) story in situational understanding. Again controlling for scientific

Table 2
ANCOVA for Effect of Story Structure on Situational Understanding

	Type III SS	*df*	*MS*	*F*	*p*	Partial Eta Squared
Health story						
Corrected model	91.388	2	45.694	3.758	.026	.064
Intercept	244.476	1	244.476	20.106	.000	.155
Story structure	70.143	1	70.143	5.769	.018*	.050
Error	1337.497	110	12.159			
Total	21500.00	113				
Corrected total	1428.885	112				
Story structure R^2	.064					
Adjusted R^2	.047					
Technology story						
Corrected model	110.467	2	52.233	6.644	.002	.101
Intercept	158.367	1	158.367	19.050	.000	.139
Story structure	71.525	1	71.525	8.604	.004**	.068
Error	980.955	118	8.296			
Total	17143.00	117				
Corrected total	1030.786	116				
Story structure R^2	.101					
Adjusted R^2	.086					

*$p < .05$. **$p < .01$.

Table 3
Pearson Correlations of Situational Engagement and Understanding

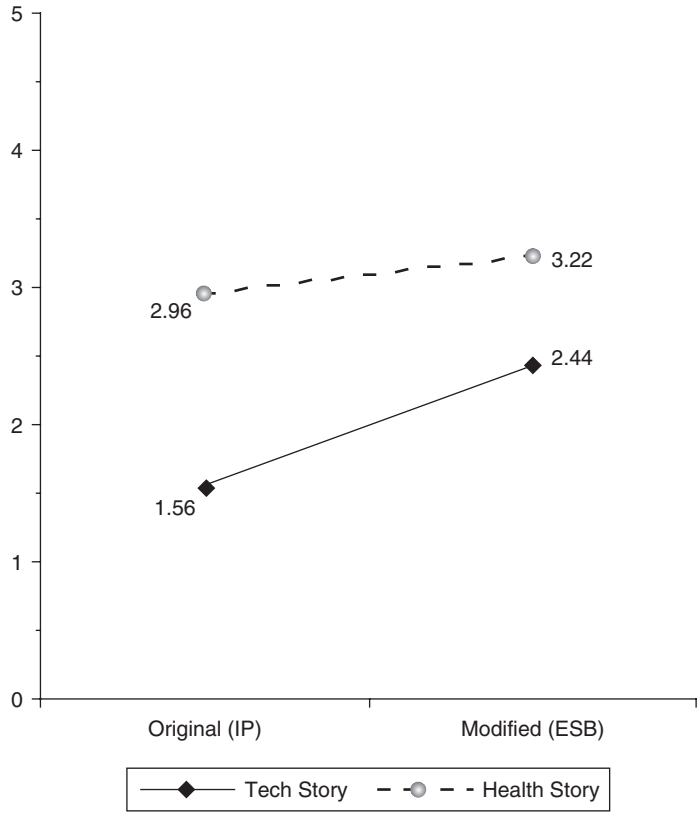
	N	*r*	Significance
Health story			
Original (inverted pyramid, IP) text	54	.36	.008*
Modified (explanatory structure building, ESB) text	54	.38	.003***
Technology story			
Original (IP) text	61	.16	.21
Modified (ESB) text	61	.25	.05

*$p < .05$, two-tailed. ***$p < .005$, two-tailed.

literacy, ANCOVA produced a significant main effect of text structure on situational understanding of the technology story, $F(1, 120) = 8.604$, $p = .004$, $\eta^2 = .068$. Hypothesis 1 is supported for the technology story. Similar to the health story, the number of idea units generated by the explanations of participants who read the modified technology story ($M = 6.23$, $SD = 5.68$) exceeded those for the original version ($M = 4.97$, $SD = 8.58$), but the difference was not statistically significant.

Differences in situational interest in the modified (ESB) technology story ($M = 1.23$, $SD = 0.91$) and the original version ($M = 0.81$, $SD = 0.68$) produced a significant main effect, $F(1, 120) = 8.267$, $p = .005$, $\eta^2 = .064$. Hypothesis 2 is also supported.

Figure 1
Comparison of Means for Situational Interest by Story

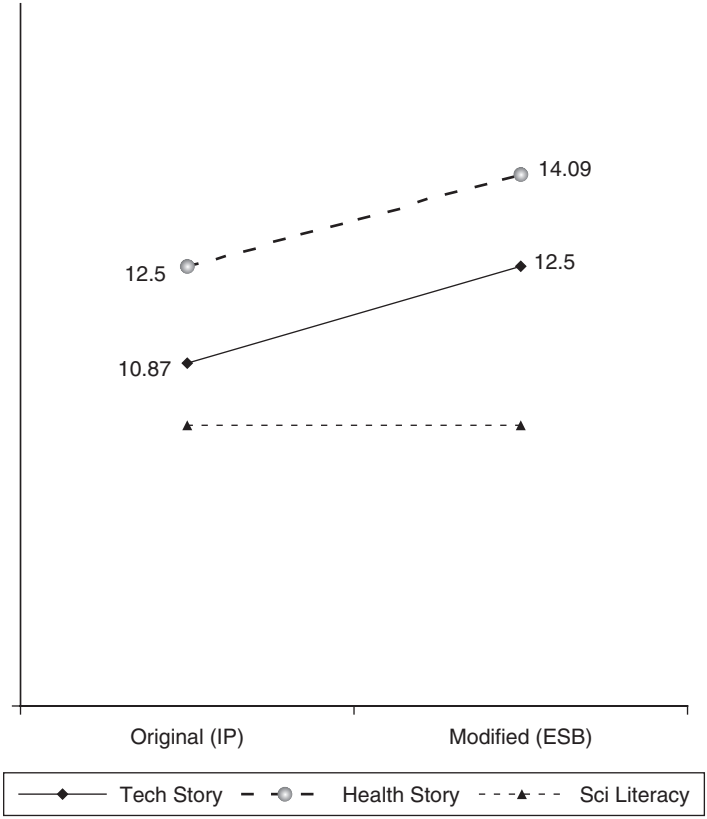


Also, in support of Hypothesis 3, Pearson correlation of interest with understanding revealed a significant association for the modified (ESB) technology story, $r(61) = .25$, $p = .05$, but not for the original IP version. Figures 1 and 2 compare means for situational interest and understanding, respectively.

Discussion

Extensively researched models of text comprehension in the fields of cognitive and educational psychology were investigated for possible application analyses of news text. This investigation was motivated by the increasing amount of news

Figure 2
Comparison of Means for Situational Understanding by Story



sources available to the public and the corresponding increase in news content about complex issues, such as those about science, health, and technology.

As predicted, theoretically guided modifications to the textual structures of science and technology news, including explanatory text for terms and processes, appeared to facilitate a deeper situational understanding of the content by nonexperts. The modifications appeared to also enhance readers' situational interest for the modified content as compared to those who read the original *New York Times* stories. This appeared to occur despite limited individual interest for the general news categories of health and biotechnology.

These data illuminate potentially important relationships among message structure, reader engagement, and subsequent understanding of complex news content. The suggestion is that more coherence in stories about science and technology could perhaps increase reader interest and, ultimately, public understanding of complex issues. Presumably, instead of prematurely terminating one's reading of complex news content, enhancing the reader's interest in and understanding of content could lead to continuation, assuming the news story remains coherent to the reader.

If this process exists, results from this study could provide potentially far-reaching benefits for communicators of news content that the public perceives to be important but that many in the mass audience find too complex.

Also significant is that the ESB model appeared to facilitate a deeper understanding, not just cued recall or recognition of the previously read text base. If so, this study informs previous communication studies, such as those that suggested effects of news structure when comparing print versus online. The researchers concluded,

> We must point out that it is not the medium per se that is most interesting in this study but the organizational structure of the content and various reading patterns that are facilitated by the medium that are most interesting and also at the core of our findings. (Eveland & Dunwoody, 2001, p. 66)

Limitations and Directions for Future Research

Similar to other field experiments, this study's exposure of news stories to participants online can threaten internal validity. It is difficult to determine if any study participant in the field may have benefited from notes or collaboration with friends while completing the reading experiment. However, the between-subjects design, using content from two different stories, exposed to a relatively large sample, attempted to address this concern.

To increase internal validity and the reliability of the measures developed for the proposed ESB text model, future research should replicate the experiment in a controlled lab environment.

One possible limitation, given the differences in situational interest scores between stories, may be story content. The health story about breast cancer research may have been of interest to the slightly larger female portion of the sample, regardless of its structure. This may explain some of the difference in interest across story content.

Another limitation of this study is that a reader's prior knowledge is not the only variable to affect comprehension of content. Scholars found that learning from text in which causal relations were made explicit was related more to reading comprehension skill than to prior knowledge (Voss & Silfies, 1996). Therefore, although data from this study may elucidate how a relatively homogenous audience, such as undergraduate

non-science majors, comprehends news about nanotechnology or cancer research, future research might clarify how news consumers with other characteristics, such as age, education, reading rates, and so on, respond to the relationship of structure and learning.

Although there was a deliberate attempt in this study to select relatively less familiar and complex science and technology news content, future studies should test the ESB model by contrasting less familiar, complex issues with more familiar, complex issues such as global warming, stem cell research, and so on. It is not yet clear if effects of ESB are confined to only less familiar, complex news.

From a practical standpoint, this is just one study to apply well-developed models of text comprehension, and the textual analyses employed for these structures may extend beyond what one could reasonably expect from reporters in the field. Nevertheless, until more research of structure is completed, results from this study stimulate a broader discussion about the general communication processes of science and technology to the mass audience.

Conclusion

This study raises an intriguing dilemma for scholars who claim effects from news. Can one assume that stories containing relatively unfamiliar content are structured appropriately for a nonexpert audience? Data presented here suggest that the answer is no.

Furthermore, belief that the public's limited knowledge of science, health, and technology alone inhibits understanding of news may be premature. Data from this study suggest that effects of message structure are not only worthy of further investigation but that subsequent investigations should explore if these effects hold when the same structures are presented in nonlinear media. By considering the relationship between the production and subsequent consumption of complex news content, this study provides new challenges for those interested in social cognitions of news consumers. The results appeared to be consistent with van Dyke's (1988) conclusion that "news structures can also be explicitly linked to social practices and ideologies of news making and, indirectly, to the institutional and macro sociological contexts of news media" (p. 12).

Given that participants' interest in the news stories correlated positively with their understanding of the content, efforts by journalists to increase story coherence with more explanatory text and historical contexts could enhance the public's interest in science and technology news. Journalists of science and technology news in particular may wish to look for opportunities to integrate more contextual information into their lead sentences and paragraphs. These results suggest that presenting the most recent news events first may not always be the most effective strategy to generate reader interest. As demonstrated here, such a strategy may, in fact, inhibit interest and understanding.

Instead, the options for journalists may be to devote individual paragraphs in a news story to a single news event and include more explanation to assist nonscientists to place complex content into more meaningful context. Another option for

news producers is to sacrifice the high-knowledge audience by providing more ESB text for nonexperts. However, this could require a great deal of revision in how news-writing skills are taught and practiced.

A more reasonable option, assisted by the capabilities of new media, might be to produce two different versions of complex news stories to engage both the high- and low-knowledge reader. The disadvantage of this option is that it could impose additional demands on commercial news agencies that are already burdened with pressures to quickly report news events before the competition does.

Given these encouraging results for a modified explanatory structure, failing to pursue more research of news structures and their effects on the public's interest and understanding would only sustain McLuhan's (1964) claim that it is the medium—with its collection of news stories—that is the message. Given the evidence presented here that suggests different structures produce differing effects on interest and understanding, those who previously believed that science and technology news should target only the "science attentive" audience might now see opportunities to increase the population of that audience.

Appendix A

"A Budding Tumor Unmasked by the Vessels That Feed It"
Original *New York Times* version (642 words; reprinted with permission from *The New York Times Company*).

Page 1

For a tumor to grow, it needs a good supply of blood, which it gets by switching on the body's process of blood-vessel making, known as angiogenesis. Researchers are trying to develop drugs to inhibit angiogenesis as a way of fighting tumors, but they need ways to make sure the inhibitors, which have so far had mixed results, are effective early in therapy, long before the vessels affect the tumor itself.

[Participant clicks to indicate level of interest in story before proceeding to next page.]

Page 2

One computer-based imaging technology may have the potential to detect changes in the blood vessels in and around tumors, signaling the power of a particular inhibitor. The technique, an adaptation of conventional magnetic resonance imaging, or M.R.I., captures up to a thousand images taken serially of a tumor before, while and after dye is introduced. Software analyzes the images, characterizing what the dye (called a contrast agent) has revealed on its journey into and out of the tumor—leakiness, for example, a hallmark of vessels that are being formed.

The technology, called dynamic contrast-enhanced M.R.I., is largely confined to research institutions conducting clinical trials and should be considered experimental, said Dr. Peter L. Choyke, a radiologist and chief of M.R.I. at the National Institutes of Health in Bethesda, Md.

For the past three years, Dr. Choyke has been working on refining the technique in collaboration with Dr. Michael Knopp, a radiologist at the Ohio State University Comprehensive Cancer Center, and other researchers.

Dynamic contrast-enhanced M.R.I. is one of several technologies that provide noninvasive images of the creation of new blood vessels in animals and humans. It has shown particular potential in analyzing extremely small blood vessels, Dr. Choyke said, and might therefore one day find wide use in identifying tumors and monitoring therapies that inhibit angiogenesis. The process yields a loop of images that can be viewed one after another. "This process reveals a more complete map of regional vascular properties of a tumor than single snapshots taken with M.R.I. could," Dr. Choyke said.

Characterized by chaotic flow patterns and tortuous paths, blood vessels in tumors are markedly different from those in healthy tissue. Leaks are common. "Tumor vessels are full of holes, and that allows the contrast agent to leak out readily," Dr. Choyke said. "That's one of the things we measure." A judgment on how aggressive a tumor is can be based in part on this permeability, he said. "You can characterize a tumor as highly vascular—that is, amenable to an angiogenic inhibitor," Dr. Choyke said, in contrast to a lesion that does not have many blood vessels. The process might be helpful in determining whether a biopsy is necessary.

Dr. Choyke cited a woman with a high risk for breast cancer whom he had examined recently. "We saw a little area in the breast, a nodule," he said. "But it didn't enhance with the contrast agent to suggest that it was a highly permeable vascular area, so it didn't have a pattern suggesting malignancy." In such a case, he said, it would be possible to postpone a biopsy.

Dr. Knopp said that dynamic contrast-enhanced M.R.I. might prove useful in preventing incorrect biopsy results. "We are recognizing that tumors are not a single entity, but a heterogeneous array of features," he said. Dynamic contrast-enhanced M.R.I. can help guide where the biopsy is performed. "If you have a bulky tumor, we can show where there is active tumor tissue and areas not as representative of the tumor."

In the experimental method described by Drs. Knopp and Choyke in recent papers, a dye is injected and scanning is repeated until about 10 minutes of data have accumulated. Algorithms analyze the images and map how permeable the blood vessels are, how much blood is flowing and the vessels' volume. Workstations with high-resolution displays can present colorized images of the data in views that create a composite of many scans.

"A Budding Tumor Unmasked by the Vessels That Feed It"
Modified explanatory structure building version (638 words)

Page 1

For a tumor to grow in your body, it needs blood, which tumors obtain from your body's ability to make blood vessels. Researchers are trying to stop tumors with drugs that stop the growth of blood vessels, and computer images may show if the drugs are working. The process might help in determining whether a surgical biopsy in needed, according to Dr. Peter L. Choyke of the National Institutes of Health.

[Participant clicks to indicate level of interest in story before proceeding to next page.]

Page 2

Dr. Choyke cited a woman with a high risk for breast cancer whom he had examined recently. "We saw a little area in the breast," he said. "It didn't have a pattern suggesting malignancy." In such a case, Dr. Choyke said, it would be possible to postpone a surgical biopsy.

Dr. Michael Knopp at the Ohio State University Comprehensive Cancer Center said that the computer imaging might prove useful in preventing incorrect biopsy results. "We are recognizing that tumors are not a single entity, but a heterogeneous array of features," he said. This imaging technology can help guide where the biopsy is performed. "If you have a bulky tumor, we can show where there is active tumor tissue and areas not as representative of the tumor."

The computer images, taken as dye is injected into the body's tissue can show the journey of the dye into and out of a tumor. Up to one thousand computer images taken before, during and after the dye is introduced into the body can indicate if new bloods vessels are being formed. In the experimental method described by Drs. Knopp and Choyke in recent papers, the dye is injected and scanning is repeated until about 10 minutes of data have accumulated. The images are analyzed for how porous the blood vessels are, how much blood is flowing and the vessels' volume. High-resolution color images create a movie of many scans.

"This process reveals a more complete map of regional vascular properties of a tumor than single snapshots," Dr. Choyke said. Characterized by chaotic flow patterns, blood vessels in tumors are markedly different from those in healthy tissue. Leaks are common. "Tumor vessels are full of holes, and that allows the contrast agent to leak out readily," Dr. Choyke said. "That's one of the things we measure."

The technology, called dynamic contrast-enhanced M.R.I. is one of several technologies that provide images of the creation of new blood vessels in animals and humans. The technology has shown particular potential in analyzing extremely small blood vessels, Dr. Choyke said, and might therefore one day find wide use in identifying tumors and monitoring therapies that creation of blood vessels. The technology is not yet in wide use, partly, Dr. Choyke said, because different research groups use different software to analyze their data. He expects a consensus to emerge in the next few years as standard software becomes widely available and research groups move toward a universally accepted way of analyzing the data.

Dynamic contrast-enhanced M.R.I. is largely confined to research institutions conducting clinical trials and should be considered experimental, said Dr. Peter L. Choyke. For the past three years, Dr. Choyke has been working on refining the technique in collaboration with Dr. Knopp, at the Ohio State University Comprehensive Cancer Center, and other researchers.

"Dynamic enhanced-contrast M.R.I. has the greatest potential—as yet unrealized—to monitor therapy early on," Dr. Choyke said. He expects that when drugs stop new blood vessels from forming, the M.R.I. will reveal changes in blood vessels that occur before the tumor responds to the changes by shrinking or stabilizing. But Dr. Michael O'Reilly, who did pioneering research with Dr. Judah Folkman at Children's Hospital in Boston said that even if such monitoring became possible, considerable research would still be needed. Even after studies with the mice are completed, Dr. O'Reilly predicted, it will be difficult to apply the results to people.

Appendix B

Idea Unit

1 Living organisms
2 do a fine job
3 of growing crystals,
4 like the ones
5 that make up [abalone shells] *some sea shells,*
6 for example.
7 But there are lots of
8 other [inorganic] *materials*
9 including those
10 that make up [semiconductors] *explained in graf 2*
11 that living things
12 haven't gotten around to producing.

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