An Investigation of Elaboration and Selective Scanning as Mediators of Learning From the Web Versus Print

William P. Eveland, Jr. and Sharon Dunwoody

Recent studies suggest that Web delivery may produce less learning than traditional print. Left unanswered are questions of the process through which differences are produced. Using 2 theories—user control and structural isomorphism—we proposed 2 mediators of the influence of medium on learning. Path analysis of experimental data varying medium while holding content constant suggested that the Web increases learning through increased elaboration, but decreases learning through increased selective scanning compared to traditional print.

The last decade of the 20th century witnessed the movement of the World Wide Web from infancy to what now might be considered adolescence. Traditional print and broadcast media outlets have rushed to the Web to take advantage of the benefits of this new medium, such as speed of information dissemination. One question that begs to be answered is whether increased learning is among the advantages of the Web over traditional print.

Several recent studies in mass communication have examined differences in learning from the Web compared to traditional print media (Eveland & Dunwoody, 2001b; Sundar, Narayan, Obregon, & Uppal, 1998; Tewksbury & Althaus, 2000). The evidence in these studies has been somewhat inconsistent, but it generally supports the inferiority of the Web to traditional print media for learning. The present

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study provides an additional test of the relative effectiveness of print versus Web as a medium for the communication of factual information. More importantly, it also extends past work by including two information-processing variables that may mediate the effect of medium on learning: elaboration and selective scanning.

Research on Learning From Hypermedia and the Web

A central focus of many studies of learning from media is the comparison of learning from different sources, such as print and television (e.g., Chaffee & Schleuder, 1986; DeFleur, Davenport, Cronin, & DeFleur, 1992; Furnham & Gunter, 1989; Neuman, Just, & Crigler, 1992; Price & Czilli, 1996; Robinson & Levy, 1996). The present study contributes to this traditional literature by joining only a few others in mass communication that have extended the comparison of traditional print media to information conveyed using the World Wide Web (or simply "Web").

The Web is a networked implementation of a technology called "hypermedia." In many ways a simple Web document is similar to traditional print media. The Web, like traditional print, can convey both text and images. The central difference between the Web and print, then, is not so much in their content, but in their structure. Traditional print media are organized in a linear manner and are generally designed to be read from beginning to end. Although there are exceptions to this structure (e.g., a dictionary or thesaurus is not designed to be read linearly), linearity is a prototypical organization of a traditional print magazine.

The Web is unique in that it facilitates an alternative organizational structure compared to traditional print magazines. The Web, with its node and link structure, facilitates reading of content "out of order," so to speak. That is, individuals can more easily choose to move through an article in any of a number of ways instead of in a single order determined by the fixed structure of a traditional print text. Although determined traditional print users can read magazine articles in orders other than they are presented by skipping sections of minimal interest or reading out of order, this type of decision making is the structural norm in hypermedia.

Beyond the opportunity to navigate through text and images in a non-linear manner, the structural differences between traditional print and hypermedia have two additional implications that are potentially relevant for learning. When using hypermedia, it is often difficult for users to determine when all of the content has been read compared to a linear reading in traditional print media. And, the presence of in-text links indicating conceptual associations between nodes, even if not followed by users, can signal relatedness that could contribute to a more thorough understanding of the content.

Given the differences between the Web and traditional print media, both content and structural, communication scholars have sought to determine differences in learning from the Web versus print. To date these studies have not produced wholly consistent findings, although most find print to be superior to the Web when differences are detected. For example, Sundar and colleagues (1998) examined

memory from print and online versions of a newspaper article and corresponding advertisements. While they found no significant differences in memory for the news story across media, they did find significantly better memory for advertisements in the print than online conditions.

Tewksbury and Althaus (2000) exposed groups of college students to either the *New York Times* online or a print version of the *New York Times* over the course of a week. Participants were instructed to avoid news from other sources during this time. Memory for news events was higher among both print and Web users than for a control group without forced exposure, suggesting that learning occurred in both media conditions. More importantly, the general trend across numerous comparisons was for increased memory for information among print users compared to Web users. The authors suggest that these findings are attributable to a number of factors. First, there were at times different stories in the print and online versions, and this could have had some impact on the findings. Also, the Web version of the *New York Times* contained more stories on a given day than the print version, providing more opportunity to select stories from a larger base. Further, the manner in which online news is structured—the limited visual differentiation and use of textual story indices—means there are fewer cues regarding editorial decisions about story prominence. This produces more varied patterns of exposure that are based more on interest in the story topic than inherent news value. Finally, the authors suggested that depth of understanding was better for print subjects than Web subjects among stories that were read, but there were no data in this study available to explain this difference.

Eveland and Dunwoody (2001b) examined recognition and cued recall across four different versions of a magazine article about the flu virus. They compared learning, holding content constant, from a traditional print version and three Web versions: linear, nonlinear, and advisement. The linear Web version duplicated the print version in organization, providing few opportunities for user control and using traditional linear print navigation cues (e.g., forward and back buttons on each page). The nonlinear version forced user control by requiring navigation via in-text links and removing all linear organization cues. The advisement version combined the linear and nonlinear designs, providing both linear cues and nonlinear navigation options. The experiment found that learning took place regardless of the medium and Web design. However, the authors also found significant recognition differences by medium, with the highest mean for the print condition and marginally significant reductions in learning in the linear and nonlinear Web conditions compared to print. Recognition in the advisement condition was not significantly different from the print condition. No significant differences were found in cued recall.

These recent studies suggest that, to some extent, communicating information via the Web may be less effective for learning than using a traditional print medium. However, not all tests of medium effects in these studies significantly favored print, although in no case was the Web found to be superior to traditional print overall. Building on the study by Eveland and Dunwoody (2001b), we continue to explore theoretical explanations for medium differences in learning by focusing on potential

mediating variables to better understand how, if at all, medium can influence learning.

Theoretical Perspectives on Learning From the Web Versus Traditional Print

For over a decade, educational technologists have studied the uses and effects of hypermedia, which is the technology upon which the World Wide Web is based (for a review, see Eveland & Dunwoody, 2001a). These scholars and practitioners have been centrally concerned with the role of hypermedia as a replacement for traditional media, both in and out of the classroom. The two most prominent reasons researchers in this domain have identified to explain why hypermedia should be superior to traditional print for learning center around the control provided by hypermedia (user control) and the similarities between hypermedia and human cognitive processing (structural isomorphism).

User Control

The theory of user (or learner) control assumes that individuals learn in somewhat idiosyncratic ways. The best form of media presentation for one individual, therefore, is not necessarily the best form for another. "Since an individual's knowledge structure is unique, based upon his or her own set of experiences and abilities, the ways that individuals prefer to access, interact with, and interrelate information is also distinct." (Jonassen, 1988a, p. 14) Hypermedia, the technology behind the Web, is presumed by user control theory to be beneficial for learning compared to traditional media and other forms of instruction. This is because it relinquishes considerable control to the user to determine the pace, order, and content of information presented (Shin, Schallert, & Savenye, 1994). This means that individuals can create the learning environment most suited to their own personal interests, abilities, background knowledge, and learning style (Young, 1996). For instance, a content novice could choose to move slowly, first reading background and contextual information and then seeking a more detailed and sophisticated analysis of the topic. By contrast, a content expert could move quickly, skip over rudimentary information, and devote time to seeking detailed and complex information on the same topic. Ultimately, each would learn up to his or her potential, something not possible in a traditional print medium that does not encourage high levels of user control.

Research examining the influence of user control has been mixed. Some studies have demonstrated greater learning under the provision of user control (e.g., Kinzie, Sullivan, & Berdel, 1988), whereas others have found "program control" (essentially the lack of user control) to be superior for learning (e.g., Yang & Chin, 1996-1997). Still others have made claims about the importance of combining control with a means of advisement for user control to be effective (Kinzie, 1990; Milheim &

Martin, 1991; Shin et al., 1994). Unfortunately, even reviews of the literature have been somewhat inconsistent in their claims about the influence of user control, although most conclude that there is little support for superiority of user control over program control in the aggregate (Dillon & Gabbard, 1998; Niemiec, Sikorski, & Walberg, 1996; Steinberg, 1989).

Although support for user control claims of increased learning is weak based on both educational technology studies and Web-versus-print comparisons in mass communication, there is still research being conducted within this framework to understand learning from hypermedia (e.g., Burke, Etnier, & Sullivan, 1998). Given this, and the continued debate over the status of this theory in the literature, we employed user control theory to predict:

H1: Content knowledge should be greater among Web users than traditional print users.

A major assumption of user control theory is that individuals actually do take advantage of the opportunity provided by the Web to structure their learning based on individual motivations. Compared to print, Web users are not only capable of moving freely between sections of an article or story (as print users technically are), but they are actually *encouraged* to do so by the various links embedded in the text. That is, the nature of hypermedia is to scan and be selective, although certainly not all users make use of this facility (Eveland & Dunwoody, 1998).

Astleitner and Leutner (1995) identified "scanning" as one of many strategies used by individuals attempting to learn using hypermedia systems like the Web. Although not derived from user control theory, scholars studying the processing of traditional news media in informal learning contexts have proposed a concept labeled "selective scanning" (e.g., Kosicki & McLeod, 1990) that taps the process of picking and choosing among information based on personal criteria for relevance, importance, and interest. Consistent with the assumption that the user control of the Web provides the opportunity for individuals to make content selections, a recent study (Eveland & Dunwoody, 2001b) found that selective scanning was indeed greater among experimentally assigned Web users than traditional print users. Further, this differential selection process in Web-versus-print newspapers was an important explanation behind learning differences found by Tewksbury and Althaus (2000). Thus, we predicted:

H2: Selective scanning will be greater among Web users than traditional print users.

User control theory assumes that in addition to being selective, users make their decisions properly to advance learning. However, this assumption may be the major flaw of the theory. A number of scholars have questioned the quality of decision-making processes employed by those with user control, particularly novices in the content area (Dillon & Gabbard, 1998; Milheim & Martin, 1991; Park, 1991; Shin et al., 1994; Steinberg, 1989). Milheim and Martin (1991, p. 100) summarize these concerns by acknowledging that "learner control may not be appropriate in many

situations since some students may not be able to accurately monitor or assess their own learning success or failure and would therefore be unable to make appropriate control decisions." In short, it may be that by providing user control we are "putting the patients in charge of the asylum," so to speak. The selectivity decisions being made by the users, instead of facilitating learning, may in fact be what inhibit learning when user control is provided.

Unlike those operating from user control theory, communication researchers studying selective scanning in informal learning have generally assumed (and found) that selective scanning is harmful for, as opposed to beneficial to, the learning process, at least in the context of learning public affairs information from the news (Eveland & McLeod, 1995; Kosicki, McLeod, & Amor, 1987; Tewksbury & Althaus, 2000). While some manner of selectivity is necessary to "tame the information tide" (Graber, 1988), the information de-selected is often the information most necessary for the individual to gain a greater understanding of the content. This implies that the selective scanning encouraged by user control afforded by the Web could actually reduce learning instead of increasing it as predicted by user control theory. Given the concerns among some user control theorists that the decisions made by users may not be particularly conducive to learning, in conjunction with evidence from communication we predicted:

H3: Selective scanning will be negatively related to content knowledge.

Structural Isomorphism

Many prominent psychologists agree that the human mind works through a network of associative connections in which related bits of information are connected to one another (e.g., Collins & Loftus, 1975; Craik & Lockhart, 1972; Tulving, 1985). For instance, Collins and Loftus (1975) note that "A concept can be represented as a node in a network, with properties of the concept represented as labeled relational links from the node to other concept nodes" (p. 408). Using hypermedia instead of traditional books and magazines to present information—initially proposed over five decades ago—was founded upon this associative network view of human memory. Bush (1945, p. 106) believed that the human mind "operates by association. With one item in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain." To build upon this function of human memory, his proposed new medium (called a "memex") would promote "associative indexing, the basic idea of which is a provision whereby any item may be caused at will to select immediately and automatically another" (Bush, 1945, p. 107). A medium like the memex that could work as the human mind does—by making connections and access among related bits of information instantaneous—was thought to facilitate making mental connections between related pieces of information (what we call elaboration) and thus learning. Bush envisioned library resources like encyclopedias being produced with this form of automatic associative indexing as well as webs

produced by individuals and then shared with others. Ultimately, Bush's vision of the memex led to hypermedia and the World Wide Web.

A number of hypermedia theorists have taken up Bush's claim that the structure and function of the Web mimics in many ways this associative nature of human memory, or at least that it could (Churcher, 1989; Jonassen, 1988a; Nelson & Palumbo, 1992; Shirk, 1992; Tsai, 1988-1989). We label this assumption "structural isomorphism" (see also Eveland & Dunwoody, 2001b). For instance, Churcher (1989, p. 245) points out that "as hypertext builders we are in fact constructing models of our own memory implicitly." Jonassen (1988a, p. 14) agrees that "because hypertext is a node-link system based upon semantic structures, it can map fairly directly the structure of knowledge it is representing." Similarly, Nelson and Palumbo (1992, p. 287) note that in hypermedia "emphasis is placed on a representational architecture which allows authors to link semantically and logically related information in conceptual webs that mirror some of the associational power of human memory."[1]

Although writing before the popular advent of hypermedia and the Web, Salomon (1979) suggests that one of the major influences of medium—the central attribute of which is the unique combination of symbol systems—is its ability to encourage particular forms of information processing. He argues that media "*call on*—that is, *activate*—mental skills, and, by exercising these skills, they cultivate skill-mastery. Or, they *overtly supplant* mental skills, and, by modeling these skills, the symbols are internalized" (p. 231, emphasis in original). While Salomon's central interest was in differences between the media technologies of the day—television, print, and very basic computers—his arguments translate well into the structural isomorphism argument regarding hypermedia. If we consider a major component of the Web's symbol system to be its unique non-linear structure and means of navigation through associational links, it may be that Web use encourages individuals to make mental connections to a greater extent than traditional print, or indeed makes these connections for the individual directly.

Working from the associationist perspective on the human mind, a central component of the process of learning is in fact bringing new bits of information into this network and making connections between the new information and the rest of the network (Jonassen, 1988a; Nelson & Palumbo, 1992). Measures of this process have been variously labeled "elaboration" (Craik & Tulving, 1975; Eveland, 2001; Perse, 1990b; Schmeck, Ribich, & Ramanaiah, 1977; Weinstein, 1978), "reflective integration" (Fredin, Kosicki, & Becker, 1996; Kosicki & McLeod, 1990; McLeod et al., 1996), "active reflection" (Eveland, McLeod, & Horowitz, 1998), "AIME" (Beentjes, 1989; Salomon, 1984), "integrating" (Duchastel, 1990), "matching strategies" (Graber, 1988), and "generative learning" (Jonassen, 1988b), among others. Elaboration seems to be the most common term across the various fields over time, so this is the term that we will employ.

If presentation via hypermedia requires individuals to consider the relationship among components of, for instance, a magazine article in order to make decisions about which links to follow, it may encourage elaboration. Even when a link is not

followed, by noting that a link has been made a user may make a mental connection between the current content and that to which the link is pointed. That is, the user may see the link and ask himself or herself the mental question, "How are these things related?" and then produce an answer in the process of making the decision about whether or not to follow the link. A similar but explicit question-asking technique, called elaborative interrogation, has been used successfully to encourage learning in educational contexts (Woloshyn, Willoughby, Wood, & Pressley, 1990; Woloshyn, Paivio, & Pressley, 1994). In short, the implication of the structural and functional analogy between hypermedia and human memory and information processing is that elaboration will be facilitated when using hypermedia compared to traditional print, and that this elaboration will increase meaningful learning.

The first component of this expectation has not been suitably addressed in the literature. There have been no studies of which we are aware that have examined the number of mental elaborations to the same content across various media. Thus, we use the theory to predict:

H4: Elaboration will be greater among Web users than traditional print users.

By contrast, a substantial number of studies using a variety of research methods have confirmed that elaboration is a central determinant of learning. Whether measured as a self-report of general information processing or learning strategies (Eveland, 2001; McLeod et al., 2000; Miller, Alway, & McKinley, 1987; Perse, 1990a; Schmeck & Grove, 1979; Schmeck & Phillips, 1982) or an experimental manipulation, including elaborative interrogation (e.g., Hamilton, 1989; Johnsey, Morrison, & Ross, 1992; Woloshyn et al., 1990; Woloshyn et al., 1994), numerous studies have demonstrated a connection between some measure of elaboration and some measure of knowledge or learning. Thus, we predicted:

H5: Elaboration will be positively related to content knowledge.

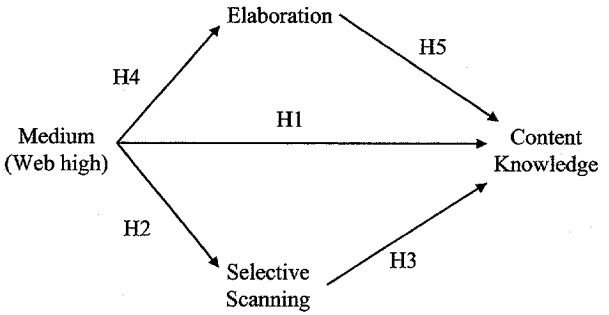
Figure 1 summarizes the five hypotheses of the study in a graphic format.

Method

Participants

Participants for this study ($N = 62$) were recruited from a number of courses in the Department of Communication at a West Coast university during the winter of 1999. Participants were approximately evenly divided among sophomores (30.6%), juniors (32.3%), and seniors (37.1%). About three quarters of participants were female, with a median age of 21. Almost two thirds of participants were Caucasian, with the largest minority group being Asian/Pacific Islander (17.7%). This young, relatively educated group of participants was important for this study because they had some

Figure 1
Predicted Relationships



experience using the World Wide Web. Overall, they reported using the Web an average of 8.2 days (*sd* = 7.7) during the past 30 days, and less than 10% claimed they had not used the Web at all in the past month.

Procedures

Upon arrival at the research facilities, individuals were randomly assigned to one of two conditions: Web (n = 32) or print (n = 30).[2] Those assigned to the print condition were directed to a classroom with desks for the remainder of the study. Those assigned to the Web conditions were directed to a computer laboratory equipped with 22 PC-compatible computers and color monitors. Analyses indicated random assignment to conditions was successful, with no significant differences across conditions on variables such as age, year in school, or gender.

The specific content for this study concerned the topic of wildfires. This story was chosen because of its particular relevance for students at the university (located in an area that frequently deals with wildfires) and an event that took place a few months before the experiment (a wildfire near the university had burned for more than a week, prompting heavy news media coverage both locally and nationally). These factors should facilitate elaboration of the story information because they suggest that our participants would have some relevant information or experience with which the story information could be integrated.

The story selected for this experiment initially appeared on the Web science magazine "The Why Files" (http://whyfiles.org/018forest_fire/index.html) and was a combination of text, photographs, and graphics. The Web version of the story was developed to represent a Web site with numerous opportunities for nonlinear navigation and at the same time offering "advisement," which is a suggested navigation strategy. The theory of user control, plus some recent evidence, suggests that this Web design strategy may be the most effective because it provides freedom for those who prefer it while offering some structure for those who need it (Eveland & Dunwoody, 2001b). Thus this site design might be considered a "best case

scenario" for the Web in comparison to print. The site consisted of an index page (describing the content of the story and providing links to different sections), nine pages of content, and a glossary of terms (on a separate page). Navigation options included links at the end of the text on each page directing the user to the next contiguous page. These links took the form of "teasers," which encouraged users to follow the story in linear order (e.g., "So why do ecologists think fires can be a good thing?" and "What are some of the limitations on the use of controlled burns here in the United States?"). In addition, at the bottom of each page were brief descriptors (organized linearly) that allowed the user access to all other pages in the story, plus "next," "back," and "story map" (index) links to ease navigation. Finally, in-text links allowed users to easily move nonlinearly through the story, either to other pages or to words in the glossary. That is, instead of waiting to finish a page of reading and then being encouraged to read the "next" page, users could jump from one page to another by following a highlighted word or phrase in the text that indicated an associative link. Again, this provided a high degree of user control.

The print condition was created by organizing the Web version into a single, linear document 14 pages in length (including a revised index and glossary). All Web graphics (except for navigation buttons) were included in the print version. Links from words in the text to the glossary in the Web version were replaced by the phrase "see glossary" after the same words in the print version. Since the Web version was conveyed on color computer monitors, the print version was presented in a glossy, full color, 8.5 × 11 inch magazine-like format. This allowed us to keep the Web and print versions similarly attractive in terms of color and graphics.

The exposure portion of the study gave all participants 55 minutes to read the content, a length of time chosen to assure that they would all be able to complete the reading.[3] Printed instructions provided to participants read:

> Carefully read (the information in this Web site / this booklet), keeping in mind that you will be tested later on your understanding of this information.[4] You will be alerted as to when you should stop reading. You may or may not have finished reading at this time. If you finish reading before time is called, go back and review the information again.

Measures

Before exposure to the stimuli, all participants completed a short pre-test questionnaire. After the exposure period, all participants completed a post-test questionnaire that specifically asked about experiences during exposure to the experimental stimulus. The five Likert items summed to measure elaboration ($\alpha = .72$, $M = 15.19$, $sd = 3.73$) were culled from indicators used in past research in mass communication (Eveland, 2001; Kosicki & McLeod, 1990; Perse, 1990a, 1990b) and educational psychology (Schmeck, Geisler-Brenstein, & Cercy, 1991; Schmeck et al., 1977; Weinstein, Zimmermann, & Palmer, 1988) and modified to better fit the present study context. These items referred to relating the information to past experiences,

thinking about actions that should be taken by policy-makers, and making connections between the content and information seen elsewhere.

Two indicators, measured on a 5-point Likert scale, were summed to measure selective scanning ($r = .48$, $M = 3.73$, $sd = 1.66$). These items were derived from past research (see Eveland & Dunwoody, 2001b; Eveland & McLeod, 1995; Kosicki & McLeod, 1990; McLeod et al., 1996) and asked participants to respond to the statements "I only read sections of the story that looked important or interesting" and "I skimmed through the story." Elaboration and selective scanning were not significantly related in the sample as a whole ($r = .09$, $p = .52$) nor within each condition (Web: $r = -.12$, $p = .51$; print: $r = -.18$, $p = .35$), and an exploratory factor analysis of the seven indicators comprising these two variables revealed a two-factor structure with primary loading on factors as expected based on a priori expectations. (Complete item wordings for elaboration and selective scanning can be found in the Measurement Appendix.)

After responding to these and other measures, participants completed a 26-item quiz on the content of the wildfire story. This quiz included: (a) four true/false questions; (b) three multiple choice questions; (c) ten short answer questions, some of which required multiple-part answers; and (d) nine definition terms.[5] These quiz items were combined to form an index of content knowledge of wildfires as covered in the story ($\alpha = .69$, $M = 21.82$, $sd = 5.63$).[6]

Analysis

We will begin by analyzing the data in terms of bivariate relationships. However, while the hypotheses of this study were phrased as expectations of bivariate relationships, we can most effectively test these hypotheses by using a multivariate model that incorporates all of the hypotheses simultaneously. This allows us to control for one explanation, such as the influence of elaboration on content knowledge, when testing another explanation, such as the influence of medium on content knowledge. This provides information on the strength of one explanation (or predictor) independent of other effects in the model. Therefore, we organized our hypotheses into a path model, where each path tests a specific hypothesis. An additional advantage of this approach is that it provides a visual representation of our results that more effectively communicates the process relationships—specifically the role of mediators—than would a traditional ANOVA approach to our experimental data analysis. We analyzed our path model using OLS regression path modeling techniques (Asher, 1983; Cohen & Cohen, 1983).

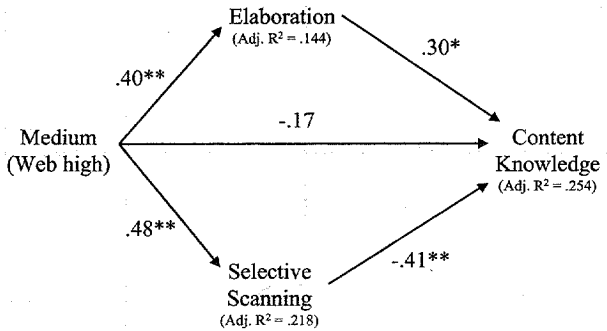
Results

Before the formal test of hypotheses, initial analyses were conducted to explore the relationships among the variables under study. Analysis of variance revealed signif-

icantly higher content knowledge among those in the print condition than those in the Web condition ($F(1,60) = 5.07$, $p < .05$, $\eta^2 = .078$). Those in the Web condition were more likely to engage in both elaboration ($F(1,60) = 10.76$, $p < .01$, $\eta^2 = .159$) and selective scanning ($F(1,60) = 19.00$, $p < .01$, $\eta^2 = .240$) than those in the print condition. Zero-order correlations indicate that elaboration was unrelated to content knowledge ($r = .20$, $p = .13$), whereas selective scanning was negatively related to content knowledge ($r = -.46$, $p < .01$).

The hypotheses were formally tested using regression path modeling.[7] Figure 2 presents the results of the path analysis and tests of hypotheses in graphic form.

Figure 2
Path Modeling Results



Hypotheses 1 through 3 were derived from user control theory and related research. Hypothesis 1 predicted that content knowledge would be greater among Web users than print users. This hypothesis was not supported. Despite the significant bivariate relationship between medium and content knowledge favoring print found in the previous ANOVA analysis, the relationship (with Web coded as 1 and print coded as 0) was found to be non-significant ($\beta = -.17$, $p = .24$) after the controls were added in the path model. Hypothesis 2, that selective scanning would be more prevalent among Web users, was supported ($\beta = .48$, $p < .01$). Hypothesis 3 was also supported, as selective scanning was negatively related to content knowledge ($\beta = -.41$, $p < .01$).

Hypotheses 4 and 5 were derived from structural isomorphism theory. Hypothesis 4 predicted that elaboration would be more prevalent in the Web than print condition. This hypothesis was supported in the path model ($\beta = .40$, $p < .01$). Hypothesis 5, which predicted that elaboration would be positively related to content knowledge, was also supported in the path model ($\beta = .30$, $p < .05$), despite the non-significant zero-order correlation between these two variables.

Overall, the model was able to account for a considerable proportion of variance in most of the endogenous variables. Over one quarter (adjusted $R^2 = .254$) of the variance in content knowledge was accounted for by just three predictors: the

medium manipulation, plus the two information-processing variables of elaboration and selective scanning. Nearly 15% of the variance in elaboration was accounted for by the medium manipulation alone (adjusted $R^2 = .144$), and over one-fifth of the variance in selective scanning was accounted for by the medium manipulation alone (adjusted $R^2 = .218$).

One of the benefits of our path model is that both direct and indirect effects of medium-on-content knowledge can be calculated.[8] Medium did have two significant indirect effects on content knowledge that compensate for its lack of a direct effect in the path model. These indirect effects explain its apparent main effect, as demonstrated in our initial analysis of variance, which showed more content knowledge among traditional print subjects than Web subjects. First, the Web medium significantly increased content knowledge through its effect of increasing elaboration on the content (indirect effect = .12). However, the Web medium significantly decreased content knowledge by encouraging selective scanning (indirect effect = −.20). These two indirect effects partially cancel each other out. However, the indirect effect through selective scanning is somewhat stronger, and in conjunction with the tendency toward increased content knowledge in the print condition as a main effect after controls ($\beta = -.17$), it suggests a total effect of medium that favors print over the Web for learning of content information (.12 + [−.20] + [−.17] = −.25).

Discussion

The results of the study most strongly supported structural isomorphism theory, and they were inconsistent with the traditional predictions of Web superiority derived from user control theory. Consistent with structural isomorphism theory, Web use actually increased elaboration compared to print, and elaboration was positively related to learning, supporting hypotheses 4 and 5. Although some might argue that this effect is itself mediated through self-efficacy for learning from the medium and perceptions of the difficulty of the medium (Salomon, 1984), our data do not allow us to examine this possibility. In any case, the findings from hypotheses 4 and 5, considered alone, would seem to bode well for those media outlets expanding from traditional print to the Web, such as major national newspapers and news magazines, because it would appear that the Web is actually superior to print media for learning.

However, our findings are not so simple. Other analyses were much less promising for learning from the Web. An uncontrolled test of the main effect of our medium manipulation revealed significantly less learning among Web users than print users. Thus, user control theory's prediction of greater learning from Web than print (Hypothesis 1) was not supported. More importantly, the increased selective scanning that we found to be encouraged by the user control afforded on the Web (as predicted in Hypothesis 2), actually decreased learning as predicted in Hypothesis 3. This is contrary to traditional user control theory expectations, but consistent with

our prediction based on mass communication theory and research and recent speculation in educational technology. It is important to realize that this mediation of the medium manipulation through selective scanning reduced knowledge among Web users to a greater degree than elaboration indirectly increased learning among those same users in this experiment. Given that the tendency of the Web to increase selective scanning was found to be greater than the tendency of the Web to increase elaboration, in conjunction with the non-significant tendency for a controlled main effect favoring print, *the net total effect of the Web is actually to reduce learning compared to print presentations.* This is consistent with what was demonstrated in our initial bivariate finding of a medium effect favoring print.

Therefore, our analysis of elaboration and selective scanning as mediators does not contradict the superiority of print found in a traditional analysis of direct effects of our data. Our results are also consistent with recent research (Eveland & Dunwoody, 2001b; Sundar et al., 1998; Tewksbury & Althaus, 2000), but extend this research by empirically demonstrating some of the processes through which medium influences learning outcomes. It also advances existing research by demonstrating that the effects of medium on information processing are considerably stronger than might be inferred by simply looking at the learning outcome differences produced in recent studies. Future research should invest more effort in understanding the cognitive mediators of medium effects on knowledge gain instead of simply looking for differences across media.

Despite our revealing findings, the present study suffers from several limitations. First, as with most experiments of this sort (e.g., Eveland & Dunwoody, 2001b; Sundar et al., 1998; Tewksbury & Althaus, 2000), our study is limited by the biased nature of our student sample. However, as others have noted, this limitation is in some ways a hidden strength, since college students tend to have more experience with the Web and are thus less likely to reveal Web deficits due to simple unfamiliarity with the medium. They also tend to be the target audience for many Web sites.

Another significant limitation of our study is its external validity. The external validity of this study was limited by the single source of content, a story about wildfires. Potentially more importantly for external validity, our study was also limited to a single Web site design. Other studies have demonstrated that effects may vary depending on the level of user control offered in a Web site (e.g., Eveland & Dunwoody, 2001b). We chose to use a design with advisement because past research has suggested that this site design may be the most effective for learning from the Web (Eveland & Dunwoody, 2001b). However, on the World Wide Web users are exposed to numerous designs as they navigate from site to site, and even if each site is well designed and contains advisement, there is little advisement when a user moves from one site to another and must adjust to a potentially different organizational scheme. All of these factors suggest that, in the real world, differences in learning from the Web versus traditional print may be even greater than we have observed in this study.

All of the implications of our study design are not negative for the potential of the

Web as a learning medium. For instance, our study focused on knowledge of the content of our stimulus materials. However, the beneficial effects of hypermedia systems like the World Wide Web from the perspective of structural isomorphism theory may be most apparent when examining not the content of knowledge, but its structure (Jonassen, 1992). That is, making elaborations—as encouraged by the Web in this study—should increase the connectedness of individual bits of information in memory, resulting in more tightly connected schemas. These schemas are potentially better indicators of expertise and sophistication than are simple measures of content recognition and cued recall as employed in this study. A number of scholars have examined more sophisticated, although also more difficult to administer, measures of knowledge structure (e.g., Goldsmith, Johnson, & Acton, 1991; Joiner, 1998; Jonassen, Beissner, & Yacci, 1993). Although one study has found little evidence of an influence of hypermedia on knowledge structure (Jonassen & Wang, 1993), this alone should not halt further work in this area, given the connection between Web use and elaboration predicted by structural isomorphism theory and demonstrated here. Future research on the Web should examine its impact on knowledge structure, particularly the impact of site organization and hyperlinks on knowledge structure.

From a practical standpoint, our findings suggest that the Web as a system of information delivery can be used to influence information processing and increase learning compared to traditional print. However, this ability is outweighed by the habits of individuals—or at least our subjects—of selectively attending to only certain parts of the information on the Web and thus reducing overall learning. In the final analysis, the difference in learning across conditions is small, so that problems with the use of the Web compared to traditional print may be offset by other Web benefits such as cost of production and speed of delivery. But it does offer a warning to those communicators who specifically seek to use the Web to improve learning compared to traditional print.

However, given the limitations of this study, our results must be considered tentative. Scholars should seek to buttress our findings by conducting additional studies in different contexts, using different Web site designs, and providing a larger domain of content through which participants may navigate that is more akin to the World Wide Web as a whole instead of a single, small Web site. Only then will we be able to be able to make more generalizable statements about the direct and indirect effects of medium on learning and recommendations to media practitioners.

Notes

[1] Although many theorists accept at least to some extent the notion of structural isomorphism, several have attempted to make clear the limitations in this perspective (e.g., Nelson & Palumbo, 1992; Tergan, 1997).

[2] Initially this study used a 2 (medium: Web vs. print) × 2 (elaboration: natural vs.

encouraged) design. In this report we have used only the "natural elaboration" condition because the elaboration manipulation only worked in the print condition.

[3] A previous study using a similar paradigm (Eveland & Dunwoody, 2001b) limited the amount of time subjects had to read the material, such that few if any were able to finish in the time allotted. In the present study, all subjects were able to complete the reading, thus eliminating the impact of reading speed differences across media as a potential explanation as it was in our earlier study. In addition, the increased time provided to subjects should have substantially reduced or eliminated the influence of cognitive load in the Web condition in this study because any increased demands of the Web site placed on the user would have been mitigated by the lack of time pressures. In fact, we found no relationship between cognitive load and content knowledge in this study, unlike our finding in the previous study. We thank an anonymous reviewer for suggesting this second point to us.

[4] Recent research comparing learning across media that has manipulated the expectation of a test has not found this to matter in later tests of learning, nor to interact with other independent variables (e.g., Eveland & Dunwoody, 2001b; Gunter, Furnham, & Griffiths, 2000).

[5] Examples of true/false questions are: "The Nature Conservancy is opposed to the use of 'prescribed burns.' True or false?" and "Forest fires are regular and natural events in many ecosystems, including the Yellowstone National Park. True or false?" Examples of multiple choice questions are: "Based on EMBYR models testing climactic conditions over 1000 years, scientists found the largest total burned acreage from which of the following conditions? Wet, normal, dry, or no meaningful differences between them?" and "In Yellowstone National Park, fire is part of a cycle that, if allowed to proceed, would replace the forest about every . . . 25-30 years, 50-75 years, 100-300 years, 1000-1500 years?" Examples of short answer questions are: "What are the benefits of the images produced by the GOES-8 satellite?" and "What is the U.S. government's current stance on dealing with forest fires?" Examples of words to be defined are: geostationary, thermodynamics, crown fires, and firebrands.

[6] Although some have suggested theoretical reasons for doing so (e.g., Lang, 2000), we were unable to separate our measure of knowledge into dimensions of recognition (true/false and multiple choice questions) and cued recall (short answer and definition questions) for a number of reasons. First, the resulting 7-item recognition measure would have been unreliable (KR-20 = .39). Second, the multiple-choice index was more strongly correlated with the short answer (r = .42) and definition (r = .53) indices than it was with the true/false index (r = .19). The multiple choice index was also more strongly related to both the short answer and definition index than these two indices were to each other (r = .35). These findings lead us to believe that the use of a recognition index composed of true/false and multiple-choice indicators, and a cued recall index composed of short answer and definition indicators, would be psychometrically inappropriate compared to the overall index of content knowledge employed in this study. Moreover, our theories do not have separate predictions for cued recall versus recognition, and thus there was no theoretical reason to separate our measure in this manner. Even if we were to separate our measure, we did not design it to cover identical content using both recognition and recall, and thus any differences in these measures could not be empirically separated from simple differences in the content of the questions.

[7] There were no apparent problems meeting the statistical assumptions of regression, particularly given the robustness of this technique. The sufficient internal consistency reliability and previous use of our independent measures suggests measurement error should not be a problem, and there were no problems with the error terms. Multicollinearity was not a concern in the model, based on an analysis of the variance inflation factor (VIF) for each independent variable. Finally, in regards to specification error, the only nonlinear bivariate relationship (a significant but weak cubic relationship between scanning and content knowledge) disappeared upon control of elaboration and the experimental manipulation.

[8] An indirect effect is calculated as the product of direct paths. For instance, the indirect effect of medium on content knowledge through elaboration is calculated as the product of the path between medium and elaboration and the path between elaboration and content knowl-

edge. Cohen and Cohen (1983) claim that any indirect effect that is the product of significant paths is itself significant.

Measurement Appendix

Elaboration

The following items were all measured using 5-point Likert scales with options of "strongly disagree," "disagree," "feel neutral," "agree," and "strongly agree."
I tried to think of the practical applications of what I read.
I tried to relate the ideas in the story to my own past experiences.
I thought about how what I read related to other things I know.
I thought about what actions should be taken by policy-makers based on what I read.
I found myself making connections between the story and what I've read and heard about elsewhere.

Selective Scanning

The following items were all measured using 5-point Likert scales with options of "strongly disagree," "disagree," "feel neutral," "agree," and "strongly agree."
I only read sections of the story that looked important or interesting.
I skimmed through the story.

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