AN EXAMINATION OF PRINT AND WEB GRAPHICS’ EFFECT
ON READERS’ RECALL

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I. INTRODUCTION

For millions of years civilizations have used information graphics to tell stories. From the Assyrians’ clay-tablet maps in 3800 B.C. to the current four-color weather map in *USA Today* (George-Palilonis 2006), information graphics have proven to be effective visual storytelling tools (George-Palilonis 2006). Journalists use these tools to answer questions visually, such as where or how an event happened and they break down complex concepts into smaller, simpler chunks for readers to comprehend quickly. Harrower (2002) notes that graphics as packages “…blend text and illustrations to convey information visually – clarifying the facts with charts, maps, or diagrams” (153).

The combination of text and visual elements in storytelling has also proven to increase readers’ understanding and retention of information. As such, Paivio’s (1971) Dual Coding Theory asserts that integrating text and visuals enhances memory because both sides of the brain are nearly simultaneously engaged with both visual and verbal information. He wrote, “The probability of remembering an item would be a direct function of the availability of both codes” (181).

Thus, during the past two decades, information graphics as tools for journalistic storytelling have steadily gained favor among both editors and readers as important and often, poignant devices. And when technological advancements, such as desktop publishing, made the production of graphics on deadline more efficient, a clear way was paved for the information graphics explosion of the 1980s. During a time when fewer individuals read the newspaper cover to cover and time-starved readers began scanning and sampling their newspaper content, information graphics provided journalists with a way to better serve the needs of readers.
USA Today, created in 1982 at the height of the graphics explosion, embraced these changes and presented the news differently than most other American newspapers. Shorter stories and more information graphics took center stage from the newspaper’s inception as editors insisted its format would better serve the “time-starved reader” (George-Palilonis 2006). Harrower (2002) writes, “Years ago, sidebars and infographics were considered optional. Nowadays, they’re essential for effective newspaper design” (153).

In the 1990s technology advanced once again and the Internet provided users faster access to more information than traditional print media. During this time, newspapers began to provide online news, and research into how users engage with online content has been mounting for the past 20 years. Some researchers have claimed the Internet can help facilitate learning because of its increased interactivity. According to Churcher (1989), Web users mentally organized information based on the hierarchy of content presented through hypertext, which in turn facilitated learning. Likewise, theories about the Internet’s potential learning benefits play nicely with Paivio’s (1971) Dual Coding Theory by supporting the idea that presentation of information graphics can affect readers’ recall especially, with interactive information graphics. For example, users’ interaction with online information graphics provides them freedom to explore information nonlinearly and create a mental organization of the information based on an online graphic’s hypertext presentation.

However, specific research regarding how information graphics in print and online affect readers’ recall and understanding of information is scarce at best and at times, even contradictory (Ward 1992). Eveland and Dunwoody (2000) found that the
Internet did not facilitate learning, but rather hindered it. In their study they used a qualitative talk aloud protocol to evaluate how efficiently users learned information from a Web site. The researchers noted that the Web’s freedom caused users to exert more effort in navigating the content and because of this, users were not learning efficiently. Therefore, the effectiveness of information graphics as storytelling devices and reader engagement, understanding, and recall of information presented therein is a promising topic for additional research.

In addition, studies that compared readers’ information recall between print and online, such as the 2007 Poynter Eye Track Study, suggest that readers don’t have the same experience with print and online formats. The Poynter studies ultimately revealed that the type of content should weigh heavily on decisions regarding how that content is presented, because print and online formats have different advantages and depending on the type of content, one format may be more effective than the other. In a book that reported Poynter’s findings, Dr. Pegie Stark Adam writes, “This suggests we need to be cautious and avoid displaying all stories in alternative ways. When deciding on story form, let the content be your guide” (Adam, Quinn, and Edmonds 2007).

The worth of research in this area is to determine whether the potential benefits of interactivity increase individuals’ recall of information. Such research could benefit traditional and online newspapers and ultimately, readers. By helping news media more effectively tailor the presentation of news, a concept particularly important given recent struggles to survive in print and online in a dramatically changing media environment. This experiment will apply interactivity concepts and Dual-Coding Theory to explore whether the chosen presentation of information graphics affects the recall of content.
II. LITERATURE REVIEW

PRINT RESEARCH

The success of *USA Today* was the catalyst for newspaper editors to not only report the news, but package it with graphics (Griffin and Stevenson 1992). Harrower (2002) wrote:

> You have information; your reader needs it; you must teach it to them as quickly and clearly as you can. Sometimes words work best. Other times, information is best conveyed visually, not verbally (149).

This thesis reviews a body of literature that focuses on information graphics in traditional and online newspapers. The following studies are organized topically: effectiveness of information graphics compared to other forms of sidebar information; information graphics design; and online research: interactivity, interactive Web site features, and effects of interactivity on users.

*Newspaper Design*

The design revolution of the 1980s meant that newspapers could no longer afford to ignore alternative story structures and information graphics as viable storytelling devices. As the popularity and importance of information graphics increased, newsrooms redirected their efforts to reshape presentation. The new tools and changes occurring in newsrooms across America gave researchers the opportunity to examine the changing newsroom dynamics and the effects information graphics would have on readers.

Garcia (1980) wrote that newspaper readers were caught in a design revolution, therefore, newspaper editors needed to become more graphically aware. He noted that, “Anyone who served an apprenticeship at a newspaper years ago can remember an
aggressive city editor shouting: ‘Think news.’ Today’s successful city editor has added
two other words to his command: ‘Think graphics’ (1). Garcia stressed that editors
needed to change their thinking about graphics and content. He wrote, “…it should be
remembered that a graphic change alone will not save a newspaper, unless it is
accompanied by relevant and contemporary thinking in terms of content” (2).

Research on information graphics has focused on correlations between design and
readership and has supported Garcia’s (1980) message. Rarick (1967) found that
readership increased when a larger headline was used. Whereas, Mullins and Weaver
(1974) found that newspapers with lower readerships had more modern formats. They
wrote, “It might seem that traditional makeup and display practices associated with the
leaders are a result of the leading newspaper being the ‘older established newspaper’ and
the trailer being the more recently established newspaper” (10).

Nearly a decade later, Utt and Pasternack (1989) found Garcia’s message still
relevant to editors and readers. They wrote, “In this study, seven in ten editors said they
feel readers take appearance into account when deciding which newspaper to read. This
compares to 49 percent five years ago” (627). And Griffin and Stevenson (1994) noted,
“Nontextual presentations of information through maps, charts, graphs, illustrations, and
other graphics have become more common” (939).

The increased use of information graphics was a trend that Utt and Pansternack
(2003) showed extended into the new millennium. These researchers examined the trends
of newspaper front pages and their online counterparts. The results indicated almost 45
percent of newspapers had increased the number of information graphics on their front
pages in the past five years.
Brantley (2001) found that since *USA Today*’s introduction, other papers had emulated its style. However, she discovered that smaller circulation papers were not more likely to adopt *USA Today*’s style. Brantley’s study did not support the findings of Gladney (1990), which suggested that smaller papers were more likely to adopt *USA Today*’s style.

Readers have responded to the changing newspaper presentation. Whether they prefer a bigger headline style or a traditional newspaper style, readers take into account the presentation of their news. As a result, journalists must consider the presentation of storytelling to be as important as the stories themselves.

*Effectiveness of Information Graphics Compared to Other Forms of Sidebar Information*

The rise of information graphics as journalistic tools led researchers to examine their effectiveness in aiding recall of information. Research in this area yields a common theme: repetition. Griffin and Stevenson (1992) found when information from a story was repeated either in a sidebar story or a graphic readers’ understanding increased. “Either technique seems to work (with a slight advantage to the traditionalist) but the redundancy of reinforcing one technique with the other is especially effective” (96). And in a subsequent study two years later, Griffin and Stevenson (1994) supported their previous findings. The researchers noted, “American news consumers, with their sketchy knowledge of other countries and cultures, are ill-prepared to put these stories into perspective” (937). The researchers examined whether maps could complement geographic information in news stories. Once again, the combination of text and graphics resulted in the strongest understanding of the story.
Wanta and Remy (1995) discovered similar results. They found that information from a news story repeated in pullout quotes greatly increased recall. Contrary to their expectations, researchers found participants had the greatest trouble recalling information from the graphics alone. In contrast, Ward (1992) found that participants who read a table in addition to a story did not understand the numbers better than participants who did not see the table. Two strengths of information graphics are that they visually breakdown complex information and give context to information presented in a story. This repetition of information often results in increased understanding and retention of the content. Thus, journalists can and do use information graphics to layer information and make content easier for readers to comprehend and remember.

**Information Graphics Design**

The effectiveness of graphics might be connected to the quality of the overall design and orderly presentation. Tankard (1987) listed ten “pitfalls” newspaper graphic reporters often encounter when creating information graphics including the tendency to unnecessarily make use of three-dimensional graphics or graphs with little variation. “This kind of graphic device can be effective in attracting reader attention and making statistical information more palatable, but it also runs the risk of distorting the statistical information” (415). Harrower (2002) agreed with Tankard and noted that graphics can be over done, and when they are, they can distort information and distract readers. He advised to keep graphics simple. “Used with wit and flair, they can make dry statistics fresh and appealing. Proceed with caution” (179).
Tankard and Harrower echoed the theme of simplicity that is also found in Tufte’s (1983) data-ink-ratio. Tufte suggested that fewer distractions in a graphic, or non-data ink, resulted in more readers who would comprehend the information. As intuitive as the data-ink ratio sounded, researchers’ studies’ have not always supported Tufte’s (1983) theory. Kelly (1989) found graphs containing a high ratio of non-data did not interfere with participants’ recall. In addition, Tankard (1989) found no significance between the recall of participants who viewed “chartoons,” or the combination of graphics and cartoon embellishments and the recall of participants who viewed a plain graph. He also found that “chartoons,” or graphics that are elaborately illustrated were often more attractive to readers than plain charts and graphs.

Ward (1992) found similar results to Kelly (1989) and Tankard (1989). However, he later warned,

Graphs may save space, and they may be a visual way of presenting statistics or attracting a reader’s attention, but they serve no purpose if the reader can’t understand them. And if people don’t understand a graph, they’ll likely do with it what they do with a story they perceive as too complicated: pass it by (325).

Thus, visual journalists must always have the reader in mind when designing information graphics.

ONLINE RESEARCH

Interactivity

Mass media has changed dramatically due to advances in technology. According to Heeter (1989), “These new technological developments illuminate inadequacies in and issues relevant to traditional conceptions of communication, particularly mass
communication” (217). She also noted researchers often define new technologies as interactive, but the concept of interactivity is often left undefined. As a result, Heeter defined six dimensions of interactivity: the extent to which users are provided with a choice of available content; the amount of effort users must exert to access information; the degree to which a medium can react to users; the potential to monitor system use; the degree to which users can add information to the system, which other users can access; and finally, the degree in which the system can facilitate interpersonal communications between specific users.

Rafaeli (1988) reiterated Heeter’s statement that interactivity was not often defined. He said, “Interactivity is a widely used term with an intuitive appeal, but it is an underdefined concept” (110). The researcher said for full interactivity to occur communication roles should be interchangeable.

Massey and Levy (1999) also tried to define interactivity in terms of journalism. These researchers split interactivity into two dimensions: content interactivity, or “the degree to which journalists technologically empower consumers over content” (140) and interpersonal interactivity, or “the extent to which news audiences can have computer-mediated conversations through journalists’ technological largesse” (140).

The researchers used adaptations of Heeter’s (1989) dimensions with consideration of immediacy to examine whether a uniformed definition could be used as a benchmark to determine the development of online journalism in Asia. They found that English-language, Asian newspapers strongest dimension of interactivity was content interactivity, which was similar to Heeter’s complexity of choice demension. The
researchers did not find interactive dimensions, such as immediacy, and allowing readers to add their own content.

A possible explanation for Massey and Levy's findings in Asia was Pavlik’s (1997) sentiment that news content online evolved in three stages: putting the content from newspaper, or “the mother ship” online; original content with interactive features, such as hyperlinks and search engines; and original content designed for Web as a new communication medium, which will immerse the user in news content. He said the majority of content online was in stage one or two, which supported Massey and Levy’s (1999) findings. He used The New York Times experimental work with omni-directional imagery, which would give users a 360-degree view of content, as an example of “immersive storytelling.” A current example of Pavlik’s stage three is The Las Vegas Sun’s Web site, which allows users to navigate an immersive, 360-degree view and audio of the 2008 New Year’s fireworks display on the Las Vegas strip.

Interactivity encourages users to participate with the content and with other users. By defining the concept of interactivity and the progression of online newspaper interactivity, researchers help to define where online newspapers stand with their current features and predict what online newspapers could offer in the future.

Interactive Online Features

McMillan and Hwang (2002) wrote, “the word ‘interactivity’ is often used as a synonym for new media, such as the Web” (29). This new technology means changes for journalism, which has always been shaped by technology. (Pavlik 2000)
“The once-basic inverted pyramid news-writing style is becoming obsolete in online news world,” according to Pavlik. “It is being supplanted increasingly by immersive and interactive multimedia news reports that can give readers/viewers a feeling of presence at news events like never before” (232).

Interactivity is a distinguishing characteristic of online, according to Millison (1999). He asserted that real-time publishing, multimedia (defined as text, graphics, audio, motion video, 3D, and animation), and time-shifted publishing (meaning stories are published to be read now or later) were additional characteristics of online journalism. Because of the interconnection of graphic hypertext-linked pages that support multimedia, traditional media rapidly tried to establish a presence on the Web. (Friedland and Webb 1996)

Peng, Tham, and Xiaomingn (1999) found Web sites often provide services that the traditional newspaper cannot offer. For example, the searchable archive and classified ads help Web newspapers become a databank for users. “The hyperlinks have changed the newspaper from singles source of information into a hub of information networks without a clear ending point” (6). Research has found users defined the level of a Web site’s interactivity by the number of hyperlinks present. (Sundar et al. 2003)

“As a medium, the Internet presents information nonlinearly, at least in part,” Dimitrova and Neznanski (2006) said. “Traditional newspapers offer a variety of entry points for readers through the juxtaposition of many stories on a single page, but are still typically read from top to bottom, or at least in sections starting from the so-called home page” (251). They found hyperlinks and photos were the most common online features
used to report on the Iraq War. They also noted that Web sites covering the war rarely used multimedia content, interactive features, and animations.

Contrary to Dimitrova and Neznanski’s (2006) findings, Beyers (2006) found American award-nominated news sites frequently offered multimedia, especially enhanced photo galleries; whereas, half as many European sites offered such galleries. In addition, the U.S. sites also offered more PDA versions. Europe and the U.S. were close in the amount of WAP/GRPS versions offered; whereas, Europe news sites offered more Short Message Services (SMS) mobile services than U.S. sites.

Key variables of interactivity, such as length of Web presence, ownership, region of coverage, strength of technological staff, and newspaper size were the focus of Zeng and Xigen’s (2002) study. The researchers found larger Web sites and those with longer online presence had higher interactivity.

Greer and Mensing (2004) also found that size was a general predictor of online offerings. These researchers found two trends emerged during the seven-year study: online news sites are offering more of everything including content, multimedia, revenue generating sources, and interactivity, and size of the newspaper is a general predictor of their online offerings. “While medium and large newspapers have become more similar, small newspapers lag behind,” the researchers stated (108).

Even ten years after the initial rush for newspaper to establish a Web presence, there is still a wide variation of online news offerings from newspaper to newspaper and even content to contented. However, online newspapers which take advantage of the Web’s ability to support multimedia presents additional tools for visual journalists to use to tell news stories.
“Investigating the elements of on-line publishing that facilitated learning is an important question for communication research,” Randolph (1998) wrote. He defined hypermedia as “technology that allows readers to click on a word or picture to jump from story to story” (64). He found participants who examined an electronic story, graphics, and hypermedia had higher recall scores than those who only read an electronic story and a graphic. He retested the participants a week later and found that all scores had decreased, but the participants who examined the electronic story, graphics, and hypermedia decreased the least.

Willis’s (1999) findings supported Randolph’s (1998) results. Willis (1999) investigated whether designing with enhanced visual elements (EVEs), or visual online elements, graphics, pictures, color, text formatting, and icons that are carefully chosen to reflect the design, in a Web presentation helped the user with long-term retention. Willis found that participants who viewed a Web presentation with EVEs had higher recall scores when retested a week later.

“The Web is a unique form of media,” Willis (1999) wrote. “The fact that it enables the use of enhanced visual elements as aids in communication makes it possible to expect results in visual communication effects which are similar to those found in traditional media research” (4).

Another way the Web can facilitate learning is the non-linear presentation of information, which allows readers to build their own mental organization of information (Churcher 1989). Conklin (1987) also noted that non-linear presentation was a strength of the Web. He said, “Another advantage is that it is quite natural in a hypertext
environment to suspend reading temporarily along one line of investigation while one looks into some detail, example, or related topic” (38). However, Conklin (1987) also noted two drawbacks of interactivity are disorientation, or the tendency to lose one’s sense of location and direction in a non-linear document, and cognitive load, or the additional effort and concentration necessary to maintain several tasks at one time.

Several researchers suggested the freedom of the Web created an environment conducive to users becoming lost in the information. “Therefore, any operationalization of interactivity that evolves navigation is a double-edge sword; increasing clicking activity among users may boost their engagement with content but also concurrently induce tedium,” said Sundar et al. (2003). These researchers found support that there can be too much interactivity in a Web site. Researchers expected a positive correlation between interactivity and recall or retention; however, the results showed participants examining a high interactivity Web site became frustrated with the layers of information.

Eveland and Dunwoody (2000) noted that disorientation is a problem particularly when the space is designed badly. The researchers found the participants spent large amounts of time and effort orienting themselves with the content and structure of a Web site, and the more time spent on the site did not decrease the disorientation. Their results supported Conklin’s findings, but they also noted disorientation might not be a problem for future generations. “As socialization to television, there will soon come a time when children grow up with nonlinear media, such as the Web, and those children, when they become adults, should be less confused by nonlinearity than are adults today” (236).

Bucy (2003) also studied disorientation, and said hypermedia offered more freedom than traditional media, which magnified the potential for losing one’s place and
increased the difficulty in finding desired information. He found that television news sites were more interesting to participants than newspaper news sites. As predicted, younger participants responded more favorably to television news sites. They found that interactive tasks were more participatory and immediate, but also, more confusing. In addition, Bucy found that several older participants refused to participate in online.

This study supports Correa’s (2003) concept of “paper readers” versus “electronic readers,” however it is important to note that Adoni (1995) found that though book reading has gone down among young readers and the amount of electronic media has increased, but she did not find that newspaper readership among younger readers decreased in the past twenty years.

Several researchers noted that age might also be a consideration of interactivity’s effect on users. For example, Eveland and Dunwoody (2000), Bucy (2003), and Correa (2003) reported that younger users are more likely to experience less disorientation. “Surveys of Internet use report that education and age are among the most important demographic factors facilitating or inhibiting Internet access” (Bucy 2003, 10).

Graber (1990) found that the visual themes proved to be more memorable in television news broadcasts than verbal themes. “Research has shown that audiences report visual content more accurately than verbal content and retention rates are much higher for visual information” (149).

Half of her participants were randomly selected social sciences professors who also nominated students who might be interested in participating. Another quarter where students entering a classroom building, which housed social sciences, chosen randomly, and the remaining were nominated blue and white collar workers. It is important to note,
the current study will use a similar process for selecting participants. Her results showed that participants remembered 16 percent of verbal themes as opposed to 34 percent of visual themes.

Sundar (2000) findings supported Graber’s (1990) results. He found that participants who viewed the picture and audio rated their Web site less coherent than the text only and picture only groups. Furthermore, he found the picture and audio and the video group rated their site with a low news quality. He noted audio and video might have scored low because participants compared the quality to radio and television, whereas the comparison for pictures and text is print. “Given the display of text and pictures compare extremely well with the glossiest of color print media, it may be argued that participant in the text and picture conditions were generally satisfied with the quality of resolution” (495).

Wicks (1995) also studied news recall. He argued that recall improved over time because participants had 48 hours to think about the information. He found no differences in recall between mediums of newspaper and television. He also found that recall after 48 hours was slightly higher than the recall immediately following the viewing.

Just as in print information graphics, visual journalists must keep readers in mind when presenting information online. The Web provides users the freedom to navigate what content they chose, when they chose. This freedom, which some say can increases learning, can also be disorienting. It is important for researchers to examine how users interact with online graphics in order to find ways to design online graphics effectively.
III. METHOD

This researcher was inspired by Griffin and Stevenson’s (1994) study, which examined whether maps could complement geographic information in news stories and found the combination of text and graphics resulted in the strongest understanding of stories. And based on this previous research, the experiment outlined for this thesis will explore the following research questions: **RQ1**: Is a reader’s recall increased when he/she is presented with an online graphic (more interactive) than a print graphic (less interactive)? **RO2**: Do younger readers exhibit greater recall of interactive graphics?

Griffin’s and Stevenson’s (1994) study used the format of information -- text versus map -- as their independent variable. In this experiment, the independent variable is also based on format, but it compares print to Web. Instead of the two-by-two research design used by the researchers, which produced four conditions (text, map, text and map, and no stimulus), this study only uses two conditions of the independent variable a print condition and an online condition.

“Inside a Tooth” by *The South Florida Sun Sentinel* served as the online graphic and “Reversing Tooth Decay,” also published by *The South Florida Sun Sentinel* served as inspiration for the print graphic. This print graphic was originally similar to the online graphic, however it contained additional information that the online graphic did not. The researcher altered the print graphic so that it reflected the same information as the online graphic in order to create a one-to-one ratio, meaning all groups saw the same information, regardless of its presentation. The researcher asked participants to review one of the information graphics and answer eight multiple-choice questions. All participants answered the same eight questions. The dependent variable was each
participant’s set of responses. The researcher summed the correct answers and averaged the scores within each group. In addition to the multiple-choice questions, a self-evaluation survey of news interest and demographic questions were included. Media use and interest are cognitive variables in the experiment. Therefore, the self-evaluation surveyed participants on how many days in the previous week they read the newspaper or watched a nightly news program and how many times in the past four weeks the participant read a news magazine.

The 64 participants were students, faculty, and staff at Ball State University. The researcher recruited participants by sending an all-Ball State e-mail requesting volunteers. The researcher felt this was the best way to reach all three groups of possible participants and ensure a broad range of ages was contacted. The researcher worked with each participant individually and explained that he or she was participating in a graduate thesis research project. Participants received the graphic either in print format or online format. Each participant also received an envelope containing the questionnaire. The researcher instructed them to review the provided graphic during a 10-minute session. When finished, participants were asked to return the graphic to the researcher and begin the questionnaire. When the questions and self-evaluation were complete, participants placed them into the envelope and sealed it, and their identifying information was not attached. Each group’s mean scores for correct answers were calculated and compared. To test the independent variables and cognitive variables (self-evaluation of interest and media use) the researcher used an analysis variance (ANOVA).

By using the experimental design outlined above and inspired by that of Griffin and Stevenson (1994), this researcher was able to explore whether the presentation of
information graphics affects the recall of content. The sections that follow present the findings of the study.

IV. RESULTS

The researcher began this experiment with two main hypotheses: 1) When more interactivity is offered by an information graphic (an online graphic), a reader’s recall of the information will increase, and when less interactivity is offered by an information graphic (a print graphic), a reader’s recall of the information will decrease; and 2) that younger readers would have better recall of interactive graphics than older readers.

Based on the research of Randolph (1998), Willis (1999), and Churcher (1987), interactivity has been shown to increase reader’s recall, and its non-linear presentation allows users to create their own mental hierarchy of information. Yet, Sundar et al. (2003), Evenland and Dunwoody (2000), Bucy (2003), and Correa (2003) found the freedom of a non-linear presentation can also as a result in increased disorientation. In addition, the research of Bucy (2003) shows that younger users may not experience this disorientation based on a general greater level of experience with online tools than older readers.

Regarding RQ1 -- Is a reader’s recall of the information increased when he/she is presented with an online graphic (more interactive) than a print graphic (less interactive)? -- This study found that although the online graphic group did have a higher recall average than the print group, the difference was not statistically significant (p=.340, p>.05). Table 1 provides a look at the their mean scores on the recall questionnaire
Regarding **RQ2** -- Do younger readers exhibit greater recall of interactive graphics? -- results also do not support the researcher’s second hypothesis, which stated that younger readers would exhibit greater recall of interactive graphics. The researcher ran a correlation matrix of these variables, and found no significant correlations (r=.167, p > .2) Thus, hypothesis two was also not accepted. See Table 2.

<table>
<thead>
<tr>
<th>Description</th>
<th>Correlation Strength</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger/online</td>
<td>.167</td>
<td>.360</td>
</tr>
<tr>
<td>Older/print</td>
<td>.136</td>
<td>.457</td>
</tr>
</tbody>
</table>

After the data was collected, the researcher suspected there may be a correlation between Question 9, which asked participants to circle the number of days in the past week in which they read a newspaper and the print participant’s recall scores. The
researcher suspected that those participants who read newspapers more frequently might have higher print recall scores, because they would be more accustomed to read information in a print format rather than an online format. Likewise, the researcher also suspected a correlation between online recall scores and Question 10, which asked participants to circle the number of days in the past week in which you read an online news site and online participants recall scores; again because participants would be more accustomed to reading information in that format. The researcher suspected that those who read online news sites more frequently would have higher online recall scores. However, a post hoc analysis correlation matrix found no support of these suspicions either (Newspaper: r=-.202, p > .2 and Online: r=.034, p > .2). See Table 3.

<table>
<thead>
<tr>
<th>Description</th>
<th>Correlation Strength</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newspaper readers/print</td>
<td>-.202</td>
<td>.267</td>
</tr>
<tr>
<td>Online news site users/online</td>
<td>.034</td>
<td>.854</td>
</tr>
</tbody>
</table>

Where information graphics are concerned these findings did not correspond with Randolph (1998), Willis (1999), Churcher (1989) and Conklin (1987), who stated the online formats provided users more freedom and therefore encouraged higher recall than the static print format. Nor do the results coincide with the findings of Sudar et al. (2003),
Eveland and Dunwoody (2000), Bucy (2003) and Correa (2003), who stated that the Web disoriented users, hindering their learning capabilities.

Overall, these results show no superior format between print and Web. The online group may not have had significantly higher recall score, but it is worth mentioning that the results also did not show significantly lower recall scores.

V. DISCUSSION

The Dual Coding Theory supports the fact that a reader’s recall of information presented in an information graphic is improved because the graphic engages both sides of the brain. Interactivity is another concept that has been shown to produce higher recall of information because it allows users freedom to create their own mental hierarchy of the content on a Web site. Therefore, the researcher deduced that combining information graphics, which are examples of the Dual Coding Theory because they use text and graphics, with the Internet, which brings interactivity to play, would result in online participants having higher recall than print participants, who only experienced the benefits of the Dual Coding Theory.

This study applied interactivity concepts within the context of The Dual Coding Theory to attempt to discover if reader’s recall improved as a result. While the results suggest the benefits of online interactivity may not increase reader’s recall more so than print, they also suggest that online participants did not experience an increased mental strain when as they initially navigated the Web page, as previous researchers mentioned.
The seeming lack of disorientation or excessive mental strain from the online group shows that the interactivity of the Web graphic did not impede their learning. The interactivity also did not significantly boost their scores, and therefore, suggests that the strength of information graphics lies in combination of text and graphics, regardless of format, as the Dual Coding Theory states.

And although some research shows that online formats induce confusion and create such a cognitive strain on the users while orienting themselves to the Web site that all possible learning benefits are lost (Eveland and Dunwoody 2000), this study did not reflect those concerns. Nor did it clearly reflect the supposed benefits of online formats. In the end, this study shows that perhaps online format is neither better nor worse than print formats. In addition, younger online participants (participants who were 18 to 34 years of age) did not outshine the older online participants (participants who were 35 to years of age and older).

It’s important to note a number of limitations this particular method presented, as well as mention that some minor modifications actually make for a stronger study with the same research questions and hypotheses as a foundation. First, a small sample size and small number of questions limited this study. Adding more questions would allow for a wider range of variance in responses. Currently, the average of correct answers for the groups were between six and seven out of eight questions. Second, no control group was incorporated into the study so it is impossible to know whether participants learned the information from what they read or if they relied on previous knowledge. One possible way to fix this would be to incorporate a control group and/or a pretest.
Third, the researcher initially only considered time as factor in the sense that all participants were limited as to how much time they could spend with the graphic (10 minutes). However, during the study, the researcher noticed print participants tended to take far less time than online participants. This is mostly likely due to the fact that the online participants had to manually click though the online graphic, which more time than simply having to read the graphic in print. In future studies, time should be documented and included as another dependent variable or standardized so every participant is forced to spend a certain amount of time with the graphic.

Fourth, the researcher limited recruitment to exclude all College of Communication, Information and Media students, faculty and staff, because of their close affiliation with print and online news content, but this may have not been necessary. Exclusion of only journalism graphics students might have eliminated the concern of including participants who were over-exposed to information graphics and therefore, potentially skewing the results. However, it was not taken into consideration to exclude health majors or pre-med students or professors who may have more knowledge of the information graphic’s content. Fifth, several participants mentioned they preferred reading graphics in print format more than online format. The research did not include a question regarding participants’ format preferences, but future studies may want to investigate whether participants’ preference correlate negatively or positively to their recall scores.

Additionally, several participants mentioned their interest in knowing whether format played a roll in improving recall and how that could be applied to educating children. Future studies may also explore the educational benefits of online testing or
compare online testing and traditional testing in the context of elementary, middle school or high school students.

Online information and print information graphics clearly have strengths and weaknesses and knowing the strengths of each format can only benefit visual journalists. Online graphics can be additional tools, not a replacement for print graphics, in the visual journalist toolbox, which, just as print information graphics, can also combine text and image to break down information for readers. And although this study did not validate the researcher’s original hypotheses, answers to research questions outlined in this study are important and significant because they provide further insight into how interactivity affects the general effectiveness of an information graphic. Likewise, as a pilot study, this thesis provides an outline for more in-depth and thorough subsequent studies that should continue to explore the relationships between interactivity, Dual Coding Theory, and recall. Finally, despite finding that interactive graphics did not increase participants recall scores more than print graphics, it’s significant that the results showed interactive graphics still provide a way of breaking down complex information that is at least as effective as print information graphics. Regardless of format, information graphics supply the reader with the combination of text and images, which as The Dual Coding Theory suggests, heightens readers’ recall of information.
Reversing tooth decay

1. Bacteria live in everyone’s mouth, even with good hygiene. They stick to teeth and produce plaque.

2. The bacteria produced acid that dissolves minerals in the enamel. Small pits or indentations may develop; these are not cavities, only a weakening of the enamel.

3. If plaque is left on teeth, tooth decay will grow deeper into the enamel, creating pockets of decay.

The enamel layer is 99 percent calcium crystals (minerals) built of closely packed rods. It is the hardest mineral in the body.

The dentine layer is composed of 50 percent calcium crystals (minerals). The remainder is water and organic material.

The pulp chamber contains blood and nerve vessels. It provides the tooth with nourishment and sensation.

4. Acid travels through hollow tubes in the dentine toward the pulp.

Cementum is a thin layer covering the root, and its structure resembles bone. From the cementum are fibers that secure the tooth to the gums.

Never fibers provide feeling for the tooth and enter from the bottom of the tooth’s roots.

Blood vessels supply the tooth with nutrients.

5. Eventually, a cavity is produced as the weakened tooth decay collapses and forms a pit. At this stage, the tooth cannot repair itself, and a filing is necessary.

In adults, it can take four to six years to penetrate enamel; a cavity may form anytime after that. Since baby teeth are thinner and less mineralized, cavities can develop in a year or two.

Without intervention, the decay will push deeper into the tooth, infecting the root and probably the bone.
Inside a Tooth

The online graphic is available at:

http://kttryon.iweb.bsu.edu/toothdecay.swf
APPENDIX

QUESTIONNAIRE

1. The three main layers of the tooth are:
   a. bacteria, starch, and acid
   b. gums, enamel, and pulp
   c. enamel, dentin, and pulp
   d. crown, enamel, and pulp

2. The bone-like material that surrounds the root and fastens it into the socket is called:
   a. dentin
   b. cementum
   c. plaque
   d. pulp

3. The pulp chamber contains _______, which nourish the tooth.
   a. dentin and enamel
   b. sugar and starches
   c. acid and bacteria
   d. blood and nerve vessels

4. In adults it takes ______ to penetrate the enamel.
   a. 1 to 2 months
   b. 3 to 5 months
   c. 1 to 2 years
   d. 4 to 6 years

5. Acid travels down ______, toward the pulp.
   a. the gums
   b. hollow tubes
   c. the crown
   d. decay

6. Bacteria produces _______, which dissolves the tooth enamel.
   a. sugar
   b. plaque
   c. acid
   d. starch

7. Pockets of decay are caused by _______ left on the tooth.
   a. plaque
   b. food
   c. sugar
   d. bacteria
8. Without intervention, decay will infect _________.
   a. gums and tooth
   b. the root and possibly the bone
   c. the enamel and dentin
   d. the dentin and pulp

SELF EVALUATION:

9. Please circle the number of days in the past week in which you read a newspaper.
   a. 0
   b. 1
   c. 2
   d. 3
   e. 4
   f. 5
   g. 6
   h. 7

10. Circle the number of days in the past week in which you read an online news site.
    a. 0
    b. 1
    c. 2
    d. 3
    e. 4
    f. 5
    g. 6
    h. 7

11. Circle the number of days in the past week in which you watched a news broadcast.
    a. 0
    b. 1
    c. 2
    d. 3
    e. 4
    f. 5
    g. 6
    h. 7

12. Circle the number of times in the past week that you read a news magazine.
    a. 0
    b. 1
    c. 2
    d. 3
    e. 4
    f. 5
    g. 6
    h. 7
13. I would rate my interest in news as:
   a. very interested
   b. interested
   c. somewhat interested
   d. neither interested nor uninterested
   e. somewhat uninterested
   f. uninterested
   g. very uninterested

DEMOGRAPHICS:

14. Age: ______

15. Gender:  M    F

16. Please circle one:
   a. professor
   b. student
   c. staff member

17. If you are a student or professor, which college are you apart of:
   a. College of Fine Arts
   b. College of Applied Sciences and Technology
   c. College of Architecture and Planning
   d. Miller College of Business
   e. College of Sciences and Humanities
   f. Teachers College


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