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How Arithmetic Aptitude Impacts Attention, Memory, and Evaluation of Static Versus Dynamic Infographics in Online News: An Eye-Tracking Study

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Abstract

Graphics accompanying online news articles were manipulated between static and dynamic formats. Eye gaze, perception, and memory data were collected as was participants' arithmetic aptitude (AA). Results suggest that although dynamic graphics are negatively evaluated, high arithmetic aptitude participants attend and recall dynamic graphics more so than those with lower AA who are drawn to and recall better static visuals. Memory and attention to graphics detracted from memory and attention to story text and vice versa.

Keywords

eye tracking, arithmetic aptitude, web content, animation, experiment

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Cursory examination of news websites reveals an often-dizzying array of visual elements. Indeed, in an apparent competition for users' attention, layout and graphic editors recurrently offer increasingly complex visual media saturated with interactive elements. Thus, infographics and the use of visual aids to help convey information related to accompanying text passages typify much internet content (Rogers, 2012). However, this proliferation has been accompanied by concerns that the visual aids may, at times, overwhelm and possibly confuse digital news consumers (Diaz, 2011). This recent clamor against the ubiquitous use of supplemental information prompted spontaneous discussions in the industry on the adequate standards of infographics and led scholars to devote attention to the subject (Bucy & Newhagen, 2004; Sundar, 2000).

Today prominent news organizations such as *The Guardian* in England (see *The Guardian Datablog*), *The New York Times*, and multiple networks are praised for their data journalism efforts. Such media supplement words to better present developing stories to an audience all the more inclined to consult news through tablets and mobile devices (Pew, 2013). However, the industry seemingly operates under the assumption that such visual embellishments not only generate heavier website traffic but also positively influence readers understanding and recall of the exposed news details. This constitutes an empirical question.

Two implicit goals of journalism are effective information transmission and generating understanding of news content (Lang, Potter, & Grabe, 2003). To wit, scholars have suggested that interactive web features in general could be overly cognitively demanding and thus detract from enjoyable and accurate consumption (Harris, 2011) as well as limit the memory of the content (Sundar, 2000). Yet, limited empirical evidence has precisely established the impact infographics may have on recall of informative details in online news environments.

Given that academic programs (i.e., Columbia University, George Mason, San Francisco University) and news organizations (*The Guardian*, *CNN*, *The New York Times*, and *The Boston Globe*) are placing greater emphasis on data reporting in journalism (e.g., Cain Miller, 2013), examining how readers attend to and remember quantitative information integrated into news content has import for both scholars and news practitioners. To answer a call for further investigation by Mayer and Moreno (2002) who claimed that media effect scholars have overlooked the issue, and to revive the scholarship in this area by extending it into the age of online news consumption, the present experiment examines how visual attention, memory for story content, and subjective evaluation of graphic format varied as a function of the dynamic or static nature of information graphics and individual differences in arithmetic aptitude (AA).

Literature Review

Infographics and Animation

Rendgen and Wiedeman (2012) recently observed in the book, *Information Graphics*, that the reliance on graphics as a means of attracting attention and conveying

information is hardly novel. Contemporary news content commonly features numerical or statistical information (Maier, 2002). Furthermore, information graphics represent only one class of content elements employed to attract attention and facilitate comprehension of textual information (David, 1998; Pasternack & Utt, 1990). Advances in media technology have previously encouraged and will continue to yield increases in their use in news media (Utt & Pasternack, 1993, 2003).

Today, animated content represents one of the most common elements on the web (Larsen, 2012; Sundar & Kalyanaraman, 2004). Defined as pictorial motion graphics, animations consist of visual elements that capture vision regardless of their nature and their associations to the tasks demanded from users (Kim & Lui, 2010; Mayer & Moreno, 2002). The use of animation to increase attention to information graphics in online news begs the following three questions: Does animation increase attention to graphic elements? Does animation impact reader recall of information contained in these graphics? Does animation impact readers' subjective response to content? The abundance of dynamic elements in visual media has led researchers from multiple fields (business, education psychology, mass communication, physics, and psychology) to investigate the actual benefits and disadvantages of animation on attention and learning, and findings are far from consistent (Li, Santhanam, & Carswell, 2009).

Some research, particularly in advertising, suggests animation positively influences memory and subjective evaluation (Lang, Borse, Wise, & David, 2002; Yoo, Kim, & Stout, 2004). Scholars examining animation outside the context of advertising have also found benefits of the technique. Experienced web users did not suffer any significant setbacks in their ability to extract information from animated content, nor was information search impeded by the location of animation placed on the side of the pages (Diaper & Waelend, 2000). Research examining the use of animation in educational settings also reveals the effectiveness of including animations. One experiment demonstrated that students exposed to text paired with animations scored more than 20% higher on math achievement tests than students placed in nonanimation conditions (Szabo & Poohkay, 1996). Furthermore, this finding was consistent for students categorized as high or low on math achievement levels based from pretests scores.

Additional evidence has shown that, similar to the use of infographics in traditional newspapers (e.g., Griffin & Stevenson, 1994a, 1994b), the addition of a pictorial animation to a verbal explanation positively influenced students' academic performance (Mayer & Moreno, 2002). The authors revealed that when on-screen texts appeared next to animations, students demonstrated a stronger ability to understand academic materials. Additionally, Utt and Pasternack (1993, 2003) have chronicled the increased use of information graphics in print news as a means of competition in the media marketplace. Numerous studies have also demonstrated the value of such graphics to enhance story comprehension and memory (Griffin & Stevenson 1994a, 1996; Griffin & Stevenson, 1994b; Ward, 1992).

The use of infographics and animation on the web, however, seems to draw more criticism than accolades, and researchers have claimed that integration of animation in news content comes at a potential cost (van Schaik & Ling, 2006; Zhang, 2000). This

current increase in visual elements online opened the door to an amalgam of what Heer and Shneiderman (2012, p. 1) described as "confusing widgets, complex dialog boxes, hidden operations, and incomprehensible displays." Empirical data validate this claim. Research examining visual complexity in websites in general has shown that as visual animations get more complex, audience appreciation of the information presented decreases (Tuch, Bargas-Avila, Opwis, & Wilhelm, 2009).

Furthermore, results from experimental studies in education have identified how the use of infographics invites visual overload (Mayer, Heiser, & Lonn, 2001). Scholars also tested the importance of a cognitive fit and show how the congruence of the presented content with the context aids learning and recall (Hervet, Guèrard, Tremblay, & Chtourou, 2010; Li et al., 2009). Additionally, the perceived irrelevance of the animation may prompt people to even ignore the information (Hong, Thong, & Tam, 2004). In a study of flash animations on websites featuring relevant textual and animated content, the very same authors found a significant relationship between recall of information and the status of an animation such that animations hindered recall of both static and dynamic content on a webpage (Hong et al., 2004).

Studies of visual complexity in general in online environments suggest that complexity is associated with negative evaluations of website home pages (Tuch et al., 2009), although this relation may be moderated by user goals during browsing (Deng & Poole, 2010). These findings are underlined by research in the advertising literature demonstrating that animated advertising is intrusive and interferes with users' goal-oriented behavior (Cho & Cheon, 2004; Ha & McCann, 2008). This perceived intrusiveness is crucial, as it possibly leads to selective avoidance of graphic elements (i.e., "banner blindness," Drèze & Hussherr, 2003).

Ultimately, research presents two different perspectives. The initial discussion alludes to studies of animation in an education setting (Hoffler & Leutner, 2007). The work published in this area explains the benefit of dynamic multimedia content on recall and learning outcomes when animations supplement details offered in text. Although such empirical studies evaluated multimedia materials, they rarely conducted their experiments on the web, a platform now favored by data journalists.

A second body of evidence coming essentially from advertising provides an understanding of the impact of animation used online. Indeed, examinations of online advertising show how applying motion to online advertising can be effective at eliciting attention (Lang et al., 2002; Yoo et al., 2004). However, studies employing eye tracking as a measure of visual attention have failed to support the effectiveness of animation (Day, Shyi, & Wang, 2006; Josephson, 2000). Moreover, animation is not a binary (i.e., absent or present) but exists along a continuum (Sundar & Kalyanaraman, 2004). To that end, Yoo and Kim (2005) demonstrated positive effects in terms of both attention and memory for moderately paced animations, but excessive animation was detrimental to subjective response and memory for ad content.

Finally, although previous work indirectly suggests individual differences may mitigate the influence of animation, no studies to date have precisely examined the issue. As news infographics are commonly employed to help provide supplemental

numerically based information (Lester, 1995), it is important to address whether an individual's AA influences reader's response to news infographics.

AA

In addition to characteristics of the medium, individual characteristics also govern reaction in the form of opinion, attention, and recall to message elements. Research has long documented selective exposure to media messages as a function of a variety of temporary or more durable individual characteristics, such as political beliefs (Lazarsfeld, Berelson, & Gaudet, 1944), sensation seeking (Perse, 1996), and affective state (Bryant & Zillmann, 1984). Moreover, studies of visual attention have also acknowledged that individual differences can impact intrastimulus attention or attention to elements within a single media message (e.g., age, Kirkorian, Anderson, & Keen, 2012; gender, Rupp & Wallen, 2007). Given the prevalence for information graphics in today's news content to convey quantitative or statistical information (Griffin & Stevenson, 1996), AA could influence visual attention to these elements.

Borne out of investigations into how statistical information presented in media content exerts influence compared to personal exemplars, AA has drawn considerable attention as an individual characteristic influencing consumption and influence. Researchers have shown that individuals with above-average arithmetic ability can process and recall information presented numerically in news media more accurately than individuals with more diminutive skills (see Blake & Daschmann, 2008, Callison, Gibson, & Zillmann, 2012, 2013; Zillmann, Callison, & Gibson, 2009). Specifically, research has pitted quantitative information against case studies or vivid portrayals of how a phenomenon has impacted a particular person. Such findings have demonstrated that AA influences perceptions of safety risk, empathy with reported victims, and general overall integration of media content into worldview with low-ability readers overestimating eventual impact of threats (Gibson, Callison, & Zillmann, 2011). Likewise, researchers have concluded that health communication media audiences with higher AA levels interpret the presented information more accurately and are less susceptible to peripheral message components (Reyna, Nelson, Han, & Dieckmann, 2009).

As a personal characteristic, AA represents an integral variable when investigating how media audiences attend, perceive, and recall news as it is presented with graphics—many of which relay information numerical in nature (Lester, 1995). If one assumes that news information cannot influence perceptions or guide decision making if it is not stored and recalled, then factors that impact these processes are of keen interest. Considering the sheer volume of media content consumers encounter daily, it has been suggested that careful processing and integration of factual data represent an exceedingly difficult task (Damasio, cited in Begley, 2008). Moreover, the increasingly complex and crowded interfaces that characterize visual media make processing the abundance of information within a single message all the more challenging (Bergen, Grimes, & Potter, 2005).

Yet, the troubles do not end here for a news consumer. Assuming that individuals with higher AA are more capable of recalling numerical information than are their low AA counterparts, the presentation of the information itself could undermine the superior abilities. As outlined in the quantification heuristic proposed in exemplification theory, those with inferior arithmetic abilities may pay only shallow attention to this quantitative base rate data and instead invest more of their resources in the vivid exemplars (Zillmann, 1999, 2002). For those most easily overwhelmed by numerical information, they may be particularly repelled by the difficulty associated with attending to numerical information presented in a dynamic, moving fashion. On the other hand, the more capable processors equipped and inclined to attend to numerical information may suffer when that attention is "sidetracked and overwhelmed" by cognitively captivating content (Zillmann et al., 2009, p. 412). As a result, superior processors may more deeply engage the captivating content while disregarding the more pallid, which in the case of electronic news may include the story text that serves as the foundation for the visuals. While exemplification theory focuses on exemplars as the primary means of drawing attention away from factual information, engaging web structural features—such as dynamic graphics—could affect allocation of resources to the information they present.

Hypotheses

Research suggests a negative correlation between complex presentation of information on web pages and the subjective evaluation of the site (Tuch et al., 2009). Moreover, it was found that in such environments, the public may in fact engage in selective avoidance of graphic elements, also alluded to as "banner blindness" (Drèze & Hussherr, 2003). As such, the following hypothesis is tested.

Hypothesis 1: Articles including dynamic graphics will be evaluated more negatively than articles with static graphics.

Additionally, research into AA has suggested that persons with heightened aptitude for comprehending numeric data also attend to and are influenced by that information differently than those who are weaker in aptitude (Callison, Gibson, & Zillmann, 2012, 2013; Zillmann et al., 2009). As such, it is plausible that differences in aptitude may also influence reactions to and perceptions of content depending on whether numeric is content presented dynamically as opposed to statically. In an attempt to investigate how aptitude may interact with graphic display type on content evaluation, the following research question will be tested.

Research Question 1: Does evaluation of static versus dynamic content vary as a function of consumer AA?

Limited research previously investigated whether an individual's mathematical ability can mitigate one's recall of information presented in dynamic format. To date,

one experiment revealed that participants who scored high in a pretest of math achievement increased by more than 20% their learning outcomes when exposed to animated information compared to students with low math aptitude (Szabo & Poohkay, 1996). This finding does not provide a clear direction in a study focused on infographics in news, but coupled with the recent AA research, it does suggest that news consumers with high AA will possess the ability to fully consume and also more accurately recall information presented in a dynamic format. As such, the following hypotheses are tested.

Hypothesis 2: People with a higher AA level will pay greater attention to dynamic content than those with a lower aptitude, whereas this effect will not be seen with static content.

Hypothesis 3: People with a higher AA level will show a better recall of dynamic content compared to those with a lower aptitude, whereas this effect will not be seen with static content.

Method

Design and Independent Variables

To address the research questions and hypotheses, a 2 (static vs. dynamic graphic) × 2 (AA low vs. high) × 2 (story) mixed-measures experiment was conducted. Participants were randomly assigned to read one of four online news stories that systematically varied in story content and use of static versus dynamic infographics. AA served as a between-subject variable, with participants designated as high or low. As each participant was exposed to two news stories where the graphic format manipulation was applied, story was the sole within-subjects repeated measure.

Factorial variation in the *static* or *dynamic* nature of the infographic was achieved by creating two versions of graphics to accompany their associated stories. The graphics contained story-related statistical information in the form of line charts or histograms that were either dynamic or static. In the dynamic conditions, the lines and histograms advanced though a short video loop. For example, in the dynamic condition, participants read a story accompanied by figures with a line graph showing three unemployment levels at three dates, with the line moving across the graph's three dates and then resetting and repeating. In the static condition, the graph appeared only in its completed form, with no moving line across the three dates. Background color and information content within the graphics remained consistent across conditions.

Participants were assigned to the high ($n = 63$) or low ($n = 71$) AA groups based on their responses to a 10-item measure designed to gauge individual differences in the ability to complete basic mathematic problems (Zillmann et al., 2009). The measure asks participants to answer questions such as "'The storm (a tornado) damaged 80% of all buildings in the small community.' *What portion of the buildings was damaged?*" Participants then select the correct answer from one of five options. Correct

responses are scored and summed to calculate an overall AA score. Participants were then designated as high ($M = 7.41$, $SD = 1.12$) or low ($M = 3.46$, $SD = 1.40$) based on a median split of sample results. Between-group differentiation was verified via analysis of variance (ANOVA), F (1, 312) = 319.52, $p < .001$, $\eta^2_p = .71$.

Two different *stories* were created and used as stimuli to verify that any observed effects were a function of the variable of interest and not an idiosyncratic property of a particular stimulus. Likewise, stories employed three accompanying infographics to operationalize the *graphic repetition*. These served as methodological controls, as attention to a particular infographic or story was not of interest vis-à-vis the hypotheses and research questions.

Dependent Variables

Effects of the independent variables were gauged on three different dependent variables, namely, recall, attention, and subjective evaluation. *Recall* was operationalized via six multiple-choice questions pertaining to the information presented in the stimulus. Three aided recall items were related to the information presented in the news stories, while the three others targeted information featured in the static or dynamic graphs depending on the experimental condition. Incorrect answers received 0 and correct answers were recorded as 1. Composite recall scores were then computed first for the information present in the news stories ($M = 2.41$, $SD = .77$) and second for numerical information presented in the graphs ($M = 1.56$, $SD = .89$). No information provided in the text was also present in the graphics and vice versa.

Attention to information graphics was examined by the use of eye tracking. The technique has become increasingly popular in mass communication, marketing, and advertising, as it allows a more precise measurement of exactly what elements in an individual's visual field receive attention (Duchowski, 2003). As a result, eye tracking is a useful tool in the study of visually complex media, as it provides a more precise measurement of intrastimulus attention to select elements within a media message (e.g., Bucher & Schumacher, 2006; Cummins, Tirumala, & Lellis, 2010; Josephson & Holmes, 2008; Kallenbach, Närhi, & Oittinen, 2007).

The technique relies on the assumption that individual gaze on a message element serves as an unobtrusive measure of attention to that element. Human vision is characterized by recurrent, brief periods of rest, or fixations, connected by saccades (Yarbus, 1967). During these fixations, a small portion of the visual field falls within the eye's foveal vision where visual acuity is greatest. A critical assumption of this technique is that these fixations indicate precisely what is being cognitively processed, and the duration of gaze is indicative of the amount of processing (Josephson, 2000).

Two measures were employed to operationalize visual attention, namely, *fixation frequency* and *gaze duration*. Fixation frequency is a ratio-level measurement of the number of times the eye was stationary within a researcher-defined area of interest (AOI), and gaze duration is also a ratio-level measure representing the aggregate sum of the duration of these fixations (Jacob & Karn, 2003; Poole & Ball, 2006). AOIs

within the stimulus were defined as areas occupied by the infographics accompanying the stories.

To gauge subjective response, participants were also asked to complete a set measures pertaining directly to the stimuli. Answering a total of 12 questions using a 10-point scale with 0 = *not at all* and 10 = *extremely*, participants rated their level of interest in the article, whether they found the issue important, and whether the article was enjoyable to read and informative. They then proceeded to evaluate the layout of news story as well as the trustworthiness of the content. Finally, they reported whether they would return to the website, recommend the site to a friend, whether the included figures were helpful, and eventually if newspapers and magazines should have visuals, particularly when they publish stories dealing with complex matters.

Sample

A convenience sample of 218 participants was recruited from mass communication courses at a large Southwestern university to participate in the study in exchange for extra course credit or to fulfill course research requirements. Of those, 73 were dismissed due to an inability to achieve reliable gaze calibration due to individual differences in eye biology, a common challenge to eye-tracking research (cf. Jacob & Karn, 2003). In addition, data for four participants were lost due to technical malfunctions. Although the proportion of the sample dismissed exceeds some estimates (cf. Jacob & Karn, 2003), it is less than dismissal rates in some studies (e.g., Isaacowitz, Toner, Goren, & Wilson, 2008; Isaacowitz, Toner, & Neupert, 2009). Moreover, the time constraints of the experimental session necessitated that only those who could be calibrated in a quick and reliable fashion were retained in the sample. Finally, the relatively high dismissal rate reflects a conservative approach, ensuring the validity of the gaze data within the analysis. Final sample size for the paper-and-pencil measures of memory ($n = 134$) differs from measures of attention ($n = 130$). Participants ranged in age from 19 to 27 ($M = 2.09$ years, $SD = 1.34$). A majority was female (59.7%).

The specificity of this sample certainly presents some limitations in terms of the generalizability of the conclusions. Nonetheless, recent data from the Pew Research Center indicated that 18- to 24-year-olds adopt a similar news consumption behavior to those who are 25–49 (Pew, 2012, 2013). The reported trends show that more than 60% of young adults graze for news throughout the day just like the 30–49 do. Moreover, approximately 30% of the 18–24 and the 25–49 equally see news on social network sites. Finally, data reveal a similar pattern of online news consumption for people younger than 50 who access news content through a smartphone, a tablet, or another mobile device.

Stimuli

Two fictitious news stories were written by a former professional journalist for use in this study, one focusing on congressional efforts to boost the U.S. economy and the

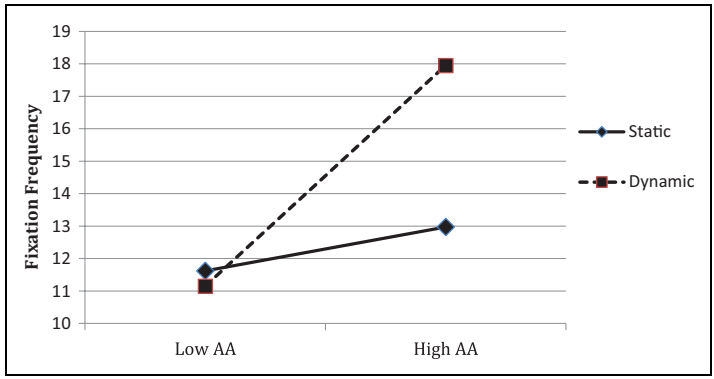

Figure 1. Influence of graphic format and arithmetic aptitude on fixation frequency.

other describing a report from the Centers for Disease Control and Prevention discussing childhood immunization rates. Stories were hosted on a local web server and browsed via internet explorer. Structure and layout of both stories were identical, with each story being comprised of four paragraphs. Accompanying infographics were explicitly referenced within the stories (i.e., " . . . depicted in Figure 1"). Infographics were uniformly located on the right of the webpage.

Procedure

Participants were recruited to participate in a study to evaluate a news story, and data were collected at individual sessions. After completing an informed consent statement, participants were seated at a computer workstation, approximately 24 in. from the monitor. The participant's gaze was calibrated using a 9-point calibration image. Participants were then asked to maximize a web browser and read the assigned story as they normally would. Participants were allowed to read the story for as long as they wished. Assignment to story and graphic format was random.

Upon completion of the story, a research assistant led the participant to a quiet location outside the lab to complete paper-and-pencil measures of AA, memory, subjective response, and demographics. Participants were not allowed to use any outside aids (i.e., calculators, cell phones).

Apparatus

Gaze was monitored throughout exposure to the stimulus using ASL Eye-Trac 6 with high-speed D6 remote optics coupled with Gazetracker software (GazeTracker v9.0.8000.1000 FULL for ASL) for recording and exporting gaze data. Gaze was sampled at 120 Hz. Stimuli were presented on a 21-in. diagonal LCD computer monitor with 4:3 aspect ratio. A small camera, housed within a self-contained unit, was

located just below the monitor to track gaze, and the system is noninvasive. ASL reports visual accuracy of .5° visual angle.

Results

Data Reduction

Ratings on the 12 items in the perception scale were subjected to a principal component analysis and an orthogonal rotation of the components. Three factors emerged with eigenvalues greater than 1, accounting for 65.60% of variance (41.20%, 13.42%, and 10.98%, respectively).

The first factor, labeled *News Value*, showed high loadings on 5 items, namely interesting (.72), important (.77), informative (.74), enjoyable (.79), and trustworthy (.55). The ratings showed a high degree of interitem consistency ($\alpha = .82$), and the composite measure was created by averaging the ratings across the items. The second factor, labeled *Layout*, yielded high loadings on five traits, namely professional layout (.57), distracting layout (−.66), likelihood to return (.81), likelihood to recommend (.79), and usefulness of figures/graphics (. 64). After reverse scoring "distracting," the ratings showed a high degree of interitem consistency ($\alpha = .80$), and the composite measure was created by averaging the ratings across the items. Finally, the factor *Visuals* resulted in high loadings on 2 items, namely, support for more visuals (.79) and complicated topics should have visuals (.79). The ratings showed an acceptable degree of interitem consistency ($\alpha = .62$), and the average of these ratings created the composite measure.

Data Analysis

Hypothesis 1 posited that participants would evaluate articles featuring dynamic graphics more negatively than articles with static graphics. Hypothesis 1 was supported. Despite the fact that graph format had no impact on perceptions of the articles' news value, $F(1, 130) < .001$; $p = .99$; $\eta^2_p < .01$, it nonetheless influenced the affinity for the content layout, $F(1, 130) = 31.50$; $p < .01$; $\eta^2_p = .20$. Articles with static layout were rated more positively ($M = 4.91$, $SD = 1.71$) than were articles with dynamic graphics ($M = 3.13$, $SD = 1.91$).

Results revealed a main effect of format on affinity for visuals, $F(1, 130) = 9.27$; $p < .01$; $\eta^2_p = .07$. Articles featuring static graphics rated higher on the affinity of visuals construct ($M = 7.71$, $SD = 1.66$) than did articles with dynamic graphics ($M = 6.75$, $SD = 1.87$).

In response to Research Question 1, the data analyses presented earlier showed no main effect, $F(1, 130) = 1.46$; $p = .23$. 01; $\eta^2_p = .01$, or any interaction, $F(1, 130) = 1.24$; $p = .27$; $\eta^2_p < .01$, of AA on perception of news value. Findings were parallel in regard to affinity of layout with aptitude having no main effect, $F(1, 130) = .05$; $p = .82$; $\eta^2_p < .001$, nor an interaction involving aptitude and format on affinity, $F(1, 130) = .006$; $p = .94$; $\eta^2_p < .001$. The same was true for main effect of aptitude on affinity

for visuals, $F(1, 130) = .35$; $p = .55$; $\eta^2_p < .01$, and the interaction with format, $F(1, 130) = .02$; $p = .90$; $\eta^2_p < .001$.

Hypothesis 2 suggested that people with higher AA abilities would pay more attention to the dynamic content than people with low AA scores, and Hypothesis 3 expected people with higher AA levels to have a stronger recall of dynamic content. To address Hypothesis 2, a series of mixed-measures ANOVAs were performed with graphic format, AA, and story as between-subject variables. Graphic repetition was the sole within-subject variable. The two tests employed fixation frequency and gaze duration, respectively, as the dependent measures. The two tests failed to find an effect of graphic format on visual attention. However, test statistics approached significance, particularly with gaze duration, fixation frequency: $F(1, 122) = 2.93$, $p < .10$, $\eta^2_p = .02$; gaze duration: $F(1, 122) = 3.67$, $p = .06$, $\eta^2_p = .03$.

To further examine the influence of AA on visual attention to information graphics test, statistics from the aforementioned ANOVAs were consulted. Results of both tests were uniform. Regarding fixation frequency, $F(1, 122) = 9.09$, $p = .003$, $\eta^2_p = .07$), data indicated that high AA participants allocated more fixations on information graphics ($M = 14.05$, $SD = 10.15$) than those lower in AA ($M = 9.45$, $SD = 7.52$). Results regarding gaze duration were similar, $F(1, 122) = 7.14$, $p < .01$, $\eta^2_p = .06$). On average, participants higher in AA spent roughly 1½ s longer examining the graphics ($M = 4.89$, $SD = 3.80$) than those lower in AA ($M = 3.36$, $SD = 2.86$). In sum, participants with greater AA allocated greater attention to information graphics than those lower in AA.

Additional analyses facilitate a complete understanding of the relationship between AA and graphic format in terms of visual attention as posited by Hypothesis 2. The hypothesis proposed that people with higher levels of AA paid more attention to both dynamic and static content than people with lower math ability. Although analysis of gaze duration failed to reach statistical significance, $F(1, 122) = 2.56$, $p > .05$, a test of fixation frequency provided significant support, $F(1, 122) = 3.99$, $p < .05$, $\eta^2_p = .03$. As seen in Figure 1, high AA devoted more attention to graphic format than participants with lower levels of AA did. Moreover, relative to static images, dynamic graphics effectively elicited attention for those higher in AA. To more directly engage Hypothesis 2, differences in attention as a function of AA were examined independently for static versus dynamic infographics. Results indicated that the difference in attention between low AA (fixation frequency $M = 11.62$, $SD = 6.24$) and high AA (fixation frequency $M = 12.97$, $SD = 7.69$) was minimal when examining static infographics, $F(1, 60) = .59$, $p > .10$. A significant difference in fixation frequency as a function of AA was however evident for dynamic infographics, $F(1, 62) = 11.19$, $p = .001$, $\eta^2_p = .15$. High AA participants allocated more frequency fixations ($M = 17.95$, $SD = 10.70$) than those low in AA ($M = 11.15$, $SD = 5.60$). So, as hypothesized, those with superior AA allocated greater attention to dynamic infographics relative to low AA participants, although this effect was not observed when examining static infographics.

Finally, Hypothesis 3 suggested that people with higher AA abilities possess additional cognitive resources to recall dynamic content compared to those with low AA

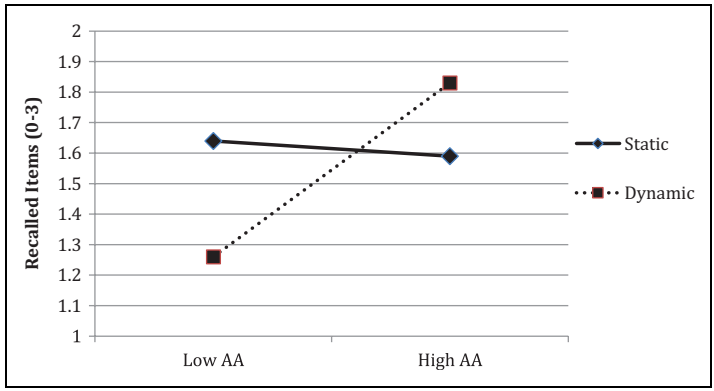

Figure 2. Influence of graphic format and arithmetic aptitude on recall of information presented in graphs.

abilities. Hypothesis 3 was supported. The analysis of the effect of AA and article format on recall of graph information proved significant, $F(1, 130) = 4.07$; $p < .05$; $\eta^2_p = .03$. High AA participants in the dynamic condition registered the best recall of information presented in the graphic ($M = 1.83$, $SD = .97$) as can be seen in Figure 2. Conversely, low AA participants in the dynamic condition had the lowest recall ($M = 1.26$, $SD = .83$). In the static condition, low AA participants and high AA participants received more middling scores ($M = 1.63$, $SD = .82$ and $M = 1.59$, $SD = 89$, respectively). As for parceling the interactions, there was no significant difference between static and dynamic format for the low AAs, $F(1, 69) = 3.61$, $p = .06$, nor for the high AAs, $F(1, 61) = 1.04$; $p < .31$. Data analysis did reveal the high AAs have significant better recall of graphically presented information than low AAs in the dynamic condition, $F(1, 65) = 6.61$, $p < .05$, $\eta^2_p = .09$, but that low AAs and high AAs score similarly in the static condition, $F(1, 65) = .05$; $p = .82$. Again, no main effects for either format or AA surfaced.

Interestingly, the review of the influence of format and AA on recall of information presented in the article revealed how news consumers may process content. Here, findings yielded an opposite trend. In fact, participants who effectively recalled dynamic graphics appeared to have the weakest recall of the story text, $F(1, 130) = 7.19$, $p < .01$, $\eta^2_p = .05$. A review of the associated means showed that while high AA participants in the static format condition best recalled article text information ($M = 2.68$, $SD = .53$) compared to their low AA counterparts in the same format condition ($M = 2.24$, $SD = .94$), the effect reversed itself in the dynamic format condition where the high AA participants had lower recall ($M = 2.20$, $SD = .82$) than their poorer AA scoring companions ($M = 2.47$, $SD = .69$). While the difference between static and dynamic content among the low AA participants was not significant, $F(1, 69) = 1.43$, $p = .24$, the high AAs recalled significantly more story text in the static condition than did the high AAs in the dynamic condition, $F(1, 61) = 7.47$, $p < .01$,

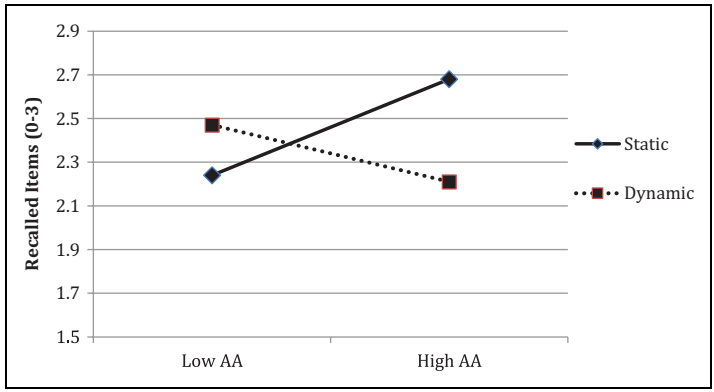

Figure 3. Influence of graphic format and arithmetic aptitude on recall of article information presented in text.

$\eta^2_p = .11$. Likewise, in the static condition, high AAs had better story text recall than did low AAs, $F(1, 65) = 5.47$, $p < .05$, $\eta^2_p = .08$, while the difference between low AAs and high AAs in the dynamic condition was not significant, $F(1, 65) = 2.10$, $p = .15$, $\eta^2_p = .03$. Figure 3 provides a graphical display of the data. Alone, neither format nor AA generated a significant main effect on recall of factual information.

Subsequent regression analyses suggest that recall for both story information and graphic information is driven by attention. A pair of regression equations was tested to examine the impact of fixations allocated to story text and graphics on recall for those two elements, and results were intuitive. Regarding recall of story text, the overall regression equation only approached statistical significance, $F(2, 127) = 2.74$, $p = .07$, $R^2 = .04$. However, examination of the individual predictors indicated that attention to story text ($B = .00$, $\beta = .19$, $p = .04$) better predicted recall of story information relative to attention to graphics ($B = .00$, $\beta = .04$, $p = .70$). Regarding recall for graphic information, the regression equation was significant, $F(2, 127) = 7.71$, $p = .001$, $R^2 = .11$. As one would expect, attention to graphics ($B = .01$, $\beta = .31$, $p = .001$) predicted recall for information presented therein, whereas attention to story text ($B = .001$, $\beta = .06$, $p = .47$) had no relationship with recall for information presented in graphics.

Discussion

In a media environment increasingly dominated by the omnipresence of animations and infographics, whether they appear as data journalism reports complementing news stories, advertising banners, supplemental sidebars to articles, or simply irrelevant widgets (Josephson & Holmes, 2008), scholars have begun to turn their attention to the influence such visual elements have on processing (Bergen et al., 2005; Sundar, 2000). To resuscitate an area of research seemingly cast aside by media scholars (Mayer & Moreno, 2002), and most importantly to focus on the effects of dynamic infographics accompanying

online news consumption, this experiment examined how the nature of information graphics and individual differences in AA influenced visual attention, memory for story content as well as subjective evaluation of graphic format, all points of interest for news organizations eager to divulge informative content to the public

Results revealed a significantly greater preference generally and regardless of AA for articles accompanied by static graphics than for articles that employed dynamic visuals. This affinity for a static presentation manifests itself both in measures about overall story layout and in the use of graphics in particular. This finding seems to reflect the thoughts of media professionals, layout editors, and software programmers alike, who have criticized the dominant use of dynamic infographics sometimes included in the web simply because technology permits (Diaz, 2011; Harris, 2011; Heer & Shneiderman, 2012; Hoffler & Leutner, 2007). Interestingly, perceptions of news value of the stories were not impacted by graphic format. This finding clearly demonstrates that news outlets should exercise caution in the use of embellishments such as animations merely because technology permits. Certainly, the example of the data blog at *The Guardian* appears as a good case study.

Beyond the audience's preferences for a specific presentation style, this study intended to clarify, regardless of perceptions and assumed preferences, the effect of different graphic formats on memory for and attention to information presented and how this may vary according to an individual's arithmetic ability. In regard to memory, data first showed that people able to process numerical information at a high level recalled the information presented in dynamic infographics more accurately than individual with low AA. While no differentiation appeared between the levels of aptitude when static information was presented, the data seem to suggest that cognitive overload may cause people with low mathematical skills to be overwhelmed, while those with higher arithmetic scores flourish. Such a conclusion suggests that by increasingly presenting news content online in a complex and dynamic manner, news professionals take the risk of losing a certain population. At a time when news trends show that a large proportion of adults graze for online news throughout the day on social networking sites through mobile devices (Pew, 2012), the simpler may well be the better.

The nature of this eye-tracking research also revealed that, expectedly, people with high AA may recall more precisely dynamic graphics because of their affinity for it. While results indicated that the level of AA did not impact the degree of attention placed on static content, the high AAs spent more time looking at dynamic graphics compared to their low AA counterparts. Clearly, memory for information is to some extent a function of consumption of that information (Yoo & Kim, 2005). In this case it seems the dynamic content does in fact draw the attention of those with higher aptitude scores, but data also show that a higher level of processing takes place as well as indicated by increased memory. Whether this consumption pattern results from one group being more capable of processing dynamic numerical material, or whether it is driven by selective exposure where those of inferior aptitude simply avoid the taxing materials while the more apt are drawn to it, AA undoubtedly constitutes a salient personality trait in future investigations.

Finally, news professionals should acknowledge the fact that while data revealed that low AAs showed a limited recall of information presented in dynamic graphics, such audience members seemingly allocated their resources to the story itself. In fact, both memory and eye-tracking results indicated that people with lower AA scores had a better recall of the story text than people with high AA levels who demonstrated an increased focus on the graphic information rather than the news story. This finding, while perhaps falling in line with much of the limited capacity model of motivated mediated message processing (see Lang, 2000) puts content producers in the position to have no easy, best-for-all choice in constructing online news.

Results presented here explain that dynamic graphics do in fact lead to more attention and better memory for the graphically presented data for high AAs. Yet, it also indicates that this is detrimental to the information presented in the story proper. Additionally, data editors and infographic designers need to understand that for people with low AA, the opposite is true. Such audience members demonstrate a stronger recall of graphic information when the visual is static and a more precise recall of news stories accompanied by dynamic animations.

Overall, the data precisely reinforce a news principle of core value to the journalistic profession, that is, know your audience. Content producers eager to surf on the growing wave of data journalism to tell news stories with dynamic animations online need to have a clearer picture of the abilities of their consumers when deciding upon types of infographic selected. Embracing news technology comes with larger risks for news professionals. At a time when certain prominent news organizations such as *Newsweeek*, *The Christian Science Monitor*, and several others pay particular efforts to their online platforms to customize their news portals for their subscribers, such findings may act as a starting point to editorial discussions. Indeed, these findings offer implications for understanding which news consumers may or may not desire or be able to process ancillary information graphics that accompany story content. As such, use of these elements may best be employed as a story feature that readers could selectively choose to read or ignore through embedded hyperlinks. Obviously, this suggestion is ripe for continued empirical testing.

Conclusion

Overall, investigating how visual attention, memory, and subjective evaluation vary as a function of infographics format and individual differences in AA bears valuable implications for both researchers and practitioners dealing with digital media. Specifically, the study advances knowledge by suggesting that, despite a broad dislike for dynamic graphics, these visuals do positively impact attention and memory for high-aptitude audiences. This gain, however, must be considered in conjunction with the finding that low aptitude audiences did not attend or remember information presented dynamically, and perhaps as important, any attention and memory for graphics detracted from consumption or memory of information presented in the actual text of the accompanying news article.

For academicians, the study provides additional insight into concerns of how structural features of digital content influence not only cognitive processing but also allocation of resources. For media professionals, the study offers more pragmatic advice—online audiences are not enamored with flashy graphics, and the inclusion of dynamic graphics must be planned with caution and with audience characteristics in mind to enhance the dissemination of information to the public. While news professionals have often been advised to craft their news reports for a consumer with an average 11th-grade reading level, findings here may further indicate that the simpler is also the better in terms of infographics. Ultimately, as pertinent as the conclusions may be, professionals need to interpret the results with caution. Despite data suggesting that online news consumption behavior is identical for young adults (18–24) and those aged 25–49 (Pew, 2012, 2013), this study nevertheless was conducted with full-time college students. Replication of this work would certainly be advised with a more nationally representative sample.

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