The Impact of Imagery versus Graphical Information
 – An Experimental Comparison –

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Abstract: To measure the difference between the recognition of pictorial images and simple data displayed in a graph or chart, a survey with varying images was developed with the intent of eliciting some type of reaction. The images were either pictorial or graphical in nature and covered multiple themes. Topics ranged included both from politically charged issues as well as sedate ones such as puppies running in a park. For each subject, there was both a picture and a graph and any of the images had the potential to elicit a response. Each image, along with a slider to measure strength of response and a hidden timer, was on a separate page and the order of the pages was completely randomized. The reaction strength and time of participants to the various image pairs was compared.

Keywords: Data Visualization, Emotion, Image Perception

1. INTRODUCTION

With the ever-increasing pace of data collection and analysis comes the growing need for understanding how to present the information gleaned to a non-technically focused audience. While the techniques of data visualization are intended to allow viewers to grasp complex patterns easily, the affective impact of data visualization is also critical. Beginning with the idea of how AI could be developed or programmed with the aid of visualizations, this study evolved into a survey evaluating how strongly, and how quickly, the human brain responds affectively to graphs or pictorial information on similar topics.

2. LITERATURE REVIEW

How are data visualizations processed? In other words, how does a person perceive, remember, and respond to an idea presented to them as visual information?

Images have a long history of having an effect on humans in an academic setting. It is known, from a 1986 study at the University of Minnesota, that instructors using pictures in their teaching were 43% more persuasive than NOT using some type of pictorial method [1]. A 2016 study done by Manolis Mavrikis at the UCL Knowledge Lab in London [2] demonstrated a connection between eye movement and student success in a coding project. A test at the University of Sussex [3] concluded that humans are drawn to areas in photos that are sharper and brighter. Furthermore, they found a preference for sharper darker areas over blurry areas.

While people are exposed to thousands of visual stimuli each day, only certain experiences stick with them. How and why some memories are retained better than others is also key in understanding the affective impact of data visualization. As explained by one study [4], “explicit memory refers to the memory that involves conscious recollection of information; on the other hand, implicit memory does not depend on conscious recollection.” Furthermore, this study examined how two perception styles affected this: global and local. Someone with a global perception style would view the entire object, while someone else with a local perception style would focus on the individual parts of the whole. When shown a letter ‘D’ made up of smaller letter ‘L’s, one with a global perception style would recognize the D first, while one first noticing the L’s would have a local perception style. Implicit memory is correlated (r = 0.52) with perception style, while explicit memory is not.

Image processing speed by the brain is also of note. Neuroscientists have found that the brain is able to identify images seen for as little as 13 milliseconds. This was a significant difference in the previously record of 100 milliseconds. The brain has rapid-fire processing abilities, which allow it to direct the eyes from one thing to the next, such as where to look next in a coding project. The eye moves, on average, about 3 to 4 times per second, and the brain processes not just the image, but also understands and directs what the eyes need to look at next...
Neuroscientists at MIT did this research by showing new images to members of a test group for decreasing set amounts of time: 80 milliseconds, 53 milliseconds, 40 milliseconds, 27 milliseconds, and 13 milliseconds. The lower bound was determined by the capability of the computer monitor used [5]. Even though there was a decline in performance between 53 and 40 milliseconds, it was found that the brain was generally able to process information such as shape, color, and orientation. As the images were mixed up in six or twelve picture sequences, it appears that there is a one-way flow of information to the brain allowing for continued processing of information even while the eyes were receiving a new image.

The use of data visualization for conveying complex concepts, the effects of images on students, the concepts of explicit and implicit memory, and the speed and accuracy of human processing and memory were all influential on the development of the research question: “How do responses differ, in affect strength and in speed, when exposed to either a graph or pictorial image on the same topic?”

3. EXPERIMENTAL COMPARISON

3.1 Survey Design

A set of potential graph/picture topics was prepared and then pretested on Dr. Tipton’s DSCI 450: Data Visualization class. The topics chosen from this set for the actual survey were in three groups: Anxiety (Global Warming, Test), Political (President, Immigration, Gun), and Leisure (Movie, Super Bowl, Dog). Each image in a pair was given its own page on the survey. All images used in the survey may be found in Section 5, after the conclusion. Each page had the question “How strong is your reaction to this image?” below the image with a slide for responding. The response options available were “Skip”, “1 = None”, “2”, “3”. “4” and “5 = Strong”. Intermediate responses were not possible and the slider initially presented in position “3”. Time to first click, time to last click, time to page submit and click count was collected internally on the server side by the Qualtrics system used to electronically manage the survey. Respondents were told that this was happening and requested to “please answer all questions as quickly as possible as they are being timed.” However, respondents did not have access to the timing information. The pages with the images were completely randomized by the Qualtrics system to limit the impact of an ordering effect.

After the block with the images, the survey ended with a section where demographics were requested: Age, Gender, and Race. Respondents had the option of providing write-in answers to the gender and race questions if they did not prefer to use the options provided. Not answering any of these questions was also allowed.

3.2 Procedure

Once IRB approval was obtained, the survey was sent to undergraduate students at Eastern Washington University (EWU) in the Information Systems and Business Analytics (ISBA) Department and the Accounting Department (ACCT) by their instructors midway through the Winter Quarter of 2018. It was also sent to graduate students at EWU in the MBA program by the graduate director. The survey was administered electronically and anonymity was guaranteed through the set-up of this system. The survey was available for two weeks. The survey was available via mobile devices or a computer. It was accessed either general link generated by Qualtrics or by a QR Code that redirected to that link.

Timing information (click count) and the standard deviation of the scores across all images for a respondent was used to assist in the cleaning process by helping identifying people who were just rapidly clicking “next” without actually choosing their reactions. Of the 47 responses recorded by Qualtrics, 6 were removed for this reason, resulting in a usable sample size of 41. The demographics of the resulting cleaned sample are in Figures 1-3.
3.3 Analysis

Median differences in slide viewing time and median differences in the strength of reactions between pictures and graphics for a single topic were examined using matched-pairs Wilcoxon tests. For comparing median differences in slide viewing time segmented on the difference in reaction strength (graph – picture = negative, zero, positive), the Kruskal-Wallis test was used. Medians, rather than arithmetic means, were chosen to measure the centers of the distributions of the responses due their robustness in the presence of skew.

Table 1: Results for matched-pairs Wilcoxon test on Difference in Time Spent (Graph – Picture)

<table>
<thead>
<tr>
<th>Topic pair</th>
<th>Median of Graph</th>
<th>Median of Picture</th>
<th>Median of (Graph-Picture)</th>
<th>W</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gun</td>
<td>7.53</td>
<td>4.83</td>
<td>3.33</td>
<td>812</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>President</td>
<td>8.30</td>
<td>4.57</td>
<td>4.70</td>
<td>796</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>Global Warming</td>
<td>5.20</td>
<td>4.66</td>
<td>0.56</td>
<td>549</td>
<td>0.063</td>
</tr>
<tr>
<td>Super Bowl</td>
<td>6.48</td>
<td>4.08</td>
<td>2.26</td>
<td>624</td>
<td>0.006</td>
</tr>
<tr>
<td>Movie</td>
<td>6.20</td>
<td>5.33</td>
<td>0.01</td>
<td>432</td>
<td>0.495</td>
</tr>
<tr>
<td>Dog</td>
<td>8.11</td>
<td>4.17</td>
<td>4.18</td>
<td>799</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>Immigration</td>
<td>7.62</td>
<td>4.67</td>
<td>3.73</td>
<td>680</td>
<td>0.001</td>
</tr>
<tr>
<td>Test</td>
<td>9.31</td>
<td>6.44</td>
<td>3.00</td>
<td>624</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Table 2: Results for matched-pairs Wilcoxon test on Difference in Response Strength (Graph – Picture)

<table>
<thead>
<tr>
<th>Topic pair</th>
<th>Median of Graph</th>
<th>Median of Picture</th>
<th>Median of (Graph-Picture)</th>
<th>W</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gun</td>
<td>3.00</td>
<td>3.00</td>
<td>-0.50</td>
<td>67</td>
<td>0.018</td>
</tr>
<tr>
<td>President</td>
<td>3.00</td>
<td>3.50</td>
<td>-0.50</td>
<td>90</td>
<td>0.144</td>
</tr>
<tr>
<td>Global Warming</td>
<td>4.00</td>
<td>4.00</td>
<td>-0.50</td>
<td>102</td>
<td>0.013</td>
</tr>
<tr>
<td>Super Bowl</td>
<td>2.50</td>
<td>3.00</td>
<td>0.00</td>
<td>179</td>
<td>0.810</td>
</tr>
<tr>
<td>Movie</td>
<td>3.00</td>
<td>3.00</td>
<td>0.50</td>
<td>260</td>
<td>0.093</td>
</tr>
<tr>
<td>Dog</td>
<td>3.00</td>
<td>4.00</td>
<td>-1.00</td>
<td>35</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>Immigration</td>
<td>3.00</td>
<td>3.00</td>
<td>0.00</td>
<td>81</td>
<td>0.380</td>
</tr>
<tr>
<td>Test</td>
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<td>2.00</td>
<td>0.50</td>
<td>269</td>
<td>0.270</td>
</tr>
</tbody>
</table>

Figure 4 and Table 1 contain the results for the analysis of median difference in slide viewing time. It is worth noting that all pairs except Movie were statistically significantly greater than zero at the 10% level. All pairs except Movies and Global Warming were statistically significantly greater than zero at the 5% and 1% level.

Table 2 contain the results for the analysis of median difference in response strength. It is worth noting that only Dog is statistically significantly different at any typical level, while Gun and Global Warming join Dog at the 5% level and Movie joins these at the 10% level.

Table 3 contain the results for the analysis of median differences in slide viewing time segmented on the difference in reaction strength (graph – picture = negative, zero, positive). No topic pairs are statistically significant, suggesting that the relationship between time spent viewing an image and reaction strength may not be related. However, this may also be a result of the limited number of responses.
4. INTERPRETATION

Unsurprisingly, people seemed to take longer to digest specific information and conclude when viewing graphics than when making a gut decisions based off viewing a picture. Trends regarding respondent reaction strength were not as clear. While people generally appeared to care about pictures more than graphs, this difference was only statistically significant at the 5% level for three topics, Guns, Global Warming and Dog.

3.5 LIMITATION

Due to the small sample size and limited population to draw from, results from this study should be considered suggestive only.

3.6 FUTURE RESEARCH

Expansions of this research should include using the heat map function within Qualtrics to include respondent perception styles. Follow-up focus groups or one-on-one interviews may help shed light as to what specific aspects of particular images may have been driving certain responses. A link between global and local perception style preference and differences in response speed depending on graph vs. picture is a potential area of future investigation. Mixed-method research methodology is suggested as a future path for this work.

4. CONCLUSION

While this experiment did not break major new ground with respect to its result that “people generally appeared to care about pictures more than graphs,” it did successfully serve as a pilot study into the viability of using Qualtrics as a platform for gathering data on affective data visualization design.

5. SURVEY IMAGES

The image pairs below and on the following pages were used for the experimental comparison survey. They are in the same order as in tables 1-3.
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Keywords: Data visualization, Emotion, Image Perception
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