Scan Paths on Event Posters: An Eye Tracking Experiment

Glen Charles Lopez
Ateneo de Manila University
Department of Computer Science and Information Systems
Quezon City, Metro Manila, Philippines
glen.charles.lopez@gmail.com

Jun Rangie Obispo
Ateneo de Manila University
Department of Computer Science and Information Systems
Quezon City, Metro Manila, Philippines
rangieobispo@gmail.com

Mark Joseph Ronquillo
Ateneo de Manila University
Department of Computer Science and Information Systems
Quezon City, Metro Manila, Philippines
markronquillo23@gmail.com

ABSTRACT
In graphic design, elements and principles are used by practitioners in creating materials that effectively convey message to readers. Some of these include repetition, alignment, proximity, white space, etc. Given that these principles are followed, some portion of certain materials does not have great importance; hence, a hierarchy among these elements is established. Some portions are intended to catch the attention of users at first glance. Some are given more focus when reading. This study aims to somehow validate the intention of designers whether this hierarchy of elements is followed when viewers read graphic materials – in this case, posters. Test subjects are asked to view a sequence of event posters and their gaze is tracked by the EyeNTNU-120 Eye Tracking System. Data collected was processed to validate whether the intended scan path and area of focus as intended by the designer following the principles of design are followed. The results from this eye-tracking experiment exhibit a low association between the supposed scan paths prescribed by the explicit design of the graphic designer with the given posters. The viewers of the posters tend to balance off the time between looking at the illustrations and the text details. This greatly depends on which kind of element, either text or illustration, is more present in the poster.

Categories and Subject Descriptors
H5.m. **[Information interfaces and presentation]** (e.g., HCI): Miscellaneous.

General Terms
Measurement, Experimentation.

Keywords
Eye tracking, Scan paths, Event posters.

1. INTRODUCTION
For the longest time, the field of graphic design has been following a set of elements and principles that guide its practitioners to the creation of effective materials. More specifically, there are the principles of composition that are pointers to the arrangement of the objects that are put together to deliver a coherent and certain message. Some of these principles include repetition, alignment, balance, contrast, proximity, and white space. Not all portions of a certain material have the same weight of importance; therefore, the creation of hierarchy among the elements is required. Highlighting or bringing up certain portions and letting other parts fade away into the background creates tension within the material that makes eye movement possible.

This arrangement is usually explicitly determined by the designer of the material in order to direct the eye of the users from one point to the next. These elements in a poster can include the main focal point, the prominent heading/text, some supporting text, and the other smaller elements that support the material.

It is in the interest of this study to know, given a certain context, if the explicit use of the principles of composition in the creation of posters truly directs the viewer's eye through the different areas within the material.

This study aims to answer the following questions:

1. Is the succession of points (scan paths) where the users (or viewers) look at an announcement/event poster consistent with how the designer explicitly designed the material?
2. Where do viewers focus more on when looking at such materials?

Given an announcement/event poster, the viewers follow scan path by which they look at the material to extract information. That sequence is expected to match how the graphic designer, or creator, explicitly used the compositional principles of design to direct the viewer's eye movement. Also, the users are also presumed to take more time on the area where the pertinent details of the event, e.g. venue, date and time, are written in order for these to be remembered.

This study will be helpful in affirming the explicit use of the principles of design on information materials such as announcement/event posters. This study can also help designers understand the behavior of the eye movement of users so they can design to expedite information transfer and catch most of the viewer's attention.

2. RELATED WORK
When people read, it is almost always at the same time they look for information. Regardless of the medium, people will run through the material looking for what they want, and probably focus on something that catches their attention.

The Web has become the largest source of information. Hence, web search services have become more conscious in their efforts to present information to the users such that they would be able to maximize productivity. Gaze of the users will significantly vary on the task they perform: either looking for information or

navigating to web pages [2]. The URL, title, and snippet actually are read equally by the users, but a significant difference in the gaze duration become evident depending on the task of the user. It is evident that when people look for information, snippets are given longer gaze duration. This is primarily because users try to evaluate whether the information they are interested in can be found on that page. When just navigating around, i.e. looking for a particular site, users gaze longer on the URL to evaluate the reliability of the site. Though, the difference between the length gazing at the snippet and the URL is quite small.

Among the three (URL, title, snippet), when varying among the lengths of these (short, medium, long), the snippet length has the most significant impact on the task success. Longer snippets are quite helpful in information seeking because users can see more information on what they are looking for. On the other hand, it becomes quite detrimental when navigating since they would give less attention to the URL found at the bottom.

When people now look at particular web pages, their gaze duration on the different areas of the web page would now play significant role on the task they wish to perform [1]. A typical web page could be divided into ten (10) regions: nine equal regions (3x3 blocks) above the fold, and a single region everything below the fold. An eye tracking experiment reveals that the gaze of the users on these different regions varies depending on the task at hand - either information seeking or page recognition. On the first second of looking at the web page, users look immediately at the center-left portion of the page. On the other hand, when trying to recognize the page, users view directly at the top-left portion. In all tasks, the four top-left regions (top-left, top-center, center-left, and center-center) have the most significant use since users focus more on these regions on both types of tasks. It is also worth mentioning that the right sides of the page (top-right, center-right, and bottom-right) have very insignificant roles. Users do not pay much attention on these sides.

This entails that placement of information on a particular space may have significant impact on the efficiency of users on their tasks.

The research conducted by Hong Fa Ho [4] used the eye-tracking technology for investigating how the e-consumers perceive online images of women handbags. The study extended the point-to-point scan paths and fixations that is normally used in the area of textual reading researches to a region-to-region concept for the purpose of measuring visual behavior on several regions of interest in the image more effectively. Our study intends to use the same approach for grouping of data.

Improvements on layout for posters have been the focus of some studies in previous years. A study by Mike Pascoe, PhD [6] tried to use the eye-tracking technology to show how much time he gazes at each part of the poster layout. He used Attention Maps and Focus Maps to visualize the data and he also used Regions of Interest to quantify what parts of the layout the user focused on.

Eye-tracking technology has been used also in determining the effectiveness of design elements in a newspaper. Holmqvist [5] et.al. conducted a study that examines the effect of local design factors on the way the reader scan the newspaper and how long does the user look at a certain area in the newspaper. The study tried to answer questions like: Do fact boxes attract reader's attention? Does color lead to longer visual dwell times? Some of the local design factors positioning, size, color, drop quotes, and pictures.

The researchers concluded that for the criteria of attraction for early reading, the most important local design factors are the large size and position (Upper left). Color does not seem to have an effect for that criteria. Lastly for the dwell time, large size and large picture are considered the most important local design factor and the Position doesn't seem to have an effect for the dwell time.

When working on the layout of a daily newspaper spread, designers make assumptions on how the readers will read the spread. These assumptions include local design factors like colors, positions and sizes. Another study by Holmqvist. et. al. [7] tried to explore the relation of the newspaper designers' predictions concerning the readers' visual behavior when they are reading the spreads to the actual visual behavior of the readers. They have partitioned each paper into 16 areas of interests (AOI) and for each area there are two prediction parameters: (1) rank in temporal order, and (2) dwell time.

The study aimed to find out whether there are layout factors that coincide with a greater mismatch between designers' prediction of reader' visual behavior. Three factors significantly contributed to prediction of the degree of mismatch between the designers' prediction and the actual eye movements for the temporal rank parameter which are the following; position of the AOI in horizontal direction, type of picture and color. While for the dwell time parameter, the type of picture, size of picture and color are the factors that contributed significantly for the degree of mismatch.

3. METHODS

3.1 Profile of Test Subjects

This test engaged four students of the Ateneo de Manila University Loyola Schools. Two are undergraduate students and are graduate students. The test subjects declared high interest but medium knowledge in graphic design.

3.2 Data Collection Instruments

This study uses the EyeNTNU-120 Eye Tracking System [3] with a sampling rate of 120 Hz, and angle error < 0.3°. The device is connected to a laptop via USB 2.0 port that runs a Windows 8.1 operating system. Test subjects place their head in a chin rest while the device is held by a lazy pod near the test subject's left eye (see Figure 1). Fixation Calculator will then process the data collected to get the necessary figures such as total contact time (TCT), latency of first fixation (LFF), number of fixation (NOF), and duration of first fixation (DFF).

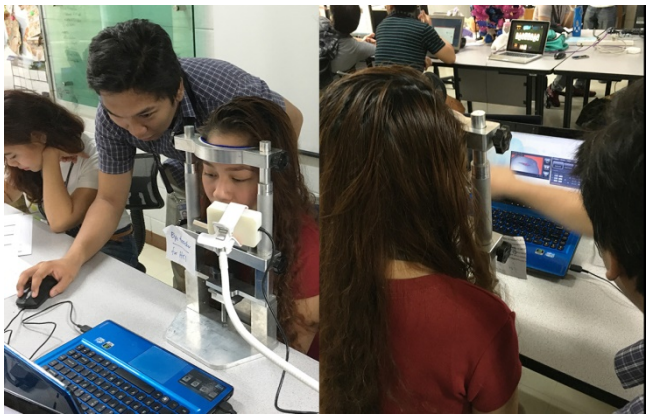

Figure 1. EyeNTNU eye tracking system with test subject

3.3 Stimuli and Regions of Interest

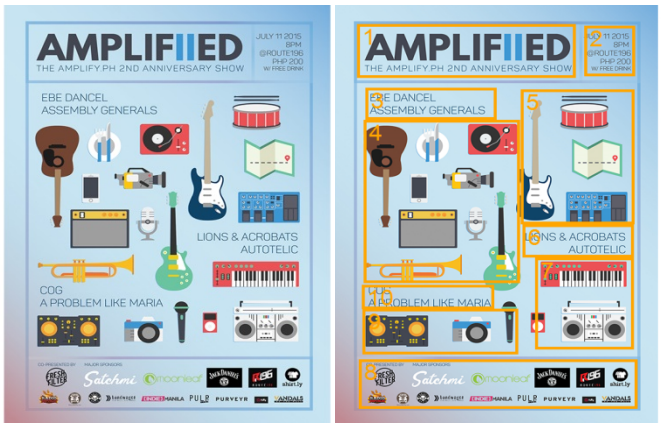

Figure 2. Sample Stimuli with Regions of Interest

In Graphic Design, the principles of composition are used to direct the viewer's eye to the different parts of the material. These may include variety or lack thereof of size, color, rhythm, pattern, etc. Even posters, though the main objective is to inform viewers of certain events, still follow the principles of design. For this study, four event posters are used as stimuli.

The regions of interest (ROIs) are determined by the graphic designer who provided the stimuli. Each poster has 6-8 ROIs depending on the clustering of the details in the poster. In the experiment, the posters are set to 1366X768 resolution with white background. The ROIs are ordered accordingly as to the intent of the designer on how viewers would look at the various elements of the poster, i.e. ROI 1 should be the first element that the users would look at, followed by ROI 2, and so on.

Figure 1 is one of the stimuli used in the project with the specified ROIs. The most dominant element is the main text designated as ROI 1. It is also presumed that viewers will start looking at the upper-left hand corner given that there is no clear or initial focal point. Different ROIs were assigned for the details with texts and the illustration portions as to these may elicit a longer fixation time. Also, notice that there is an almost Z pattern to the ideal scan path in order to go through all of the details.

3.4 Tasks

After a successful calibration of the eyes of the test subjects to the tracker, the task to be performed was straightforward. Test subjects are asked to look at a series of four event posters sequentially, just as how they would normally look into these. They are asked to be familiar with the basic elements and details found in the poster. For each poster, they are given 20-30 seconds to look into the different details and parts.

3.5 Data Analysis

After the test subjects have undergone the experiment, data from the eye tracker was collected and processed through the Fixation Calculator. To improve the accuracy of the numbers, the data went through some adjustments using the provided heat map tool. Also, for those values that were counted as zero, they were not included in both averaging the available values and also in the sorting of the order of some of the properties listed below. The descriptions below are also partial basis to the interpretation of the data collected.

To answer the first research question, the Latency of First Fixation (LFF) is used. Generally, the shorter the LFF on a particular ROI means the test subject more quickly transfers his attention on the particular area. When the LFFs of the different ROIs are sorted in ascending order, it will determine the scan path of how the viewers look at the poster.

To answer the second research question, both data on Total Contact Time (TCT) and Number of Fixations (NOF) are used. The larger the TCT suggests that the viewers had spent longer time in that particular ROI, i.e., the more attention the user has devoted to that part of the poster. This will determine which parts users deal much more focus and attention. The more NOF there is on a particular ROI shows how many times the viewer kept on looking back at a particular ROI. This means that the viewer shows significant interest on that ROI.

4. RESULTS AND DISCUSSION

4.1 Latency of First Fixation

The LFF dictates the sequence/order of the gaze of the user throughout the poster. The ideal order prescribed is also the setting of the order of the ROIs. All the areas that were not determined as ROIs are counted as others and are not part of the ordering of the gazes.

For the first poster (see Figure 2 for image and Table 1 for results), out of the 10 determined ROIs, 5 out of 10 were looked by the prescribed order of the designer. R03 is the ROI that is looked at first because of its placement at near the upper-left of the poster.

Most of the ROIs that were not looked at in order were text details including R01, R02, R03, R06, and R10. An exception to this was R09.

Table 1. LFF for first poster

ROI	LFF (Milliseconds)	Order	Text or Illustration
R01	2697.25	3	T
R02	19939	10	T
R03	1568	1	T
R04	2845	4	I
R05	3060	5	I
R06	2030.333333	2	T
R07	10238	7	I
R08	10402.5	8	T
R09	14613.25	9	I
R10	5984	6	T
Others	1803		--

The remaining posters (see Figure 3) also have displayed notable results. For the second poster (see Table 2 for results, see Figure 3 leftmost for image), out of the 7 determined ROIs, 3 out of 7 were looked by the prescribed order of the designer, with R07 excluded as data was not recorded properly. This included the most prominent ROI, R01 as it is the biggest element in the page. Other elements that were looked at in the ideal order were R03 and R06

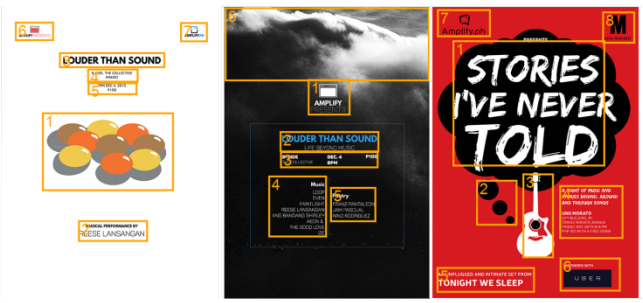

Figure 3. Posters 2 to 4 with ROIs

which were text details. R03 is text bigger than most of the other elements. R06 is an element on the upper-left hand corner which would suggest that after scanning the page from the top to bottom, the eyes would be directed to the said corner to begin scanning the poster more thoroughly.

Table 2. LFF for second poster

ROI	LFF (Milliseconds)	Order	Text or Illustration
R01	2832	1	I
R02	13411.5	5	T
R03	8563.666667	3	T
R04	4770.5	2	T
R05	10535.5	4	T
R06	19396	6	T
R07	0	--	T
Others	444.5	--	--

For the third poster (see Table 3 for results, see Figure 3 center for image), out of the 6 determined ROIs, only 2 were looked at according to the prescribed order. These include R02, which is a text element exactly at the center of the page, and R06, which is an image element at the top of the page. The two ROIs were looked in order because of its characteristics (1) being colored differently and (2) occupying the page more than the other elements.

Table 3. LFF for third poster

ROI	LFF (Milliseconds)	Order	Text or Illustration
R01	5742.333333	4	I
R02	1567.5	1	T
R03	5691.75	3	T
R04	7384.75	5	T
R05	5494.666667	2	T
R06	10321.66667	6	I
Others	541.25	--	--

For the fourth and last poster (see Table 4 for results, see Figure 3 rightmost image), out of the 8 determined ROI2, only 1 was looked according to the prescribed order. R02 was not counted because of the lack of data. There were several ROIs that were only off one place from being looked at the ideal order which are R03 (4th), R04 (3rd), R05 (6th), R06 (5th), and R08 (7th). These ROIs only missed one mark and are almost adjacent to one another.

Table 4. LFF for fourth poster

ROI	LFF (Milliseconds)	Order	Text or Illustration
R01	143.6666667	1	I/T
R02	0	--	I
R03	10004.5	4	I
R04	6146.333333	3	T
R05	14559	6	T
R06	10694	5	T
R07	2442	2	T
R08	24879	7	T
Others	1573.75	--	--

4.2 Total Contact Time

The TCT values serve as our basis to determine where did the testers focused more while looking at the posters. This value basically means the dwell time the users spent looking at a particular ROI.

For the first poster, the test subjects focused more on the following ROIs with their corresponding total contact time: R04 with 1166.5 ms, R08 with 1185 ms, and R01 with 928 ms (see Table 5 for results). These regions are illustrations in the poster: the title and the sponsors section respectively.

Table 5. TCT for first poster

ROI	TCT (milliseconds)	Text or Illustration
R01	928	T
R02	230	T
R03	332.75	T
R04	1166.5	I
R05	729.25	I
R06	145.5	T
R07	453.75	I
R08	1185	T
R09	128	I
R10	36.75	T
Others	1396.25	--

The second poster has similar results with the first one where illustrations and the title got the highest dwell time (see Table 6 for results). R01 has 980.75 ms and R03 has 838.25 ms total contact time.

Table 6. TCT for second poster

ROI	TCT (milliseconds)	Text or Illustration
R01	980.75	I
R02	186.75	T
R03	838.25	T
R04	65.5	T
R05	40	T
R06	7	T
R07	0	T
Others	2840	--

The third poster, however, unlike the previous posters, the test subjects paid more attention to the text details (event information) compared to the illustrations (see Table 7 for results). R05 has 507 ms and R04 has 472.5 ms total contact time.

Table 7. TCT for third poster

ROI	TCT (milliseconds)	Text or Illustration
R01	178.75	I
R02	398.5	T
R03	291.5	T
R04	472.5	T
R05	507	T
R06	344.75	I
Others	2024.5	--

For the fourth poster, the data showed that the test subjects focused more on the title, the text detail (event information) and

the sponsor section (see Table 8 for results). Focus was more dedicated to text elements in the poster. R01 has 1146.2 ms, R04 has 438 ms and R06 has 229 ms.

Table 8. TCT for fourth poster

ROI	TCT (milliseconds)	Text or Illustration
R01	1146.25	I/T
R02	0	I
R03	117.75	I
R04	438	T
R05	32.25	T
R06	229.25	T
R07	8.25	T
R08	29.25	T
Others	2128.5	--

4.3 Number of Fixations

The Number of Fixations (NOF) refers to the number of times the testers focus entered a given region. These values can be used as a basis for evaluating which regions in the poster the test subjects are interested in.

For the first poster, the data showed that the testers are interested in the illustrations, sponsors section and the title, regions with its NOF are the following: R04 has 58, R08 has 57 and R01 has 48 respectively (see Table 9 for results). Since it is aligned with the results of TCT in this poster, then the testers paid more attention to the regions they are interested in.

Table 9. NOF for first poster

ROI	NOF	Text or Illustration
R01	48.75	T
R02	16.5	T
R03	22	T
R04	58	I
R05	36	I
R06	10	T
R07	28	I
R08	57.25	T
R09	8	I
R10	8	T
Others	71.5	--

The dominating regions for the second poster are R01, an illustration, with 50 NOF and R03, a text detail that has 33 NOF (see Table 10 for results). This is consistent with the results of TCT for this poster.

Table 10. NOF for second poster

ROI	NOF	Text or Illustration
R01	50.75	I
R02	20.5	T
R03	44	T
R04	9	T
R05	3	T
R06	2	T
R07	0	T
Others	126.75	--

The third poster (see Table 11 for results) showed that testers are interested in both R04 (26 NOF) and R05 (25 NOF) where the two ROIs are both event information (text). The third ROI that got the highest NOF is R02, the title, which has 20 NOF. The same set of ROIs composes the results of TCT in this poster which shows the alignment of the results on both criteria.

Table 11. NOF for third poster

ROI	NOF	Text or Illustration
R01	11.66666667	I
R02	20.25	T
R03	15.75	T
R04	26.25	T
R05	33.66666667	T
R06	31.33333333	I
Others	119.5	--

The fourth poster NOF also has consistent results with that of the TCT (see Table 12 for results). R01 has 58 NOF, R04 has 23 NOF and R06 has 14 NOF. This consistency for all the four stimuli strongly suggests that at certain regions in the poster, test subjects show significant interest.

Table 12. NOF for fourth poster

ROI	NOF	Text or Illustration
R01	77.33333333	I/T
R02	0	I
R03	9	I
R04	30.66666667	T
R05	4	T
R06	28.5	T
R07	2	T
R08	2.5	T
Others	119.5	--

4.4 Heat Map

The analysis tool also provides a way to visualize the data gathered via heat map. A heat map represents data using colors. A red shaded region means most dwell time while the green one has the least. For the first poster, the visualization showed that the testers gaze more on the illustrations area and the title. The same goes with the second poster. For the third poster, highest dwell time is concentrated on the text details. Lastly, the fourth poster, the heat map showed the title and the text details got most of the focus of the testers. The TCT and NOF are aligned with what the heat map represents. These are the exact regions that testers paid more attention to.

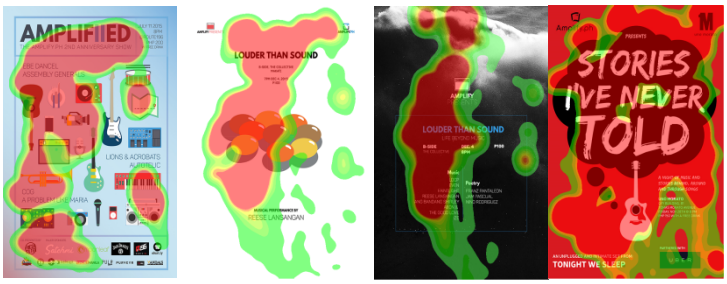

Figure 2. Heat map of the fur stimuli (posters)

5. CONCLUSION

Out of the 31 predetermined ROIs for the four posters, only 11 ROIs were looked at at the prescribed order of the graphic designer. This is an approximately 35.5% success rate. As noted in the discussion of results, there were a number of ROIs that had invalid values and there were a couple that only missed one step in its order either before or after. There is some level of consistency but, as will be discussed in the recommendations, a change in the context of viewing the posters using another type of eye-tracker equipment would hopefully increase the success rate.

More specifically regarding the posters, there were some posters where the viewers paid more attention to the title and the illustrations in the poster. On the other hand, there were posters where the viewers focused on the text details displayed. For the final poster, the title and the text detail got more dwelling time. These areas are aligned with the heat map. Overall, this study concludes that the viewers focused more on the title and illustrations contrary to assumption that the viewers will dwell more on the poster's text details.

6. RECOMMENDATIONS

With the completion of the experiment, the authors give two recommendations to further improve the results.

The context of viewing the posters and the eye-tracking experiment should be made more actual. An example would be attaching an eye-tracking apparatus to a viewer and allowing the person to walk through a corridor with the given posters displayed on specific places.

For a more consistent and reliable data for the study, the researchers recommend to increase the number of test subjects up to ten or fifteen test subjects. This increase will give more reliable data for processing.

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