Djamasbi, S., Siegel, Tullis, T. "Designing Noticeable Bricklets by Tracking Users' Eye Movements," in Proceedings of the Forty-Fifth Annual Hawaii International Conference on System Sciences (HICCS), Computer Society Press, January 2012, pp.525-532.

Designing Noticeable Bricklets by Tracking Users' Eye Movements

Soussan Djamasbi
Worcester Polytechnic Institute
djamasbi@wpi.edu

Marisa Siegel
Fidelity Investments
marisa.siegel@fmr.com

Tom Tullis
Fidelity Investments
Tom.Tullis@fmr.com

Abstract

To be successful, websites must not only contain useful information, but provide that information in a quickly and easily accessible manner. One method of delivering this experience is to design websites that effectively guide users' attention to key information on the page. Grounded in the model of visual hierarchy, this study examines several attributes that can affect users' attention to key information. Using an eye tracking device, users' eye movements were recorded while completing tasks on web pages. The results provide partial support for the model of visual hierarchy and indicate that tracking users' eye movement is an effective method for informing design.

1. Introduction

Websites have become an important channel of communication for many companies, with many e-businesses utilizing it as their only method of communication with customers. Consequently, most companies dedicate a significant amount of resources to creating websites that benefit both their internal (e.g., employees) and external (e.g., customers) users [3, p. 74]. Effective communication affects user experience [5]; research indicates that user experience is significantly and positively correlated with return on investment (ROI) [11]. This underscores the fact that designing web sites that are effective in communicating key information to users is of utmost importance to companies.

Although a great number of human computer interaction (HCI) studies have focused on examining user experience, little research has used the model of visual hierarchy as a part of these investigations. Additionally, few studies have incorporated the use of eye tracking in examining users' viewing behavior. This is particularly important because recent research indicates that examining users' viewing behavior by tracking their eye movements is a particularly useful method for informing the design [7].

In this study, we focus on the design of bricklets. Bricklets are contained areas on a page that have specific useful information making the navigation faster and easier for a user. These bricklets often include important notices or provide shortcuts (e.g., via links) to desired information. Figure 1 provides an example of a bricklet.

While many factors can influence the effectiveness of bricklets, in this study, we focus on the effects of characteristics explored in the theory of visual hierarchy: size, graphics, location and color [8]. In particular, we focus on how these factors can affect how noticeable the bricklets are to users in a realistic web environment. To examine whether the above factors can affect how quickly a bricklet is seen by users, we conduct a laboratory study, in which we track users' eye movements.

2. Theoretical Background & Hypotheses

Visual hierarchy is a cognitive approach to user-centered design. In practice, webpages with a strong visual hierarchy will have contrasting perceptual elements of varying visual importance [8]. Without this variation in emphasis, Tufte states, "nothing is emphasized; the design will be noisy, cluttered and informationally flat" [14, p.74]. By creating a visual hierarchy, companies can naturally guide users in viewing their webpages in an effective and meaningful way.

Arranging elements on a web page so that they create a clear visual hierarchy (i.e., have varying levels of visual importance) can be done through the manipulation of a variety of characteristics [8]. In the following subsections, we describe the significance of four of these characteristics and the related hypotheses.

Size. The size of an element is an indicator of importance, with larger elements having a greater level of perceived visual importance and, consequently, a higher level in the visual hierarchy [8]. For example, a large image is likely to be viewed faster than a smaller image. This is commonly seen in practice; for example, the titles and headings in this paper are a larger font size than the text in the body.

Based on this, we hypothesize that the size of a bricklet will affect its noticeability:

H1) A bricklet of larger size will attract fixation faster than a bricklet of smaller size.

Graphics. Images and graphics affect visual hierarchy because viewers tend to be attracted to them [9]. Because images tend to cue importance, users are more likely to attend to them [8]. This point of view has been supported by a number of recent eye tracking studies showing that images and graphics attract fixations [4,5].

Therefore, we hypothesize that having a graphic inside a bricklet will impact its noticeability:

H2) A bricklet containing a graphic will attract fixation faster than a bricklet that does not include a graphic.

Color. Colors are particularly useful in making a web element visually distinguishable [8]. In particular, basic visual search has been shown to be influenced by the basic features of a stimulus, such as its background color [15]. For example, a bright target object is likely to be detected more quickly on a dark background than it is detected on a light background [15].

The use of color to attract attention is seen in practice on websites in the form of banners, often for advertisements. Banners are typically designed with the specific purpose of being notable and clearly distinguishable from other items [1]. However, as banners have become more prevalent, web users have developed what has been coined as "banner blindness": the tendency to ignore banners due to the very aspects that initially were designed to attract attention [2].

Because of this phenomenon of banner blindness, it is possible that manipulating background color with the goal of attracting attention may cause users to mistake the bricklet for an ad or banner and consequently avoid it [3]. Thus, a more "colorful" bricklet may indeed become less noticeable.

Based on this, we hypothesize that participants are likely to view the bricklet without a contrasting background before the bricklet that has a contrasting background:

H3) A bricklet without a contrasting background color will attract fixation faster than a bricklet with a contrasting background color.

Location. The location of elements on a web page influences how effectively information is communicated with users [10]. For example, many webpages are structured with three vertical sections – a main, larger center section and two smaller rails on the left and right [7]. With this layout, the center section is naturally the most likely to be viewed due to its size and location. Additionally, content in the left rail is more likely to be viewed than content placed in the right rail because, at least in Western countries, users typically scan left to right on the page [7,8].

These behaviors have been shown in a number of eye tracking studies providing evidence that users tend to exhibit an F-shaped viewing pattern. This viewing pattern is characterized by two long horizontal scans near the top of a page and one long vertical scan on the left side of the page, forming an "F" fixation pattern [13]. This behavior has been attributed to users' left-to-right viewing preference [8]. These viewing tendencies are likely to affect noticeability.

Based on the above research, we hypothesize that the location of a bricklet affects its noticeability:

H4) A bricklet located on the left side of a webpage will attract fixations faster than a bricklet located on right side of the page.

3. Method

To investigate the above discussed hypotheses, a laboratory experiment was conducted. This section provides a brief description of how the laboratory study was conducted.

3.1. Experimental Material and Task

A total of 8 webpage prototypes (4 pairs) were used in this study. Because the objective was to measure the noticeability of bricklets, the prototypes were developed so that each pair of prototypes differed only in one section: the bricklet under investigation. The prototypes were based on the home pages of several financial investment websites. Because bricklets play a significant role in communicating information in this type and genre of websites [3], the prototypes served as a suitable experimental material. Additionally, using the bricklets and overall design from actual financial webpages provided a realistic environment for testing the bricklets' noticeability.

As demonstrated in Figure 1, which shows one set of prototypes (S1 & S2), each pair of prototypes differed only in the bricklet, and only in terms of one characteristic under examination:

S1 & S2: size. S1 had an area of 270,000 pixels, while the area of S2 was nearly twice that at 520,000 pixels. Elements inside the bricklet in S2, such as text and image, were also increased in size relative to S1 (Figure 1).

G1 & G2: graphic. G1 had a textual element with a green background. Instead, G2 contained a graph with green bars. A graph was used as the graphical element because charts are a common and attractive feature on this genre of websites (Figure 2).

C1 & C2: background color. C1 had a white background, matching the background of the webpage. C2 had a bright green background, which contrasted with the white background of the web page. Green was used to blend with the color scheme of the page. Although many advertisements may intentionally use colors that clash, it is unlikely that a non-advertising bricklet on a financial site would do so. Therefore, in prototype C2, green was used to blend with the color scheme of the page (Figure 3).

L1 & L2: location (left vs. right). L1 is located on the right side of the page. L2 is located on the left side, shifting the main content to the right. There is no difference in the vertical position of L1 and L2 (Figure 4).

All bricklets were located above the fold of the page; that is, the user did not need to scroll the page in order to see them.

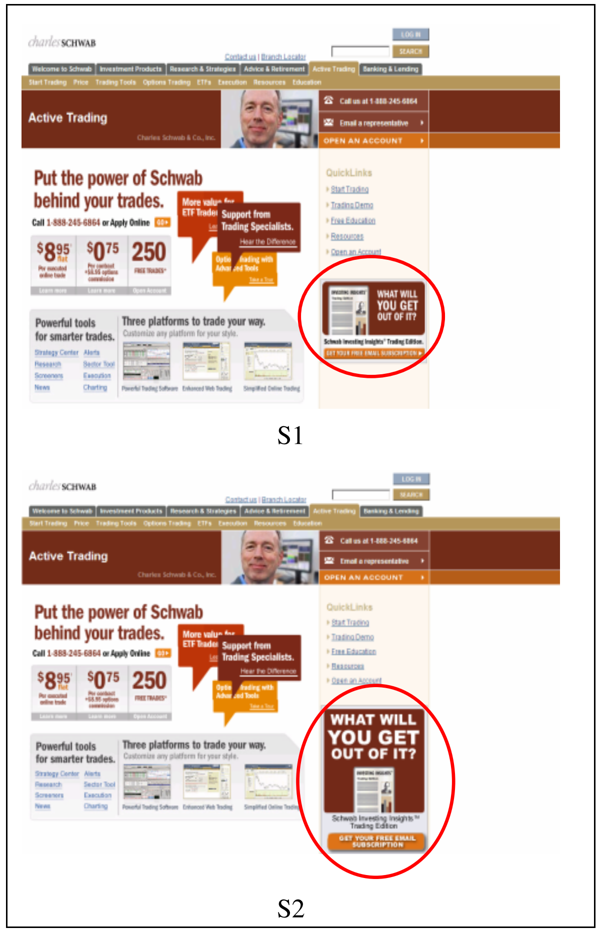


Figure 1: The bricklets under investigation are marked with red circles. Bricklets in prototypes S1 and S2 differ in size.

Two of the major goals for bricklets such as these are to draw users to featured information that is contextually relevant, and to allow users to more easily navigate cross-section to access information. Thus, we asked users to complete a set of tasks that were directly associated with the bricklets under investigation. For example, the task for prototypes S1 & S2 stated, "You would like to start receiving Schwab's Investing Insights emails. Where you would go to start the process?" Similarly, the task in prototype G1-G2 gave users the following instructions: "You have just started a new job and would like to roll over your old 401(k), where would you go to start that process?" The answers to these tasks were located in the designated bricklets that are marked in Figures 1 to 4.

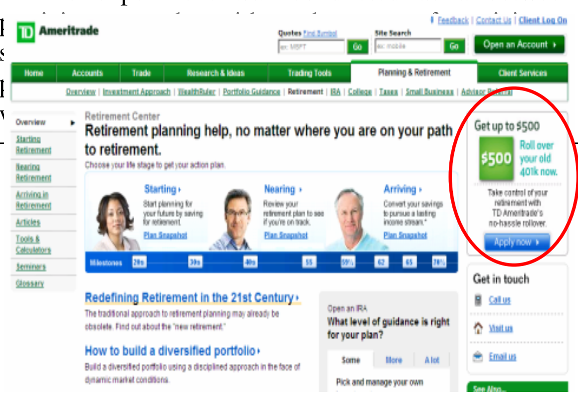
Djamasbi, S., Siegel, Tullis, T. "Designing Noticeable Bricklets by Tracking Users' Eye Movements," in Proceedings of the Forty-Fifth Annual Hawaii International Conference on System Sciences (HICCS), Computer Society Press, January 2012, pp.525-532.

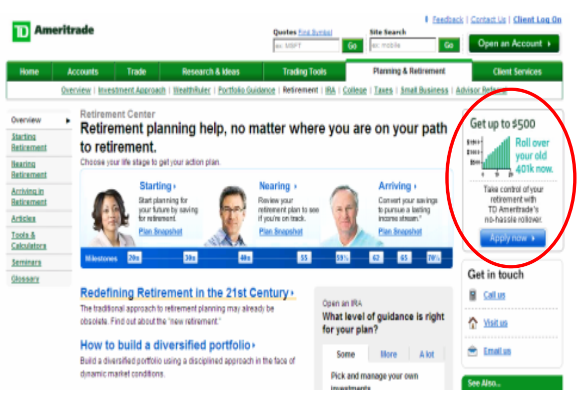
Users additionally completed a number of distracter tasks unrelated to the bricklets that were interspersed with the tasks related to the bricklets. These tasks were included to avoid having participants complete a series of tasks for which the answer was consistently the same design element.

3.2. Participants & Design

Forty professionals, 15 males and 25 females, from a variety of disciplines (business, legal, technology, sales, administrative) participated in the study. The age of the participants ranged from 23 to 60.

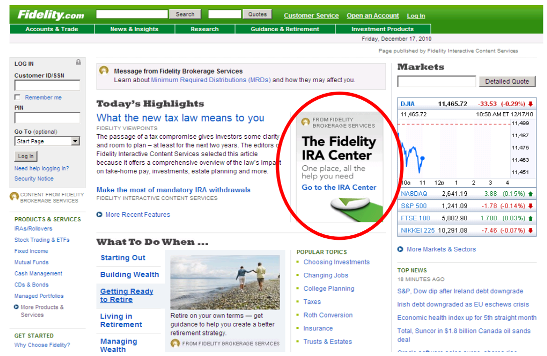
The experiment was conducted as a between



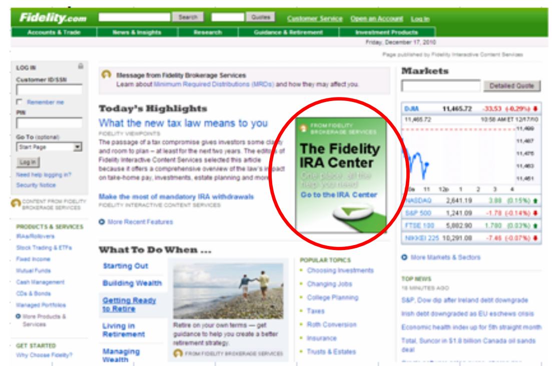


G2

Figure 2: The bricklets under investigation are marked with red circles. The difference between the two Bricklets in prototypes I1 and I2 is that one includes a graphic (chart).



C1



C2

Figure 3: The bricklets under investigation are marked with red circles. The difference between the two Bricklets in prototypes C1 and C2 is their background color.

3.3. Measurements

To measure the effectiveness of the bricklet design in capturing users' attention, the eye movements of the participants were tracked. As in prior research, fixation was defined as a gaze of a minimum of 30 milliseconds [6]. Because fixation is a reliable indicator of attention [6,7,12], time to the first fixation was used to indicate how quickly the bricklet was able to attract attention. Time to first fixation is calculated as the time from the initial stimulus presentation (i.e., when the webpage appears) until the first time the participant fixates on the area of interest (AOI) [6].

3.4. Procedure

After participants reviewed and signed a statement of informed consent, they were escorted into the usability lab. The eye tracker was then calibrated to each participant in a brief procedure during which a participants' eyes are tracked to particular locations on the screen to increase the accuracy of the tracking.

Following the calibration, the moderator left the room and the first stimulus was presented. As previously described, participants saw only one prototype from each pair of prototypes (e.g., prototype S1 or S2, but not S1 and S2). Prototypes were presented in randomized order. After viewing all prototypes, participants were debriefed and presented with two movie ticket vouchers as compensation.

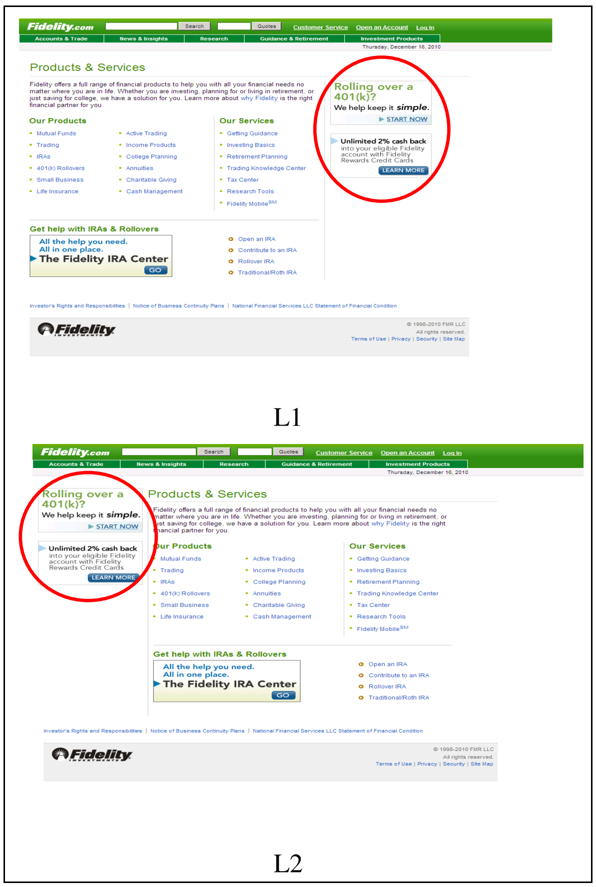


Figure 4: The bricklets under investigation are marked with red circles. The difference between the two bricklets in prototypes L1 and L2 is their location (top left vs. top right side of the page).

4. Results

In this section, each hypothesis is evaluated based on the results of the study.

Size. The first hypothesis, H1, predicted that the larger bricklet would be noticed before its smaller counterpart (Figure 1). Contrary to what was expected, the one-tailed t-test did not show a significant difference between the times to first fixation for the two bricklets. Thus, this hypothesis was not supported by the results (

Table **1**).

Table 1. Results of the t-test comparing time to first fixations on marked bricklets in Figure 1.

Time (sec)	Mean	Std. Dev.
Smaller bricklet (S1)	15.21	15.08
Larger bricklet (S2)	15.54	16.82
df= 38, t Stat= 0.02, p(one-tail)=0.49		

Graphic. The second hypothesis, H2, stated that the bricklet including a graphic would be noticed before its counterpart without a graphic (Figure 2). The results indicated that users noticed the bricklet with the graphic faster (11.54s) than the bricklet that did not have a graphic (18.08s). Although this difference was not significant, it tended toward significance. With additional participants, this potential difference may prove to be significant.

Table 2. Results of the t-test comparing time to first fixations on marked bricklets in Figure 2.

Time (sec)	Mean	Std. Dev.
Bricklet without chart (G1)	18.08	15.08
Bricklet with chart (G2)	11.54	10.75
df= 38, t Stat= 1.42, p(one-tail)=0.08		

Color. The third hypothesis, H3, asserted that the bricklet without the contrasting background color would be noticed before the one with the contrasting background color (Figure 3). The eye tracking data indicates that C1 (4.92s) was viewed significantly faster than C2 (17.29s), supporting H3.

Table 3.Results of the t-test comparing time to first fixations on marked bricklets in Figure 3.

Time (sec)	Mean	Std. Dev.
Bricklet without contrasting background (C1)	4.92	6.89
Bricklet with contrasting background (C2)	17.29	24.03
df= 22, t Stat= 2.21, p(one-tail)=0.02		

Location. The final hypothesis, H4, predicted that the bricklet on the left would have a shorter time to first fixation than the bricklet on the right (Figure 4). The results indicated no significant difference in time to first fixation between the bricklets. Therefore, H4 is unsupported.

Table 4. Results of the t-test comparing time to first fixations on marked bricklets in Figure 4.

Time (sec)	Mean	Std. Dev.
Bricklet on the right (L1)	12.69	3.56
Bricklet on the left (L2)	12.11	3.48

df= 35, t Stat= 0.16, p(one-tail)=0.43

5. Discussion

In this paper, we examined the impact of size, graphic, color, and location of a bricklet on its noticeability. Grounded in prior research, we hypothesized that bricklets that are larger, include an image, do not have a contrasting background color, or are located on the left side of the page will be noticed before their counterparts. To test these hypotheses we examined the time that it took the participants to notice the bricklets (i.e., the time before the first fixation on the bricklet).

The results did not support the expected impact of increased size on noticeability; that is, users did not look at the larger bricklet faster than the smaller one. This was surprising result because, according to the model of visual hierarchy, size is one of the most impactful attributes affecting visual hierarchy. The size difference may not have dramatic enough to produce a notable difference with the number of participants in the study. Although the area nearly doubled from the smaller bricklet to the larger, the horizontal size was not modified at all. Additionally, the bricklet was located on the right side of the page; if it had been in a more prominent location, the size may have had greater impact.

The bricklet that included a graphic tended to be viewed faster than the bricklet without a graphic, but only almost significantly faster. The graphic used in this study was a chart, which is a common and useful type of graphic found on many financial websites. With a larger number of participants, we suspect the results would become significant. Nevertheless, future experiments are needed to verify this speculation.

As expected, the bricklet without the contrasting background was noticed significantly faster than the bricklet with the contrasting background. This is consistent with the phenomenon of banner blindness. Furthermore, it is interesting that this effect manifested even when the color of the background matched the color scheme of the website.

Finally, the results did not show a difference based on the location of the bricklet. The lack of support for the impact of size and location on noticeability of bricklets in this study suggests that the list of attributes that affect visual hierarchy may not apply equally to all the items on a page. Future research, however, is needed to investigate this interpretation.

6. Limitations & Future Research

This research was conducted as a laboratory study. The laboratory setting, however, was designed in a way to resemble a realistic user environment. Nevertheless, as with any laboratory study, the generalizability of our results is limited to the setting and task. Future studies are needed to increase the confidence in generalizability of the results.

This study was focused specifically on financial websites. Because users may react differently in distinct contexts, other genres of web pages unrelated to finance may lead to different results. It may be that on a commercial e-business website, bricklet size or location may be more impactful on attention. Furthermore, future studies should examine the combined effect of the size, images, color, and location on noticeability of bricklets.

Naturally, the theory of visual hierarchy becomes more complicated when multiple characteristics of an element are manipulated; is large text higher in the visual hierarchy than a smaller image? Is bright text on the right side of the page higher in the hierarchy than light text on the left side? This study, and the related hypotheses, did not attempt to answer these questions, but instead tried to determine if the independent manipulation of these characteristics supports this theory in a realistic web environment. Future studies should consider manipulation of these characteristics in a controlled environment.

Additionally, further research is needed on the potential nuances of each factor that contributes to the visual hierarchy. For example, in this study we did not see a difference due to size – what is the minimum difference in size to see an increase in visual attention on an element? What locations are most prominent on different page layouts?

7. Conclusion

The results of this research provide interesting insight into the application of visual hierarchy for web design.

From a theoretical perspective, this research provides further evidence for the theory of visual hierarchy, while providing a basis for future research on its components. One of the main factors affecting visual hierarchy was supported (color), and one was tentatively supported (graphics). Two additional factors (size and location) were studied, providing a baseline for future research. The use of eye tracking in this study provided objective data to support the theory, while providing further evidence of this research method's value in future studies.

From a practical perspective, this research provides further information to help companies improve the experience of their users. It was clear that a contrasting background color may be detrimental to a bricklet that is intended to attract attention. On the other hand, a graphical display of data may draw users more than a textual or numeric display. While the results did not support size and location differences, this of course does not indicate that size and location are unimportant factors; designers should utilize these to affect attention as well.

8. References

[1] J.P. Benway "Banner blindness: The irony of attention grabbing on the World Wide Web", In *Human Factors and Ergonomics Society 42nd Annual Meeting*, Chicago, Illinois, 1998, pp. 463-467.

[2] J.P. Benway and D.M. Lane "Banner Blindness: Web Searchers Often Miss 'Obvious' Links", *ITG Newsletter*, 1, 3 (December 1998), http://www.internettg.org/dec98/banner_blindness.html.

[3] S. Djamasbi, T. Tullis, J. Hsu, E. Mazuera, K. Osberg, and J. Bosch "Gender Preferences in Web Design: Usability Testing through Eye Tracking", In *Proceedings of the 13th Americas Conference on Information Systems*, Keystone, Colorado, 2007, pp. 1-8.

[4] S. Djamasbi, T. Tullis, M. Siegel, F. Ng, D. Capozzo, and R. Groezinger "Generation Y & Web Design: Usability Testing through Eye Tracking", In *Proceedings of the Fourteenth Americas Conference on Information Systems*, Toronto, Canada, 2008, pp. 1-11.

[5] S. Djamasbi, M. Siegel, and T. Tullis "Generation Y, Web Design, and Eye Tracking", *International Journal of Human-Computer Studies*, 68, 5 (May 2010), pp. 307-323.

[6] S. Djamasbi, M. Siegel, T. Tullis, and R. Dai "Efficiency, Trust, and Visual Appeal: Usability Testing through Eye Tracking", In *Proceedings of the 43rd Hawaii International Conference on System Sciences*, 2010, pp. 1-10.

[7] S. Djamasbi, M. Siegel, and T. Tullis "Visual Hierarchy and Viewing Behavior: An Eye Tracking Study", *Lecture Notes in Computer Science*, 6761 (July 2011), pp. 331-341.

[8] P. Faraday "Visually Critiquing Web Pages", In *Proceedings of the 6th Conference on Human Factors and the Web*, Austin, Texas, 2000, pp. 1-13.

[9] P.J. Lynch and S. Horton *Web Style Guide, 3rd edition: Basic Design Principles for Creating Web Sites*. New Haven: Yale University Press, 2009.

[10] J. Nielsen "F-Shaped Pattern For Reading Web Content", *useit.com* (April 2006), http://www.useit.com/alertbox/reading_pattern.html.

[11] J. Nielsen "Usability ROI Declining, But Still Strong", *useit.com* (January 2008), http://www.useit.com/alertbox/roi.html.

[12] K. Rayner, S.P. Liversedge, S.J. White, and D. Vergilino-Perez "Reading Disappearing Text: Cognitive Control of Eye Movements", *Psychological Science*, 14, 4 (July 2003), pp. 385–388.

[13] S. Shrestha, and K. Lenz "Eye Gaze Patterns while Searching vs. Browsing a Website", *Usability News*, 9, 1 (January 2007), http://www.surl.org/usabilitynews/91/eyegaze.asp.

[14] E. Tufte *Visual Explanations*, Cheshire, Connecticut: Graphics Press, 1997.

[15] J.M. Wolfe and T.S. Horowitz "What attributes guide the deployment of visual attention and how do they do it", *Nature Reviews Neuroscience*, 5 (June 2004), pp. 495-501.