Djamasbi, S. and Hall-Phillips, A. (2014) "Visual Search," in *Eye Tracking in User Experience Design*, A. Schall and J. Romano Bergstrom (Eds.), Morgen Kaufman, 2014, pp. 27-43.

Chapter 2: Visual Search

Introduction

Paying attention to how users look for information on websites is becoming increasingly important in designing positive user experiences. Users are no longer impressed with the basic utility of a website but are now becoming more demanding for websites that have superb user experiences.

More and more research shows that paying attention to how users visually search web pages can be very helpful in designing satisfying user experiences. Eye tracking is an invaluable tool for studying how people search web pages because it allows us to "see" exactly what users look for on web pages.

In this chapter, we look at eye-tracking studies that examine how people visually search sites for information. We will discuss research that examines why and when people turn a blind eye to information that looks like advertisements. Finally, we provide a list of take away points for designing positive visual search experiences.

How do we visually search for information on web pages?

Paying attention to how users view web pages can provide a wealth of information for designing successful websites. Better yet, understanding why people inspect web pages the way they do

can help predict users' reactions to particular web page designs. For example, the theory of visual hierarchy (Faraday, 2000) helps us predict a user's fixation behavior by explaining that users search a web page through a two-phase cognitive process. During the first phase, or scanning phase, a user skims through the page to find an entry point to the page. Once an entry point is found, the user starts the second phase or inspection phase, during which the user looks around the entry point for information. Essentially, a user inspects a page by going through a chain of entry points, each of which, like an anchor, allows the user to scan for information (Figure 2.1).

Figure 2.1. A user's gaze, demonstrating scanning and inspection behavior. Yellow circles represent entry points. Green circles represent inspecting fixations around the entry point.

***CALL-OUT BOX 1 ***

Eye tracking can provide unique insight into visual search tasks. Researchers often ask participants to think out loud and describe what they're doing, but there are two potential downsides to this approach: 1), the participant can become distracted from the task, 2) the participant may not report everything that he or she sees, either as an omission or because the information is not observed at a conscious level. Eye tracking provides an objective measurement of participants' visual patterns that allows us to determine what aspects of our designs draw attention first and most.

For websites like ours, this is particularly valuable when educating a user on a complex topic, making it clear what the next step in a process is, or driving users towards a call to action. – **Tom Tullis, VP, User Experience Research, Fidelity Investments, United States**

CALL-OUT BOX 1

Both of these phases are influenced by the characteristics of the objects on the web page. Whether an object on a page can act as an effective entry point depends on a number of characteristics, such as location, size, color, text style, and type (e.g., whether it is textual or image based). By manipulating these characteristics, we can entice users to pay special attention to an object. For example, increasing the size of an object on a web page is a good way to convey to a user that this object is important and therefore encourages the user to pay attention to that object before (or more often than) other smaller objects on the same page.

The location of an object can have an impact on the order in which a user views it. Top locations typically cue importance, and top left locations are typically attended to because that is typically

where reading begins (Faraday, 2000). We are accustomed to reading from top to bottom and from left to right, so we tend to view objects on top left locations on a page before or more frequently than other objects located on the right side of the page or in lower locations.

As with the scanning phase, the inspecting phase (the second phase, which starts right after an entry point is found) is also influenced by the characteristics of the objects. The way objects are arranged on a page is an important factor in this phase. We tend to limit our visual search in this phase to the area that encloses the entry point and items that seem to be related to it. For example, we tend to perceive items around the entry point with the same background as being related.

Proximity is also important—items that are close to each other signal that they have a relationship. Eye tracking shows that fixations in this phase, which is limited to the area around an entry point, follows a left to right, top to bottom reading order for text and bulleted points. We don't use the left-right, top-bottom pattern of fixations when we are looking at images or links around the entry points (Faraday, 2001).

What does visual search look like?

When we search a web page, we can only pay attention to one object at a time. This means that our search behavior naturally creates a hierarchy or sequence. Eye tracking is a helpful tool to show this behavior.

When users look at web pages, they have a tendency to look at the top and left portions of the page (Faraday, 2000). This pattern of visual search has also been called the golden triangle or "F" shaped pattern of viewing. The frequently reported "F" shaped pattern (Buscher, Cutrell, & Morris, 2009; Nielsen, 2006) tells us that when we scan a website, we tend to miss some very important information that is placed on the right portion of the page (Figure 2.2).

Users are also less likely to look at information that is "below the fold" of a web page, which requires scrolling. Eye-tracking research shows that fixations on a web page decrease as users scroll down a page (for further reading see Djamasbi, Siegel, Skorinko, & Tullis, 2011a; Djamasbi, Siegel, & Tullis, 2010; Granka, Joachims, & Gay, 2004; Shrestha & Owens, 2008).

Figure 2.2. An example of a user's typical viewing sequence when searching a website (Djamasbi, Siegel, & Tullis, 2011b).

However, favoring the top rather than the bottom of the page seems to be more pronounced in younger users. For example, in one study, when comparing the fixation behavior of professional employees of a company, Generation Y participants (ages 18-34) paid far less attention to areas below the fold, compared to their Baby Boomer colleagues (ages 47-65) (Djamasbi et al., 2011a). In that same study, cluttered pages were less appealing to both generations, but the younger users had significantly less tolerance for clutter (Figure 2.3). Clutter often results in a "flat" visual design, where there seems to be little or no difference in relative importance of objects on a page. Clutter makes it harder for users to find entry points on a page. The viewing behavior of the two generations was quite similar for pages that were not cluttered. The uncluttered pages enticed both generations to view them thoroughly (Figure 2.4).

Figure 2.3. Heat maps comparing younger and older participants' viewing pattern for a cluttered page (Djamasbi et al., 2011a). Younger participants (left) exhibited far less patience when they explored a cluttered webpage, compared to older participants (right) who examined the same page more carefully. On these pages, the areas covered by fixations (colored areas on the heat maps) were significantly smaller for younger participants than older participants. Fewer areas on the page received intense fixations (red areas on the heat map) by younger participants compare to older participants.

Figure 2.4. Heat maps comparing younger (left) and older (right) participants' viewing pattern for an uncluttered page. Both generations exhibited a similar pattern of viewing on pages that were not cluttered.

The tendency of users to favor only a portion of the page coupled with the fact that web pages have limited screen real estate makes it quite challenging to design an effective communication experience. A good design encourages users to look at the entire page, not just the top left portion that they typically favor. This means that as user experience designers, we have to find out what type of design could possibly change the natural viewing bias of users. For example, would the natural viewing bias change if a website uses an image-based design rather than a text-based design? What about the arrangement of textual information—would it change the way we search for information on a webpage?

*** CALL-OUT BOX 2***

Eye tracking makes the invisible visible. We often employ eye tracking when we observe an unexpected behavior using a different methodology, such as a quantitative online study. Eye tracking is one way we can understand what is actually happening in those instances.
With eye tracking, we've found that the subtlest design modifications can drive large differences in user behavior. Seemingly small changes such as background color, placement, and labeling can drive large differences in users' scan patterns. Ultimately, this can be the tipping point between a successful call to action and a failure. - Marisa Siegel, Principal User Researcher, User Experience Research, Fidelity Investments, United States

The answer to both questions is yes. Research shows that when we search image-based pages, our "F" shaped pattern of viewing is no longer apparent, although we still favor above the fold (Shrestha & Lenz, 2007). Also, when textual information is arranged in two columns, we change our search behavior. While we still favor above the fold, we tend to look at the right side and the bottom of the page more when text is displayed in two columns rather than in one column. Basically, users search web pages more thoroughly when the textual information on the page is arranged in various distinct sections and placed in multiple columns, as shown in Figure 2.5 (Djamasbi, Siegel, & Tullis, 2011c).

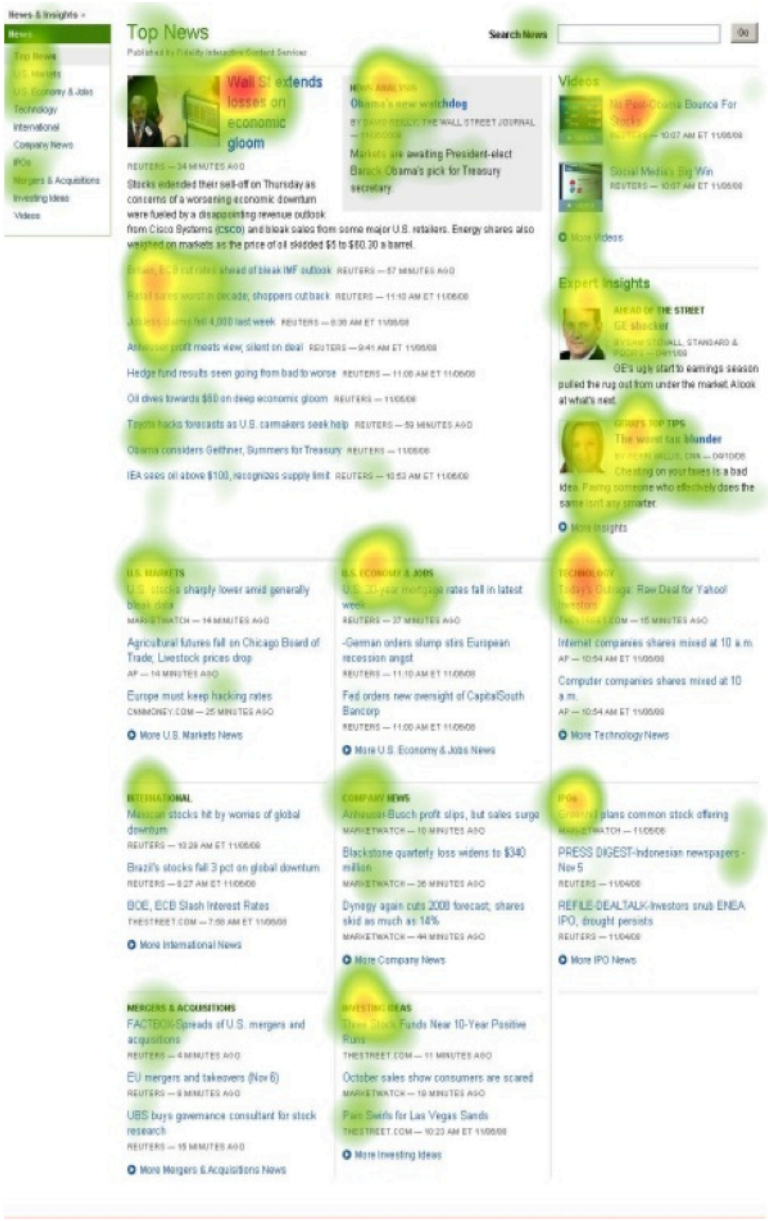


Figure 2.5. Example of dispersed viewing pattern (Djamasbi et al., 2011c). The dispersed pattern of fixations spanning the entire page shows that users inspected the page thoroughly, even below the fold, looking almost at every link and title on the page. Links and titles are particularly important in effective visual communication because they summarize key textual information.

Are there different types of visual search?

Visual search is a combination of two different types of behavior: goal-directed and exploratory search behavior, each using a different part of our brain. In goal-directed search, we actively

search for information following a specific strategy or plan. In exploratory search, we just monitor the environment, and we usually don't have a search plan in mind. Exploratory search is our default behavior because whenever we are not actively involved in looking up information, our visual system keeps screening the environment (Janiszewski, 1998; Posner & Petersen, 1990).

In both types of visual search behavior, our fixations are influenced by how objects are laid out on a web page. Objects on a web page compete with each other to win our attention. The intensity of this competition can be numerically calculated as a function of the number of objects on the viewable screen, their size, and their proximity to each other. The competition for attention theory (Janiszewski, 1998) tells us that the race for attention between the objects in our field of view affects how we screen the environment (exploratory search) and how we actively search for a piece of information (goal-directed search). Therefore, when we examine search behavior we should carefully look at how objects compete for attention (Janiszewski, 1998).

Let's look at this competition in practice. Consider a retail shopping website. Some sites display their products in a list format, while others display their products in a matrix format. Displaying products in a list format creates a more competitive environment for attracting user attention than displaying products in a matrix format (Hong, Thong, & Tam, 2005). This suggests that visual search behavior on search engine results pages (SERPs), which typically have a list format, is influenced by a visually demanding environment.

Visual search behavior of search engine results pages (SERPs)

Visual search behavior of search engine results pages (SERPs) is becoming increasingly important as more and more users use search engines daily. Among the top four search engines (Google, Yahoo!, Bing, and Ask Network), Google is by far the most popular and has the largest growth (Figure 2.6).

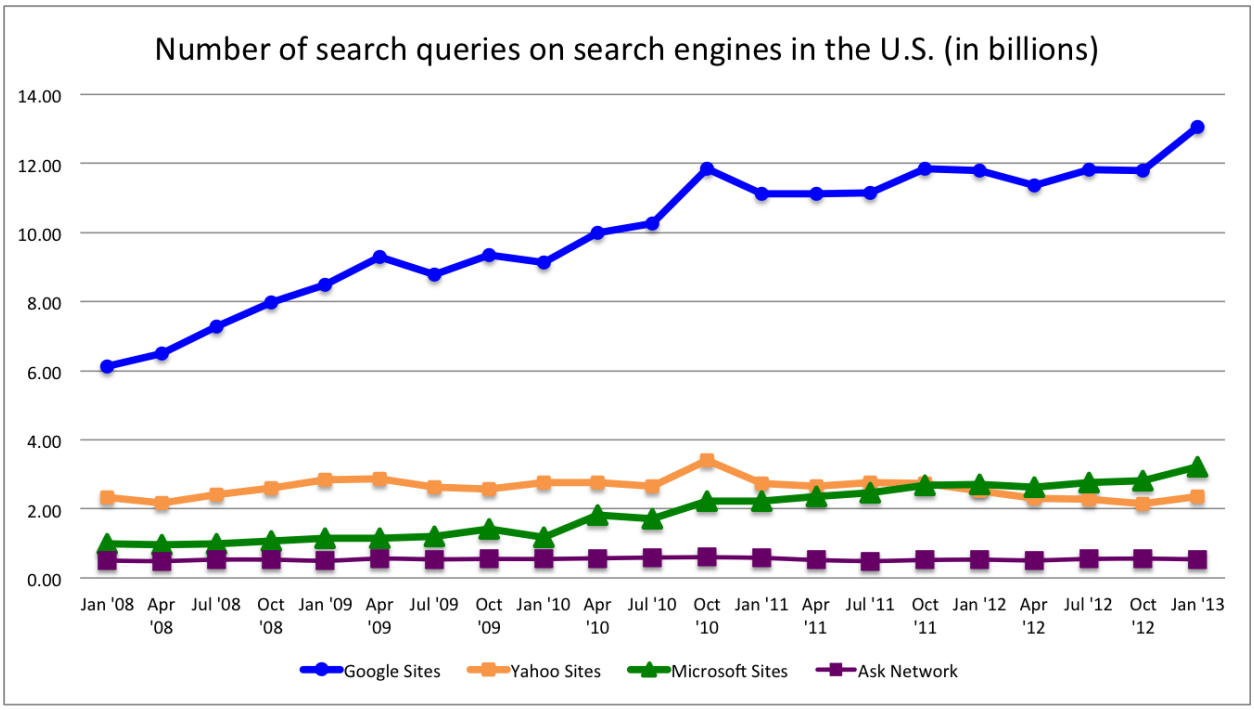
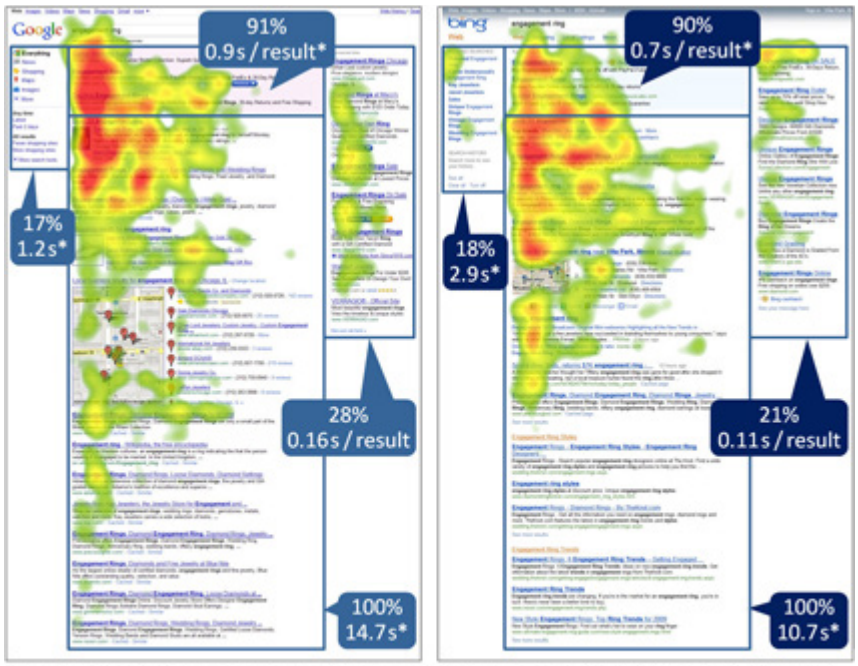


Figure 2.6. Search query frequency: Top 4 search engines (U.S.) (Jan 2008-Jan 2013) (comScore, 2013)

Eye-tracking data had demonstrated that people look at Google SERPs longer than they look at Bing SERPs (Figure 2.7, UserCentric, 2011). Longer fixations do not necessarily mean that a web page has a more engaging experience; it may also mean that users are confused or they cannot locate what they are looking for quickly. While eye tracking is a valuable tool for revealing attention, sometimes the eye-tracking data by itself may not be sufficient in helping to determine the cause of a behavior.



Heatmaps showing the aggregate gaze time of all 24 participants on Google (left) and Bing (right) for one of the transactional tasks. The red color indicates areas that received the most total gaze time (4.5 seconds and above). Each callout includes the percentage of participants who looked at the area and the time (in seconds) they spent looking there. The numerical data are an average across all four tasks. Asterisks indicate values that were significantly different between Google and Bing at alpha = .1.

Figure 2.7. Google vs. Bing: A heat map example of attention in gaze time (UserCentric, 2011). Users look at the Google search results longer than the Bing results.

Using the competition for attention point of view, a recent eye-tracking study (N=11) examined search behavior on Google SERPs. Results confirmed the competition for attention theory: areas other than the search results section, which was the focus of the task in the study, also received attention (Djamasbi, Hall-Phillips, & Yang, 2013a). Within the search results area, the competition for attention was among the top five entries as the attention on the rest of the entries was negligible. This schematic is shown in Figure 2.8. This is consistent with what we learned from the theory of visual hierarchy, which tells us that top locations attract more attention than lower locations.

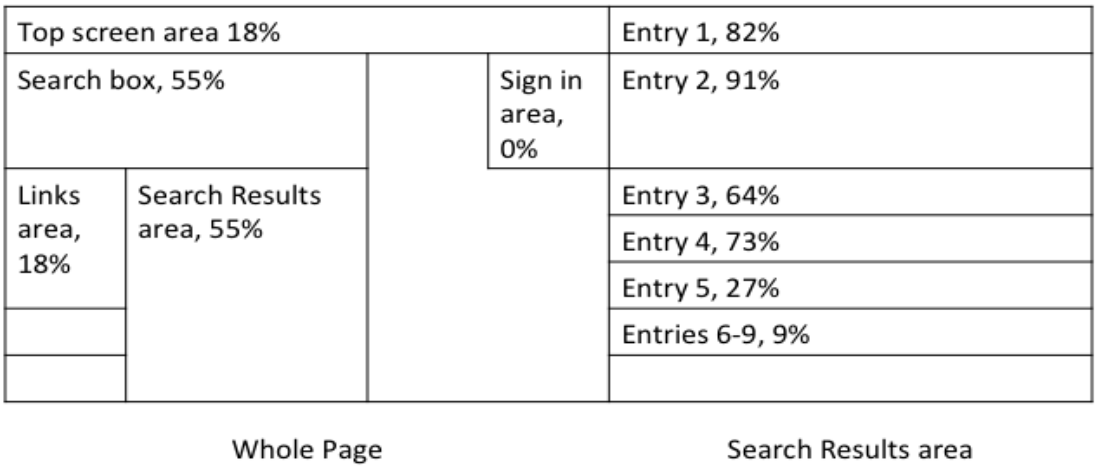


Figure 2.8. Percentage of viewers for SERP objects (Djamasbi et al., 2013a). While all participants attended to the search results area, 55% of users also looked at the search box area, and 18% of users looked at the links and top screen areas (left panel). In the right panel, Entry 5, which was lowest on the top five entry list, attracted the least number of viewers, and the top two entries attracted the most number of viewers.

Can images of faces impact our search behavior more than other types of images?

When it comes to competing for attention, a recent study showed that images of faces may be more effective than other types of images in attracting our gaze. For this reason, including faces on web pages may not always be helpful for users searching for information (Djamasbi, Siegel, & Tullis, 2012b). Grounded in neuro- and evolutionary psychology, paying attention to faces has played a significant role in human evolution thus; we are naturally drawn to faces. Using the theory of visual hierarchy and competition for attention theory a group of researchers speculated that this natural tendency to look at faces, while useful in attracting attention, might also have the unintended consequence of diverting us from the task at hand. Eye-tracking results demonstrate that faces indeed divert attention from textual information adjacent to faces. Faces, compared to

non-face images, tend to attract more fixations. Textual information, particularly titles, tend to receive less intense fixations when placed next to faces (Figure 2.9).

*** CALL-OUT BOX 3***

A distinct part of our brain is dedicated for processing the visual characteristics of faces. We are able to distinguish between faces as early as two months after birth. This ability is crucial in survival of infants who need to distinguish their mothers from other individuals. Faces are also invaluable sources of information for social communication. For example, people with Asperger's syndrome, often have trouble understanding subtle non-verbal communication because they tend not to look at faces and when they do look at faces, they often have trouble interpreting subtle facial expressions.

The effect of faces on performance is more complex. When faces are above the fold, they affect performance negatively; it takes people significantly longer to locate desired information that is placed next to faces. When faces are below the fold, however, performance improves. This behavior suggests that the location of faces is an important factor in their impact on the level of attention they demand (Djamasbi, Siegel, & Tullis, 2012b).

Figure 2.9. Heat maps shows that faces (left panel) diverted attention from the textual information while logos didn't have a similar effect (right panel) (Djamasbi et al., 2012b).

What is banner blindness, and why is it important?

We exhibit banner blindness when we intentionally attempt to avoid looking at advertisements on a web page. This is even true when we are presented with advertisements that are placed on top of the page, with images, and it can sometimes be triggered by fancy formatting (Nielsen, 2007). Banner blindness presents UX designers with a tricky challenge. As you may remember from an earlier discussion in this chapter, the very design elements that can help users find entry points to a webpage (e.g., images, formatting) can also cue users to ignore a message.

Banner blindness has a significant impact on the return on investment (ROI) of companies that count on online search traffic for reaching consumers. Online search provides a lucrative venue for marketers. In 2012, 76% of the $36.6 billion of Internet advertising revenues was generated from advertisements in search, webpage banners, and mobile ads (IAB, 2013). Unfortunately for marketers, despite this push in revenues, up 15% from 2011, consumers are still skipping ads.

Banner blindness can effectively be detected by tracking where people look as they interact with websites and search results. For example, banner blindness was detected in an eye-tracking study that examined differences in viewing behavior between males and females (Djamasbi, Tullis, Hsu, Mazuera, Osberg, & Bosch, 2007). As shown in Figure 2.10, there was a small window on the web page that assisted with navigation (a "bricklet"). While no differences in viewing behavior were found between genders, the bricklet with the simplest design (i.e., lacking pictures and color) grabbed the most attention of both men and women. This behavior was attributed to the banner blindness—the more complex design caused users intentionally to ignore it. Even though the web pages were designed to have advertisement-free content, and bricklets were obviously not ads. The graphics and background color made the bricklets stand out. This likely gave users the impression that bricklets were ads, and therefore they paid less attention to them.

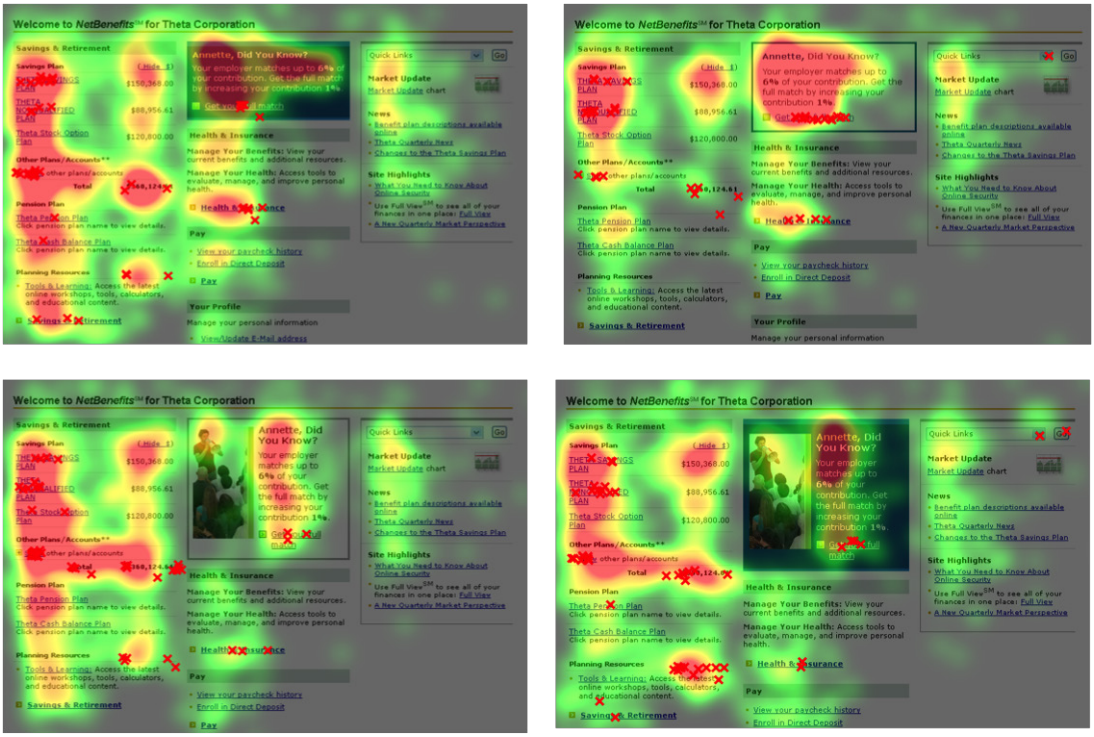


Figure 2.10. The bricklet with the light background color and no image received the most attention and clicks (top right panel). The "red x" denotes a click. This "banner blindness" is particularly noticeable for the bricklets in the two bottom panels, which have images. Of the four designs, the bricklets with images received the least amount of attention (Djamasbi et al., 2011b).

Another study showed that the contrasting background color of bricklets had a significant impact on how quickly they were noticed (Djamasbi, Siegel, & Tullis, 2012a). Bricklets with a contrasting background color, even when the contrast followed the color style of the page, caused participants to have a slower reaction time (Figure 2.11). The contrasting color makes a bricklet more salient or more "ad-like." The result is that they become a low priority in users' eyes.

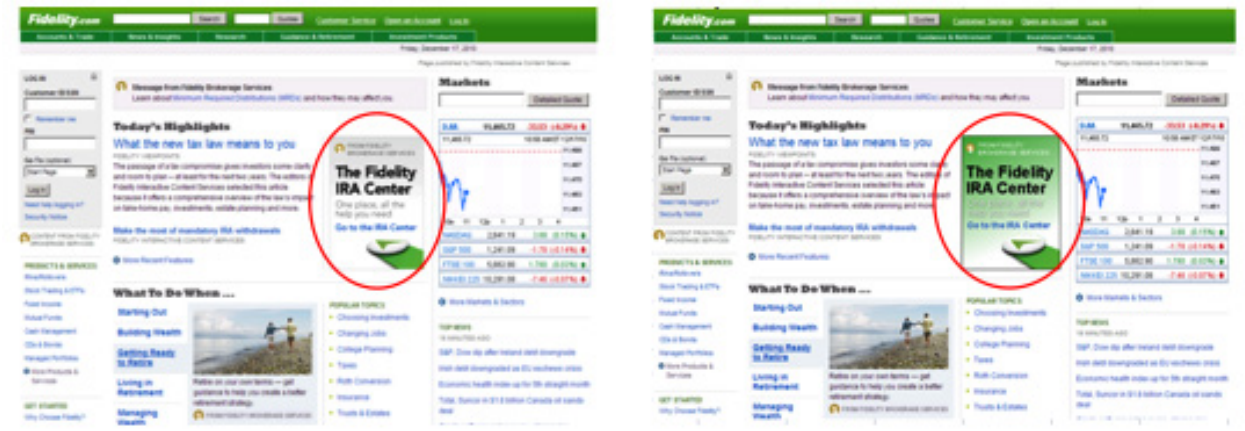


Figure 2.11. The time to first fixation on the right bricklet (circled) was significantly longer than the time to first fixation on the left bricklet (circled), which lacked contrast (Djamasbi, Siegel, & Tullis, 2012a).

When considering advertisements on a webpage, it is wise to remember that not just graphic-based ads can cause banner blindness—people are also blind to textual ads. Users pay less attention to text in ads compared to text in editorial content on a web page (Hervet, Guérard, Tremblay, & Chtourou, 2011). Users also tend to avoid text banners on the right side of the web page more than they avoid text banners at the top of the page (Owens & Chaparro, 2011). This behavior suggests that ads do not change our natural tendency to favor the top and left locations on a web page. As we learned earlier from the theory of visual hierarchy, people tend to view top locations on a page and somewhat ignore the information that is on the right side of the page.

Figure 2.12. Textual ad (left panel) and graphical ad (right panel).

Banner blindness is particularly important on SERPs, which are often used by companies and marketers to reach consumers; however, banner blindness may not be as pronounced on SERPs particularly on mobile devices (Djamasbi, Hall-Phillips, & Yang, 2013b). For example, a recent eye tracking study shows that majority of users pay attention to ads both on desktop and mobile SERPs with mobile ads receiving relatively more attention than desktop ads. More mobile users, compared to desktop user, view SERP ads. Mobile users also tend to spend a greater portion of their total viewing time looking at ads (Figure 2.13). While this is good news for marketing on SERPs particularly on mobile phones, more research is needed to find out the factors that can increase or decrease the visibility of ads on SERPs (Djamasbi et al., 2013b).

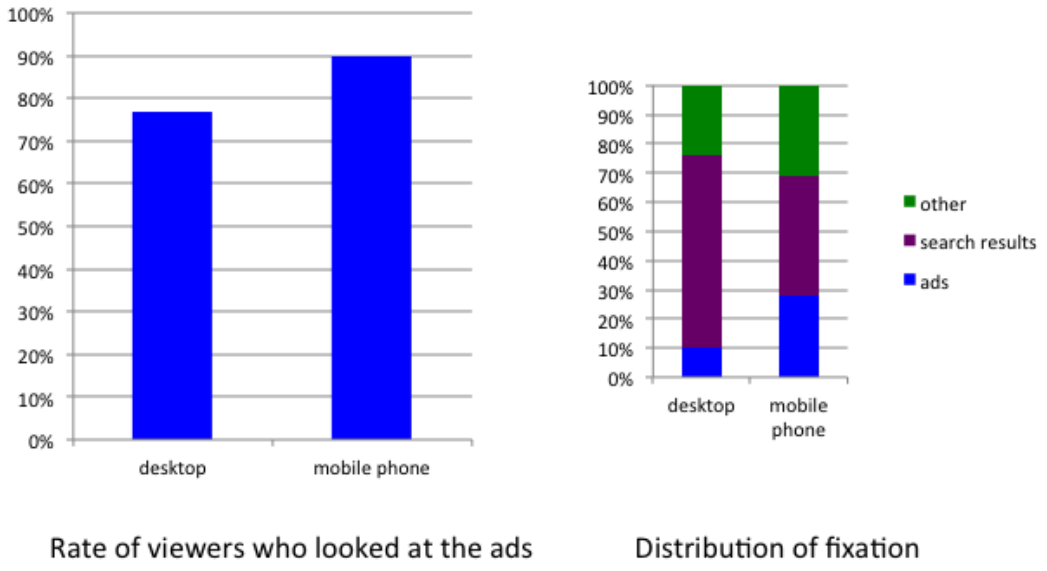


Figure 2.13. Ad attention on SERPs on desktop vs. mobile phone. 77% of desktop users and 90% of mobile users looked at ads on SERPs. On a desktop computer, SERP ads attracted 10% of total attention (total fixation on the screen). On a mobile phone, attention to SERP ads increased to 28% of total attention (Djamasbi et al., 2013b).

The road ahead for designing visual search experiences

The bottom line – designing positive search experiences matters. Creating pleasant and effective search experiences will continue to be a major topic in user experience design. Our on-the-go lifestyle will increase our need to use mobile devices to search for information. The upward trend in mobile device usage (Figure 2.14) puts a great emphasis on the importance of designing successful mobile search experiences. This in turn impacts what we expect from websites and how we search them. Eye tracking will continue to be a great tool for understanding a user's search experience whether they are searching on a desktop or on a mobile device.

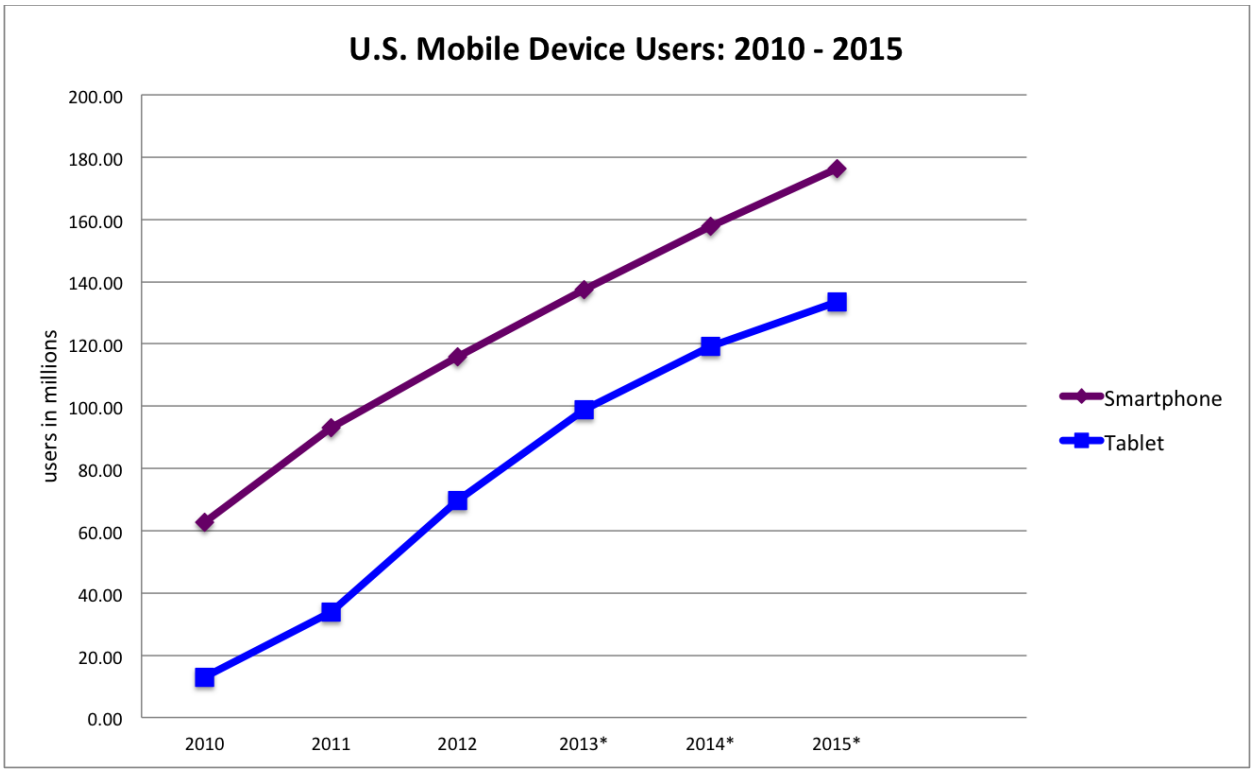


Figure 2.14. Mobile device users in the U.S. from 2010-2015;* *denotes forecasted values* (eMarketer, 2012, 2013).

CALL-OUT BOX 4

Visual design used to be purely about the emotion you got from something. You try to put your best foot forward and make an educated guess about how people would search your website. With eye tracking, now we can put more science behind it. – Dan McAuliffe, User Experience Manager, Dyn Inc., United States

Visual design has a significant impact on visual search behavior. It affects how effectively a web page communicates with its intended audience, and eye tracking is a valuable tool for assessing a user's search behavior. Some key things to remember about search:

- User experience testing is a crucial part of designing positive search experiences. Eye tracking can aid in testing the effectiveness of visual communication and a user's visual search behavior.
- Banner blindness can easily and clearly be detected by eye-tracking heat maps or by the amount of time it takes a user to notice an ad on a page.
- Testing for banner blindness is important because the very design elements that prove to be effective in attracting attention can backfire and make a design look like an ad. Even subtle contrasting colors can cue banner blindness.
- A good visual design encourages users to inspect a page thoroughly. This can be detected by fixations that are dispersed throughout the page covering important information.
- On heat maps, look for fixations on titles and links; they suggest effective visual communication.
- Be careful when using faces on web pages. Faces can be effective in drawing attention; however at times, they can be distracting and divert fixations from key information.
- Pages with a clear visual hierarchy provide a pleasant search experience because they help users find entry points to the page easily. Note the emphasis here is on "clear visual hierarchy." A page where everything in it stands out is "hierarchically flat."

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