Search Results Pages and Competition for Attention Theory: An Exploratory Eye-Tracking Study

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Abstract. The World Wide Web plays a central role in many aspects of our modern life. In particular, using search engines to access information about products and services has become an integral part of our day-to-day activities. In this study we look at users' viewing behavior on search engine results pages (SERPs) through the lens of competition for attention theory. While this theory has been used for examining consumer behavior on e-commerce websites, little work has been done to test this theory for viewing behavior on SERPs. We use eye tracking data to analyze viewing behavior. The results show that viewing behavior can have an impact on a user experience and effective search, providing theoretical direction for studying the viewing behavior of SERPs.

Keywords: Eye Tracking, Search Engine Result Pages (SERPs), Viewing Behavior, Fixation, Competition for Attention.

1 Introduction

Visual search can be grouped into two categories: 1) goal-directed search involving decisions about where to find desired information and 2) exploratory search involving decisions about how to visually explore an environment [8]. Goal-directed search models assert that salience and/or relevance of stimuli drive a person's search behavior, while exploratory search models suggest that search behavior is influenced by competition among stimuli that attracts a person's attention. Information search behavior is often a combination of both types of visual search activities [6]. In fact, exploratory search behavior can often provide a more complete understanding of goal-directed search behavior, and thus, even in situations where users are looking for specific information, it is important to consider the effect of exploratory search, in addition to goal-directed search, on their behavior [8]. When searching for information online, a goal-directed search or an exploratory search involves the use of several types of objects in the visual field, including text, photos, moving objects, and varying instances of color. We know from previous studies (i.e. [1, 3]) that the size and proximity to the point of focus of an object can affect visual acuity, giving way to a type of competition for the user's attention.

In this study we examine the influence of exploratory search behavior on users' reaction to search engine result pages (SERPs). Therefore, we examine users' viewing

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behavior through the lens of competition for attention theory. According to this theory items in our visual field compete for our attention. Naturally, those items in the visual field that face less competition are likely to receive a greater deal of attention compared to those that face higher levels of competition in one's field of vision. While the competition for attention theory was used to examine users' reactions to shopping tasks on e-commerce web sites[7] little work has been done to examine users' viewing behavior on SERPs using this theory. Thus, in this study we examine whether competition for attention theory can help predict users' viewing behavior on SERPs.

To test users' reactions to SERPs from the competition for attention point of view, we conducted an exploratory eye tracking study. First, using the competition for attention theory, we determined a score for each area that contains information on the SERPs used in our study. These scores represented the level of competition faced by their corresponding areas. Next, we determined the amount of attention received by each area by examining the number of users who viewed these areas as well as the amount of time the areas were fixated upon by users. In this study, we examine viewing behavior during the time period between the appearance of the search results on the screen to the time users take their first action, that is, either scrolling or clicking on a link. Competition for attention theory pertains to a set of objects that are present in one's visual field. To examine competition for attention among a set of objects on the screen, it was necessary to select a time period where all of the items in the set were present in users' visual field.

2 Background

According to the competition for attention theory [8], each item on a page competes for user attention. The amount of competition experienced by each item can be represented as a numerical value or a competition for attention (CFA) score, which is determined by the size and the distance of surrounding objects. The higher the CFA value for an item, the higher the competition the item experiences. Using simple objects on PowerPoint slides, Janiszewski [8] has shown that items with lower CFA scores receive longer fixations. This is because items with lower CFA scores have fewer items around them to compete with them for attention [8].

This theory has also been used in the context of web pages. Hong et al. [7] used this theory to examine the impact of information layout of retail websites on user performance of a shopping task. They posited that competition for attention is higher when items are arranged in a list format. This finding has important implications for SERPs because search results are typically displayed in a list format. While the predictions of competition for attention theory can have a significant impact on the viewing behavior of SERPs, little work has been done to examine SERPs using this point of view. For this reason, we conduct an exploratory eye tracking study to examine users' viewing behavior on a SERP.

3 Methods

To collect users' eye movements, we used the Tobii X120 eye tracker, with a sampling rate of 120Hz. The eye tracker was placed in front of a 24-inch monitor with a resolution of 1920 x 1200.

3.1 Task

The task required users to carry out a web-based search using Google on a desktop computer. Participants were told to look for a snack place in Boston that they would like to visit with their friends. They were instructed to enter a specific phrase in the search box, namely, "best snack in Boston." The participants used the actual real-time Google search engine website to perform the task. Hence, the returned search results were not altered in any way. This allowed for an organic user-experience environment.

3.2 Participants

Data from a total of 11 participants was used in this study. Participants were from a pool of undergraduate students in a major university in the Northeast. They ranged in age from 18 – 24 and they self-reported to be "expert" users of Google search engine. Participants also self-reported to use Google search engine on a daily or hourly basis.

3.3 Measurements

Competition for Attention Score. As in prior research (i.e. [8]), for each area of the page that contained information, a CFA score was calculated. On SERPs used in our study, there were five main areas that contained information: 1) the area located on top of the screen, 2) the area where the search box was located, 3) the area where the links were located, 4) the area where search results were located, and 5) and the sign in area (Figure 1). To account for the use of organic searches; CFA scores were calculated for each of the areas on each page viewed by the participants.

Shift in Attention Score. When users are engaged in a goal-directed search their attention would shift more easily when it is easy for them to identify the next area to attend [8]. This situation can be represented by the shift of attention (SA) score, which is determined for each item by calculating the ratio of strongest to second strongest non-focal CFA of the item [8]. We calculated the shift of attention (SA) score for each item on the SERPs.

Attention. We used fixation to measure users' attention to an area of interest (AOI). While a user's field of vision typically consists of an array of objects one can attend to only one of the objects at a given moment [2, 5]. A user's eyes scan the visual field with rapid and continuous movements to collect information, which can happen

during the period of time that one fixates on an item or holds a steady gaze on that item [9-11]. In addition, reading text requires steady gazes that are about 60 ms long [10]and SERPs are mainly comprised of text, therefore for this study we examined fixations that were 60 ms or longer. As in prior studies (e.g., [3]) we used fixation duration on and the proportion of viewers of the AOIs as measures of attention. Additionally, we calculated a new metric, fixation score, by multiplying viewer's rate and fixation duration. This new metric allows us to determine a composite score for an AOI by combining two important indicators of attention.

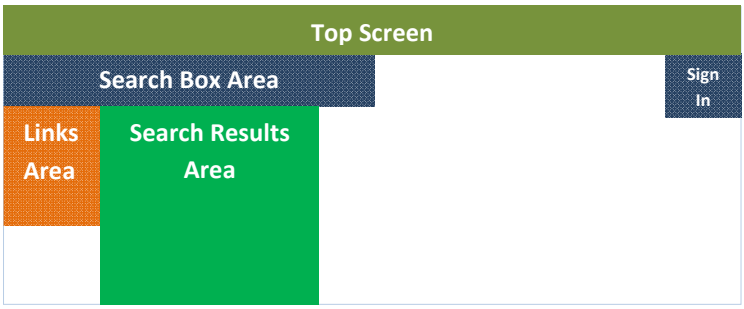

Fig. 1. Areas with information on the SERPs used in the study

4 Results

We calculated the CFA scores for the areas that contained information on the SERPs used in our study (Figure 1). Since organic search results were used in this study, a CFA score for each of the five areas of interest was calculated, for each page viewed, and for each user. The one-way ANOVA test showed that the average CFA scores for the five areas of interest were significantly different ($F(4,50)$= 215295, p=0.000) (see Table 1 for descriptive statistics).

Table 1. Descriptive Statistics for CFA scores for each AOI: Mean (SD)

Top Screen	Search Box	Links Area	Sign In Area	Search Results
2.10 (0.01)	2.59 (0.01)	2.39 (0.01)	2.88 (0.01)	0.71 (0.00)

Figure 2 displays the ranking based on the calculated CFA scores for each of the five areas of interest. As shown in the Figure 2, the Search Results Area faces the lowest level of competition, then the Top Screen, then the Links Area, then the Search Box Area, and finally the Sign In Area. Because the Search Results Area had a much lower CFA score compared to other areas, we ran another ANOVA without the Search Results Area. The results showed that the CFA scores for Top Screen, Search Box Area, Links Area, and Sign In Area were also significantly different ($F(3,40)$=26310, p=0.000).

While users' attention during search on SERPs is naturally directed toward the search results, it is likely that their attention is also diverted to other areas on the page that compete for their attention. To test this possibility we looked at number of people who viewed the five areas outlined in Figure 2. Note that the following results refer to viewing behavior right after the search results were displayed on the screen. As expected, our analysis showed that 100% of users viewed the Search Results area as the task required them to do so. However, users also visited the Search Box Area, the Link Area, and the Top Screen Area. These areas were visited by 55%, 18%, and 18% of users respectively. The Sign In area, which had the highest CFA score, was not visited by any of the users (Figure 3). The Chi-square test comparing the proportion of people viewing the Search Results, Top Screen, and Search Box and Links areas (the four areas that were viewed by users) was significantly different (X^2 = 19.95, p = 0.000). The above results support the competition for attention theory by showing that the attention of a good proportion of users was diverted to non-search results areas.

Our calculation shows that the shift in attention (SA) scores was largest for Search Box Area (1.21) and smallest for Sign In Area (1.08); for the rest of the areas this ratio was the same (1.11). These ratios indicate that the shift in attention would be easiest when participants are looking at the Search Box Area. This, in turn suggests that fixation duration will be shorter on the Search Box Area compared to other areas [8]. Contrary to our expectation, The Search Box Area did not receive the least amount of fixation compare to other areas of interest (Figure 2). An ANOVA comparing fixation duration between the above mentioned areas showed that these areas did not differ significantly in regard to amount of fixation they received (*F(3,40)*=2.35, p=0.09). These results suggest that differences in SA scores among Search Box, Top Screen, Links, and Sign In areas may have not been large enough to facilitate an easier shift of attention from the Search Box Area to the other areas.

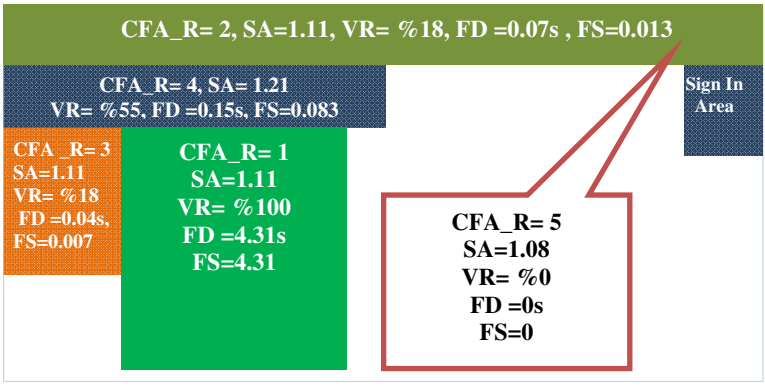

Fig. 2. Statistics for areas of interest. CFA_R: CFA ranking, SA: shift in attention, VR: viewer's rate, FD: fixation duration, FS: fixation score

Next, we looked at viewing behavior in the Search Results Area only. Just as before, we calculated the CFA scores for each entry in the Search Results area. The one-way ANOVA showed that the average CFA scores for entries 1 to 9 were significantly different ($F(8,81)$=461, p=0.000). The CFA scores for entries 2 to 6 were quite similar, indicating that these entries face similar amounts of competition. Entries 1 and 7 also had similar CFA values. Entry 9 had the lowest CFA value. We also calculated the SA ratios for each entry. Our calculation shows that the ratios for all entries had the same value (1.00) except entry 4 which had a slightly higher value (1.01).

For exploratory search behavior, according to competition for attention theory, the above CFA scores indicate that middle entries are likely to receive the smallest amount of attention. For goal-directed search behavior, SA scores suggest that middle entries, particularly Entry 4 should receive shorter fixations than others because these locations facilitate an easier shift to other locations.

The analysis of fixation duration showed that the amount of fixations on the 9 entries was significantly different ($F(8,81)$=5.38, p=0.000), with the top two entries receiving the most fixation. As shown in Table2, fixation duration was minimal below the fifth entry. Therefore, these results do not support the predictions of competition for attention theory. A Chi-square test showed that the proportion of people that viewed the entries was significantly different (X^2 = 47.20, p = 0.000). Most users looked at the top 4 entries, with the second entry having the most viewers. Fixation scores also reflect that the top 4 entries received the most attention.

Table 2. Statistics for Search Results

AOI	CFA mean (SD)	CFA Rank	%viewers	Fixation Duration(s)	Fixation Score
Entry 1	11.16 (0.50)	3	82%	1.39	1.140
Entry 2	12.31 (0.25)	6	91%	1.15	1.047
Entry 3	12.66 (0.14)	8	64%	0.66	0.422
Entry 4	12.70 (0.14)	9	73%	0.75	0.548
Entry 5	12.53 (0.12)	7	27%	0.42	0.113
Entry 6	12.16 (0.11)	5	9%	0.01	0.001
Entry 7	11.54 (0.10)	4	9%	0.04	0.004
Entry 8	10.49 (0.09)	2	9%	0.01	0.001
Entry 9	8.19 (0.08)	1	9%	0.02	0.002

5 Discussion

We conducted an exploratory study to test whether competition for attention theory can explain users' viewing behavior on SERPs. This theory has been used to examine search behavior for shopping tasks on e-commerce websites [7]; however, to our knowledge this theory has not been used to study search behavior for SERPs. Our analysis supported the predictions of the theory at the page level, showing that despite the goal-directed nature of the task used in our study, some of the users' attention was diverted to non-focal areas on the page. Within the Search Results Area however, competition for attention had little effect on how the entries were viewed. Users exhibited a top-to-bottom pattern of viewing; paying the most attention to the top two entries.

These results have important implications for theory and practice. From a theoretical point of view, the results show that the competition for attention theory can be extended to SERPs at the page level. That is, even in highly goal-directed search tasks, such as the one used in our study, attention can be diverted to non-focal areas. However, the viewing behavior within the Search Results Area was not explained by the amount of competition faced by the individual entries. One possible explanation is that the entries of the search results were displayed in a simple textual list format. According to the theory of visual hierarchy [5], this type of top-down display of information creates a clear hierarchy favoring the top entries by signaling that these entries are more important than others.

From a practical point of view, the results show that even in goal-directed searches attention can be diverted to non-focal areas. This is good news for advertisers, providing support for placing advertisements in non-traditional spaces (i.e. banners at the top or on the right-hand side). The diverted attention of a user also maintains the potential for motivating a user to click on an ad for revenue generation. For designers, the results suggest that making the non-focal areas of the page less salient may help users utilize the search results more effectively.

6 Limitations and Future Research

As with any experiment our study is limited to its setting. Nevertheless, the laboratory environment allowed us to capture users' eye movements. As customary in eye tracking studies, we had a small sample size [4] . Future studies are needed to replicate our non-significant results with a larger sample size. The participants in our study were drawn from a pool of college students. Previous studies suggest that generation may have an impact on how we view web pages [2]. Thus, future studies including other generations are needed to increase the confidence in generalizability of our results.

7 Contribution

Our results show that despite the goal-directed nature of search on SERPs, users' fixation can be diverted to non-focal areas of the page. This viewing behavior can

potentially have an impact on effective search and thus user experience of SERPs. Our study provides a theoretical direction for studying the viewing behavior of SERPs, which can assist with improving the design of such pages.

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