An Analysis Study on How Female College Students View the Web Search Results Using Eye Tracking Methodology

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Abstract - The paper presents an eye tracking analysis study to explore the viewing and searching behavior of young Arab female users while interacting with the web search engine results page (SERP) as well as factors that influence their behaviour. The study focuses on the users' reading patterns on the first seven organic hits (abstracts) to make their first selection (click). An Eye tracking experiment was designed and conducted using the most popular search engine "Google" to collect an eye tracking data on users. A group of college students at Zayed University were used as subjects. The participants' reading patterns and interaction with the list of search results have been recorded, collected and analyzed. The finding from the study indicates that on average students' stayed longer scanning results, followed horizontal search patterns, paid most of their visual attention to the top ranked results, and did not read results in sequential order but often followed mixture of searching strategies. Popular Search engines can benefit from the findings of this study to display search results appropriately and according to the users' profile, needs and expectations.

Keywords: Information visualization, Usability and eye tracking method, Search engines.

1. Introduction

The Internet has changed the way people live, work, communicate, shop and study. Social networks and search engines are the most popular and growing services available on the Internet. Nowadays online Social networks are getting extensive among internet users, especially college students. People are using social networks for different purposes like sharing information, chatting with friends, connect family members, share photos, and planning for group events. Social networking sites have quickly become one of the most popular means of online marketing and communication.

The main aim of this research work is to examine and explore the common patterns of information seeking visual behaviors of young Arab female users while viewing SERP. The research will use a new innovative eye tracking technology and methodology to track and monitor the users' eye movements on the results page. A complete usability study on SERPs using students as subjects was planned, designed, conducted and analysed. The research methodology uses both quantitative and qualitative approach. Eye tracking data and feedback on user behavior and experience using performance measures will be collected and analysed from the study. It is expected the research outcomes would help researchers gain a good understanding of how ZU students scan, read, evaluate and interact with the list of search ranked results and how their visual and clicking behavior relates to cognitive activities for decision making judgments.

The study will also identify a set of parameters that influence the viewing behaviour of the students. It will help determine the factors that influence how students' gaze on different parts on a SERP during the search session. Do users look at the same components of a search result page for different types of

queries? We are hoping, the findings from this study will help web search engines to present search results according to the needs, interests and expectations of users' with diverse culture, age group and background.

In this paper, the researcher conducted, analyzed and described an experiment that employs eye tracking methodology to help us understand how Arab female students use web search results page to find information related to specific informational tasks and whether their search strategies for scanning results are different based on topics or domains. It is expected to discover some variations and differences in the students' reading patterns, number of search results views, dwell time to evaluate the results page before the mouse is clicked, and their performance in answering query-based questions.

This study aims to explore the following key research questions:

- How students interact visually with SERP?
- Do students follow a sequential top-bottom, bottom-up or a mixture of scanning strategies to evaluate a listing of SERP?
- How many abstracts (snippets) in the listing of search results have been scanned by the students before they take the next action?
- What do students look for in a search engine result page?
- What factors influence how students gaze different areas on a SERP during search task?

The paper is organized as follows. First section discusses the eye tracking methodology and its use in information seeking behavior and web user interface. Then next section discusses the research questions, methodology as well as eye tracking experiment design. The subsequent section presents the results, data analysis and discussions. The last section contains the conclusion which includes a summary, implications and importance of the study, limitations and suggestions for future research

2. Related Work

Understanding how users search for information on the Internet/web has enormous practical implications for both commercial and academic purposes (Cutrell E., Guan Z., 2007). Search engines are considered the main entrance gate to the web because it allows finding pages of interest according to queries. Before commercialization of Google, it started as a research project at Stanford University. Google search was developed by Larry Page and Sergey Brin in 1997. According to recent WIXI analytics, Google has been listed as one of the top most visited websites beside Tweeter, face book, you tube in UAE. Google search is considered the most-used search engine on the web. Every day, it receives millions or queries through its various services. The four major components of a typical single search result includes, title, snippet, URL, and sometimes image/multimedia components. Figure 1 shows all the phases that Google uses to process a single search query.
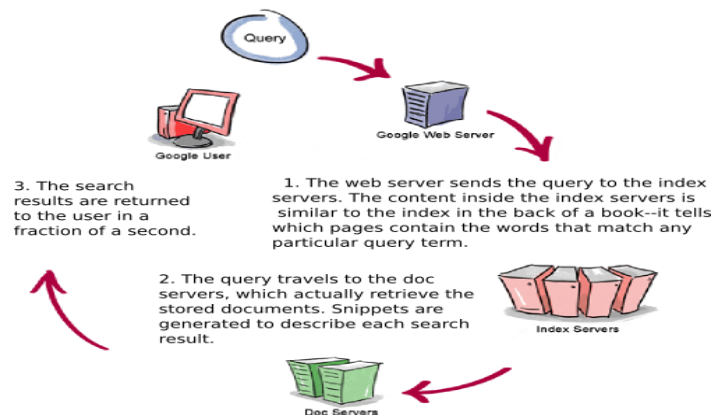

Fig. 1. Phases of Google a query process (Web-1).

Throughout the literature you will find several eye tracking studies which have focused on different aspects of search engine results and how various users have browsed and evaluated the outcome of the results. According to PEW/American life project (Fallow D., 2005). searching for information is the second most popular activity on the web, after email. Web browsers spend 70% of their time searching on the web (Web-2). In a study by Granka et al, on users mouse-clicking activity and navigation through a list of search result page (Granka et al., 2004). The findings of their study suggest that participants spend most of their time fixated on the top three results before they click on a link. Their study results indicate that users tend to follow a linear scanning strategy from top to bottom and it suggests that users devote lesser attention to abstracts below the break page (Granka et al., 2004). In a study by Kaki, founded that users identify relevant results in only 40% of the first selection of the search engine page results (Käki M., 2005).

There are several research studies that have looked at users' search patterns with search (Rele R.S., Duchowski A.T., 2005). Most previous research studies done on user search behavior focused on their mouse clicks activities using log files but not what they have seen and read (Jansen B.J., Spink A., 2006) (Mat-Hassan M., Levene M., 2005) (Wedig S., Madani O. 2006). Few research studies that analyzed user behavior on search results pages have included the intent of user query in their analysis. The two most popular and obvious intents included in their studies are informational and navigational (Buscher et al., 2010) (Guo Q., Agichtein E., 2010). Even some of these studies included specific areas of interests Area of Interest (AOIs) labeled for each individual search result in the page. An AOI tool is used to analyze how people distribute their visual attention across different results on SERP. This provides the capability to analyze the percentage of users fixating on a particular element and the duration of their stay on that component.

Eye tracking technology seems very promising in the research area of web search because eye gaze can be used as an indicator for user's attention. Eye tracking tool generates an intensive detailed of data on user's eye movements which describes user interaction with page content. To the best of my knowledge, there is no research study about user visual and browsing behavior in SERP using eye tracking technology and informational task queries has been explored for young Arab female college students.

2. 1. Eye Tracking Technology and Methodology

Eye tracking methodology has been used in many research studies for many years. Eye tracking is an advanced technology that uses high precision to measure exactly where a user is looking and for how long. It is used to study the relationships between eye movement data and cognitive activity of the user (Nielsen J., Pernice K., 2010). Frequency of fixations and duration of fixations are two important factors used to decide different aspects of the quality of screen contents. Eye movements are tracked and classified using various significant indicators of ocular behaviors, namely fixations, saccades, pupil dilation, and scan paths (Rayner, K., 1998). Eye fixations are considered the most relevant indicator for evaluating information acquisition and processing in online search and visualization environment (Pan et al., 2004). Fixations are defined as spatially stable gaze lasting for approximately 200-300 milliseconds during which visual attention is directed to a specific area of content display (Djamasbi et a., 2007). Most information acquisition and processing occur during fixation time. Saccades are rapid movements (in average 40-50 ms) of eye gazes between two fixation points. During saccade time no information can be acquired and processed. The kind of quantitative data a researcher can collect from an eye tracking test to describe the user's viewing and visual behavior are 1) which information items attract the user's attention immediately, 2) how long does the user look at an information item 3) how often the user look at a certain item on the page 4) in which order does the user visually navigate the content of the page 5) which are the areas (hotspots) on the page the user viewed at the most for information.

3. Research Methodology
3. 1. Participants
Twenty five full time undergraduate female students at Zayed University participated in this study. The participants' age range between 18 and 24 years (mean= 21) though all participants were drawn randomly from ZU Dubai campus enrolled in various degree programs. All participants had a minimum of three years on Internet experience and used the web to search for different kind of information. Most participants reported Google as their primary search engine. Most participants considered themselves savvy users of Internet search engines, using search engines at least several times a week. All participants signed a consent form stating the purpose of the study and their rights as study participants.

3. 2. Material and Tasks
A total of ten tasks were used in the study. All of the tasks were informational (i.e., they had to find factual information). The tasks vary in their difficulty and topics. The tasks were divided into three general topics or domains including Business, Fashion, and Tourism. Informational tasks were designed in which information exists in more than websites, and keywords for each task were derived by the researcher to ensure comparable search results across all participants. Each task had a description telling the participants what they should look for. In order to make the initial SERP comparable across participants, we provided them with an initial query for each task. All of the identified queries for the tasks were submitted earlier to Google and the relevant search results pages were saved in local files.

3. 3. Procedure
The Media and usability lab at ZU was reserved for one participant at the time. An unobtrusive eye tracking technology, the Tobii 120, was used in this study to collect eye movement data. The eye tracker looks much like a standard monitor. The eye tracker was calibrated for each participant before the test and collected data covering all of the tasks in the experiment. Studio software was used to record all eye tracking data and for later data visualization and data analysis. In the test, participants were asked to answer 10 query-based questions. For each query, participants were presented with a question and its corresponding SERP. It was a controlled experiment where all participants have the same questions and results. Participants were instructed to click on the result that they thought was the most appropriate to answer the question. The answers were visually embedded in the results presented in the SERP.

All participants reviewed and signed an informed consent form. Basic demographic and search experience information were collected, including age, gender, and internet and search engine experience, and the moderator explained the purpose of the study. The participants were given instructions to view each SERP page followed by one question to answer based on the content of the page. Throughout the study, the participants had control of their environment, allowing them to scroll, click and to choose when to continue to the next page. Once the study was completed, the participants were thanked for their participation.

4. Results and Discussions
The eye tracking measures (metrics) used and analyzed in the study include 1) performance success rates: percentage of query questions were answered correctly 2) heat maps: which highlights the heavy visual activities on SERPs and number and position of results viewed by students 3) dwell time: percentage of time students were fixated on SERPs 4) gaze plots: which show the visual behavior and search patterns of students on SERP. Several visualization (heat map and gaze plots) tools and statistics used in the eye tracking data analysis. The heat map represents the visual representation of the participant's attention on the page. The heat maps showed what parts of the page attracted user attention during the entire time that they viewed a page. Heat map is type of visual fixation with a color scheme. The red spots indicate high levels of fixation while yellow and green indicating decreasing amounts of fixation. Areas without any of these color shows participant did not look at that side of the page. Gaze

plot is an examiner which is used to follow the movement of participant eyes and know the sequence of eye movement. We need to investigate to see if there is a correlation between students' performance in the tasks/domains and their visual activities on SERPs including scan paths pattern and lengths, number and duration of fixations, and density of gaze behavior took place in order to make their first click.

During the eye tracking experiment, participants' eye movements were tracked and empirical data including fixation, gaze pattern and mouse clicks were collected. Both fixation and gaze data show the participant's visual behavior on the SERP while seeking for information to complete the tasks (answer the given 10 questions). Using the fixation data, a heat map was generated for each SERP to demonstrate which results (specific spots) attracted the most attention. The process of identifying results/snippets that were fixated upon by students within the first few seconds of viewing is important. It is very useful to measure the time it took students to first fixate on these snippets on SER page, an analysis of the order in which participants viewed parts of the result (hit) on the page is also provided. The study limits its focus to the top 7 search results on the first page of each query.

In the study, participants were asked to search Google results page looking for a snippet that has the most relevant information to answer the query question. The success for each query search is determined by choosing the correct answer. Table 1, shows the average success rates for all participants for each domain. It is obvious, students performed the highest (success rate: 79.6%) in fashion questions. This is due to the fact that all participants are female, and Dubai is well-known for exclusive brands and fashion designers. Surprisingly, students' performance came almost identical (success rate: 63.2 and 61.5%) in both business and tourism respectively. Again, Dubai is also considered a regional hub for business, finance and tourism.

The need to analyze the eye tracking data that led to successful and failed searches is very important. Thus, identifying any common scanning patterns behind each type of search. Table 2 shows the mean distribution of students' fixation on the SERPS per task domain. It looks that students had longer mean fixations on Tourism SERPs even though their performance was the lowest on the related queries. On the other hand they had the shortest mean fixations on Fashion SERPs where their performance was the highest. It shows that there is an inverse relationship between time spent on searching and reading the results and their performance (success rate) in order to answer the questions correctly. The results also indicates that business and tourism tasks perceived as hard (longer examination time) by students while fashion tasks were less difficult because of familiarity and nature of its domain

Table 1. average success rates across query domains.

Domain	Queries	Success rate/Q	Average success rate
Business	BQ1	43%	
	BQ2	70%	63.2 %
	BQ3	80%	
	BQ4	60%	
Fashion	FQ1	66%	
	FQ2	80%	79.6%
	FQ3	93%	
Tourism	TQ1	43%	
	TQ2	66%	61.5%
	TQ3	76%	

Table 2. Mean fixation duration per task domain on SERPs.

Domain of search task	Mean fixation duration (ms)
Business	6,990
Fashion	4,840
Tourism	8,760

When it comes to analyze the most common search strategies on SERPs were followed by students. Here, we can clearly see that the top snippets ate up the lion's share of the attention; greater than the lower ranked results, as shows in the heat maps of SERPs. Figure 2, illustrates graphically the search patterns of how students viewed the results on the list. It is very obvious that most students scanned and read the results in horizontal order with high focus and visual density on the top 2 to 3 results and least attention given to the ones at the bottom of the list. On the lowest rated results, fixation was very light and scattered, suggesting that nothing immediately drew the attention of the participants. It also shows that students maintained their horizontal reading patterns across all tasks of the thee domains
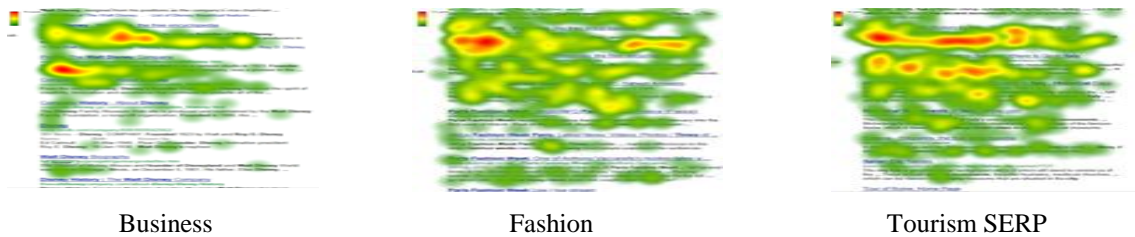

| Business | Fashion | Tourism SERP |

Fig. 2. Heat maps showing the aggregate fixation (dwell time) on SERPs domains.

Eye gaze analysis is a powerful visualization tool the researcher used to obtain deep insightful information about individual user search behaviour on SERPs. Individual student gaze plots were analyzed to identify a common search patterns (order in which participant viewed the search results). Interestingly, a wide range of search patterns were found in the collected results. It varies from a simple to more intense and erratic search behaviours. The benefit of eye gaze plot, it shows the step by step throughout the entire search process, each circle is marked with a number to indicate the order of fixation in the scan path on SERP. The size of the bubble indicates the duration of fixation on each point. Figure 3, it shows samples of eye gaze plots of all participants on SERPSs for each domain. The gaze plots support earlier results that tourism SERP received heavy visual viewing where fashion received much less search activity. Individual gaze plots were also obtained to highlight various. Figure 4, depicts various individual search behaviors from a simple to erratic one for the same SERP task domain. The plots also show that majority of students started their search from the high middle spot of the SERP and moved their way up to the top. The gaze plot visualization shows the search pattern of a user trying to look and evaluate the results that given the options considered before making their first mouse click.
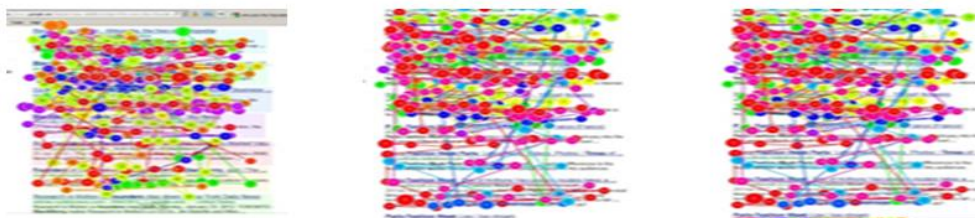

Fig. 3. All students eye gaze fixation on SERPs domains, business, fashion and tourism respectively.

Simple (efficient) search pattern   mild search pattern   erratic (exhaustive) search pattern

Fig. 4. Individual student's eye gaze patterns (fixations) on the same SERP domain.

Looking at the various results presented in figure 5 from the quantitative statistical data analysis. In general, the top 2 search results got the most fixations (attention) and visitations by all students and this is consistent across SERPs of all domains as seen in figure 5. In average, the top 2 results received 7.7 fixations on business, 7.9 fixations on fashion and 8.2 fixations on tourism, see figure 5. In the other hand, the last result on SERP of business and fashion received the least fixation (1 fixation) each respectively, where the fourth result on SERP of tourism received the lowest of (3.3 fixations). Interestingly, on average the second search result in the list got the highest percentage of fixations (95% (business), 89% (tourism), and 68% (fashion) by all students across all domains, as shown in figure 5. It indicates that something was very noticeable and lured students' attention more than the other results. On average, students viewed 3.7 results (almost half of the displayed results on the list) before clicking on any result. The students read and scanned at business results for seconds and fashion results for seconds and tourism results for seconds. Another observation regarding the time for first fixation duration on each of the search results, no significant difference was found, it ranges between 0.21 to 0.30 of a second across all domains, see figure 5. On average, students got their first fixation faster on the top two business results, after 2.56 second comparing with 3.79 seconds for fashion and 3.57 seconds for tourism, see figure 5.
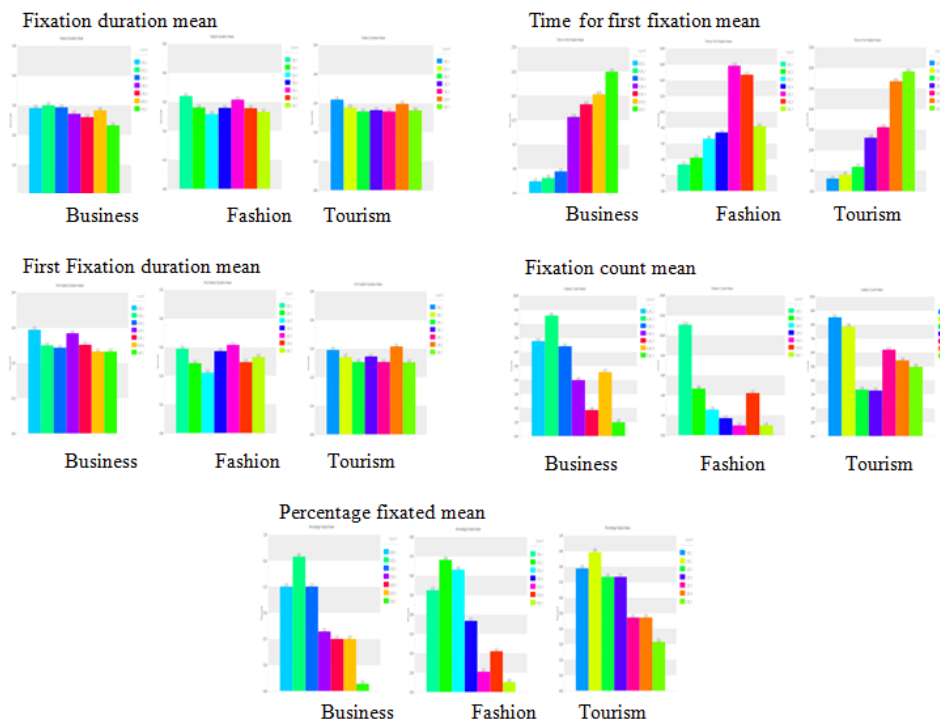

Fig. 5. Statistical analysis of mean fixation count and duration across all tasks and domains.

The eye tracking results showed that most ZU students are familiar with Google search engine and how it works. Therefore, students tend to apply similar search approach for answering the questions. Students start searching for the answer among the top ranked results of the Google search results page. However, some student are not that much quick in finding the answer from the abstracts so, they have to look at more than one result and look down the page to find the answer even though the answer was already on first result. This shows student who are in hurry and do not focus on result they might face little problem to get the answer. However, students who are well informed about Google and are focused and patient during search are easily done with their search.

In previous research study found that users will click on a result within the first 10 seconds of viewing the SERP (Granka et al., 2004). In contrary, our results show that on average students stayed longer and read more text on results page before their first click. In another study which proposed the "Golden Triangle", it suggests that users tend to scan the top 5 results on SERP. Again, our results have shown that majority of the students viewed the 3 results as depicted by the visual heat maps. Here, we can clearly see that the top snippets ate up the lion's share of the attention; greater than the lower ranked results, as shows in the heat maps of SERPs. Interestingly, the order seemed to matter: the first result with authorship got far more attention than the second, indicating position still matters.

5. Conclusions and Future Work

The paper presented a study using eye tracking methodology to explore and analyze user search strategies for Web search results page. The researcher looked at how female college students respond to search results which were displayed at different styles, details and ranks generated by the search engine. The study focused on the user's visual searching behavior and pattern on the first seven organic hits (abstracts). The research methodology used both quantitative and qualitative approach. A complete eye tracking experiment was designed and conducted using Google search engine. Eye tracking is used to study the relationships between eye movement data and cognitive activity of the user. Eye fixations are considered the most relevant indicator for evaluating information acquisition and processing in online search and visualization environment. The student participants' searching behavior and visual interaction with the search results have been observed, recorded, collected and analyzed. Data and feedback on user behavior and experience using performance measures were also recorded.

A comprehensive data analysis was performed on the collected eye tracking data. The finding from the study indicates that on average ZU students' stayed longer scanning and reading results, followed horizontal search patterns, paid most of their visual attention to the top ranked results, and did not read results in sequential order but often followed mixture of searching strategies. The factors to explain this behavior is due to the fact they have weak English proficiency, as a result they required to take a long time to acquire and process information online in order to find the proper answers. Other findings of the study include that 1) page results are mostly viewed linearly and horizontally 2) The top (three) results are most likely to be viewed and clicked by searchers 3) Searchers first click is concentrated mostly on the top three results 4) lower ranked results are less likely to be viewed by most searchers 5) Searchers follow different viewing patterns to make their first selection 6) Presentation of results can affect searchers selection and mouse clicking behavior . 7) There is a correlation between searching time spent on results and their performance (success rate) at tasks, higher time means poor performance.

It is important to stand out in the SERPs today, especially since there's so much competition for the same information. From the results, it is very clear that students looked at many search results before clicking. It also shows that results which were ranked high it more likely to grab attention from the searchers eyes. The lack of attention towards the lower ranked results could be attributed to the mindset of the searcher and the type of search query. As one might expect, the top ranked snippets drew significantly more attention than the other located further down the page. What does that all mean, it seems that top ranked results continued to get significant viewership, but importantly, lower-ranked

results were able to draw a disproportionate amount of attention. The study also highlights the importance of SEO (Search Engine Optimization) to obtain high ranking position at the SERP listing.

Information search is constantly changing and how people search is changing, too. This is also predicted by another study (Rele R.S., Duchowski A.T., 2005) which indicates that future web search interfaces will probably be different from what we have today. We are hoping that the findings of this study would give search engines architects and designers. A better understanding and insight on how users search and process information online in the GCC region, and the best way to present the results in a way that meets their need, preference, style, and expectation.

This study has opened a new research opportunities that need to be considered in the future. In particular, it would be worth pursuing to include other demographic information such as age, gender, cultural background, and technical experience in the data collection and analysis to investigate their impact on the students' performance and search patterns on more complex SERPs (with multimedia elements). Especially, by using filtration of independent variables to find any interesting correlation, differences and other factors that were not addressed by this study.

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Web sites:

Web-1: http://www.googleguide.com/google_works.html

Web-2: http://www.realnames.com