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EVALUATION OF A VISUALLY CATEGORIZED SEARCH ENGINE

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Abstract: World Wide Web is developing with the increasing demands of the users and the search engines are becoming an indispensable tool in order to find information in Internet. While web is developing day by day, people require adapting themselves to the developing conditions rapidly. Also, the intensive workload requires that people should use the time properly. Using search engines effectively turns out to be a vital. The purpose of this study is to investigate the possible search behavior of the users by using eye-tracking device. With this study, it may be possible to observe the participants' searching strategies while searching for a specific key word and seeking the related results for a subject. The results showed that, many of the participants had problems while using this search engine as they were not familiar with it. Almost all of the participants had a centralized approach while searching specific information in an unfamiliar search engine. Participants' fixation duration times and the hotspot data supported this result. Also, icon based approach was very common between participants that they tended to look at the bigger and colored icons more than the other icons.

Keywords: Search engine, searching strategies, visual categorization, and eye-tracking.

1. INTRODUCTION

Since search engines are becoming an essential tool, utilizing them effectively turns out to be a necessity for adapting themselves to the developing life conditions easily. This also causes an increase in the capacity of handling information rapidly. For the users differentiating the relevant and irrelevant information is another important issue that the search engines may offer many resources which are irrelevant to the user's needs. The existing retrieval systems are generally designed for listing the results in a fixed catalog. However, an important issue comes to mind that if structural design of the search engines is adopted in a more centralized way, would it be a solution for maintaining increase of resources capacity, transforming, deleting the unnecessary results and redesigning with relevant information. The answer is laying under the endeavors for finding the best methodology for searching in WEB (Lawrence & Giles, 1998).

Search engines have the capacity to introduce different kinds of resources in a short time. Although the usage of search engines like Google is increasing, the users have a tendency of just looking at the first result page and skip the rest (Silverstein, Henzinger & Moricz, 1999). However, it should be considered that the following result pages have the potential of containing valuable information. For this reason, design is crucial for providing the required information in small amount of time and space in an effective manner. Thus, it may be an effective way to show the results in a different way; like showing in a spider web like visual representation which was unfamiliar to them. By doing this, it may be possible to provide user with a more informative results page. There are many search engines which give the results vertically, one under the other, like Google. However, offering results through visual aids and giving the results categorized among themselves may be more helpful for

users to find the related results easily. Giving the results with a more categorized manner may aid the user, for this reason it is crucial to examine the effects of the search engines which have a visual structure and different organization model and to understand users' potential search strategies in an unfamiliar search engine. It was observed that there exist many research studies related with search engines (Makris, Panagis, Sakkopoulos & Tsakalidis, 2007; Spink, Jansen, Blakely & Kohman, 2006; Ozumutlu, Cavdur & Ozumutlu, 2006.; Thatcher, 2006; Bar-Ilan, Mat-Hassan & Levene, 2006; Rose & Levinson, 2004; Jansen & Pooch, 2001). Moreover, it is crucial for researchers to keep in mind the role of the human in information seeking on web (Kellogg & Richards, 1995), because the user position need to be located at the center part of the exploration, in order to comprehend the desires of the users and also to discover the appropriate support for existing web settings and related obstacles in the information searching process (cited in Hsieh-Yee, 2001).

Cockburn and Jones (1996) pointed out that the presentation of information is an important concern for the users because some problems regarding with deficient design may occur. For this reason it is necessary to understand the navigational features of the individuals' usage patterns for offering them the appropriate sources for sustaining their needs by using the designer's point of view. Also, designers need to provide more user friendly systems which are clear for the users. Problems with navigation can be solved by using user-centered supports. Designers need to construct systems which are very applicable for investigating the search behavior of the user on the web environment and have capacity to catch the search movements of the users and look at the process step by step.

Searching strategy is another issue for the researchers Hill and Hannafin (1997) indicate that searching strategies differ between individuals. In their research study they concluded that individuals used diverse strategies, their knowledge influenced the decision of the strategies and the perception of the users' puzzlement and the self-efficacy of the users had the power to affect the strategies that was used. Additionally, search behavior is another concern for researchers to realize the users' apprehension of the search engines. According to Bates (1989), there are different methods for exemplifying on the whole searching procedure. As Hsieh-Yee (2001) investigated that explaining the existing search patterns of the users and the factors that have an influence on the search behavior and search task are the main concern of the researchers. However, eye movement behaviors on the web pages have a small proportion in the academic studies but there are some exceptions to this area (Stanford Poynter Project, 2000; Josephson & Holmes, 2002; Goldberg, Stimson, Lewenstein, Scott, & Wichansky, 2002).

Moreover, as Chen et al. (1997) investigated, user's strategies may be affected by the various cognitive demands. To support this, they observed 10 graduate engineering students, their search paths were computed by the researchers and different strategies for different task categories were discovered. "In searching for specific information, the students used a goal-directed search strategy, which involved shorter path lengths and frequent path changes, and used browser functions that minimize cognitive load" (as cited in Pan, Hembrooke, Gay, Granka, Feusner & Newman, 2001).

Additionally, eye movements have an importance for the psychologists in terms of providing valuable information resources gathering necessary information about the perception and cognition of the individuals. These kinds of research studies can give an opportunity to the researcher to provide rich data resource. This is done by offering answers when compared with the data gathered from on button press reaction time (Richardson &

Spiwey, 2004). According to Althoff and Neal (1999) memory might be influenced by the eye movement characteristics and it has a vital function for cognitive information processing (cited in Murata & Furukawa, 2005)

By examining the research studies on search engines and the related studies on eye-tracking device, one might have an idea about their visual search engine design for the user's point of view and their cognitive processes while searching a specific word in an unfamiliar visual search engine. For this reason, the main purpose of this research study is to investigate the current search behaviors of the individuals in a specific search engine by using eye-tracking device and also this data will be fed by verbal protocol data and the video recordings of the participants in the searching process.

2. METHODOLOGY

For providing deeper information about how participants act while searching specific tasks with a visual search engine, both qualitative and quantitative approaches were used. Eye-tracking device was used to determine for gathering quantitative data about the possible searching strategies of the participants and examining the task completion duration more easily. Also, eye tracking device allowed gathering data about how much time participants spent on the search engine's three specified parts (Area of Interests) while searching the related information on tasks. Additionally, the transition number which was gathered from eye-tracking analyze showed the change behavior and the cognitive learning process of the participants. Lastly, the hotspot data showed the patterns of the participants while searching information.

Participant's behaviors, facial expressions and their eye movements recorded while solving the problems. In order to provide more information about the participants' search behavior they were asked to explain the process verbally and from this data the learning process of the participants while using the search engine was introduced. Additionally, questions about the users' descriptive preferences on computer experience and search engines were gathered through semi-structured interviews. The data was collected between December 2006 and January 2007.

2.1. Research questions

What are the possible search strategies of users in a search engine which has a semantic structure?

- How much time does the users spent on the search engine's three specified parts while completing the tasks?
- What are the differences between these three areas in terms of the transition numbers of the participants for each task?

2.2. Procedure

The sample consisted of 12 graduate students. Before the real experiment 3 of the participants were chosen for pilot study. They were asked to complete the defined tasks with visual search engine with a computer which was situated eye-tracking device. After the pilot study the data were examined and asked about their comments on the search tasks, on the

interface and the problems that they experienced with visual search engine. One of keyword changed from “Moneth” to “Van Gogh”, that it was seen that the results were not especially related with the task. Also the tasks were changed with respect to the comments of the users and specified for ensuring the comprehension of the users the tasks properly.

The real study was applied with 9 participants, 4 of whom were female and 5 of whom were male. The mean ages of the participants were 26 ranged from 24 to 32. Participants were all graduate students with a background from technically oriented departments and all of them voluntarily participated to the study. For providing descriptive information from participants they were interviewed before the experiment about their computer experience, daily internet usage, the time that they spend on searching information, the specific search engines they use usually and the reasons that lays beneath for using these search engines. From the interview data it was seen that, all the users had a minimum of six years experience with computers and searching information was a daily activity and they were spending 71 minutes for searching information on Internet. Also all participants indicated that their selection on their best search engines was “*Google*”, and 34 % of the participants added that “*Altavista*” was the second search engine that they use commonly in daily routine. 56 % of the participants stated that Google is very convenient and fast, 34 % of the participants added that the scholar search option is very usable and 45% of the participants added that Google has a broad and diverse information capacity. Although there could not be a consensus on the other comments on Google they stated the relevancy and prevalence in the Internet.

TABLE1. THE DESCRIPTIVE INFORMATION OF PARTICIPANTS

Male	Female	Age M	Experience with computer (year)	Computer usage per day (hour)	Search engine usage per day (hour)
4	5	25,6	11,7	6,5 hour	1 hour

Although entire tasks were very similar to each other, it was aimed to understand what the search behaviors of the participants change in an unfamiliar visual search engine. Keywords were pre-decided and tried before the experiment by the researcher. For each task, about 5 minutes was given to the each participant. They were free to decide to finish the task if they reached to the related information about the task.

Tasks

- Imagine that you do not know anything about rubic and you need to comprehend and use it. Find the related and necessary information about **Rubic**.
- Imagine that you do not know anything about Sudoku and a friend of yours asked you to find some information about it. Find the necessary links, definitions, rules and web sites for learning **Sudoku**.
- Imagine that you need to buy a fish (Goldfish) for you little cousin or sister/brother. However, she/he does not know anything about Goldfish and you are responsible to find the necessary information for feeding **Goldfish**.
- Imagine that you need to prepare a term project about the artist **Van Gogh**. You are free to determine the content of the paper, find the necessary information for this term project.



FIGURE 1. SCREENSHOT FROM THE TASK3 (SEARCH RESULTS WITH THE KEYWORD SUDOKU)

2.3. Data Collection and Analysis

In this study, three different data sources were used for exploring the searching behavior of the participants. Eye tracking data was the first data collected by the Clearview on Tobii eye tracker device, second semi-structured interviews before the experiment were conducted and verbal protocol and recordings of their experiments were used during the study. For analyzing these data both quantitative and qualitative approaches were used. The data which were gathered from interview was analyzed with qualitative methods and eye tracking data was used for supporting the results.

The main research question was answered by using both qualitative and quantitative approaches. The sub questions were answered by using the eye-tracking methods and interpreted for supporting the qualitative results. The participants were observed during the experiment with using the camera in the experiment environment. Each participant was recorded and notes were taken during the experiment about what they did in every task. Every participant was asked to verbalize their ideas and steps that they followed for every task.

3. RESULTS

“What are the differences between these three areas in terms of the transition numbers of the participants for each task?”

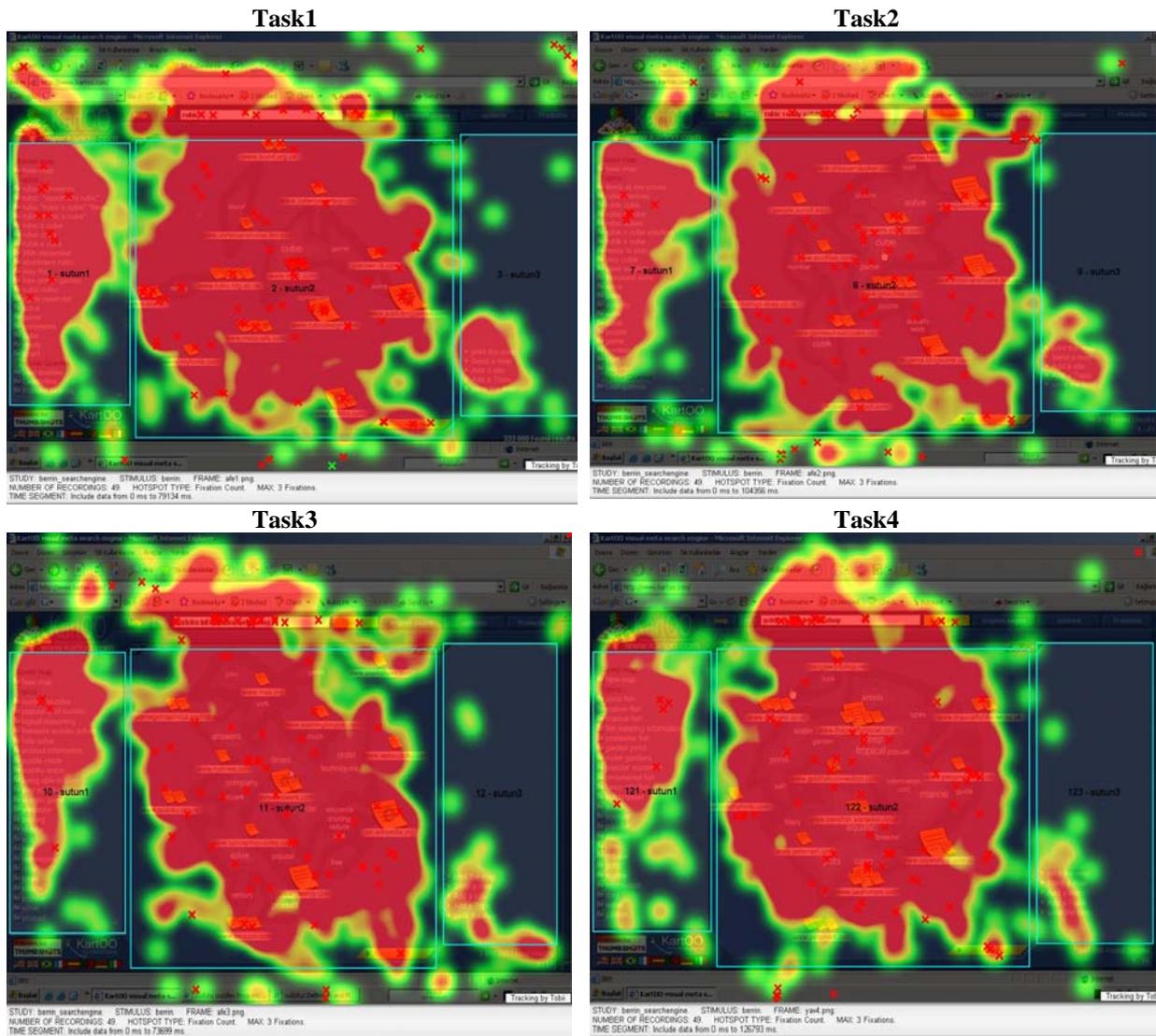


FIGURE 2. HOTSPOT PLOTS FOR EVERY TASK

Analyzing the hot spots of the screen is a powerful method for understanding the gaze behavior and for better visualization of the eye movements of the participants. Red colored area was the mainly focused area and the other parts were green colored.

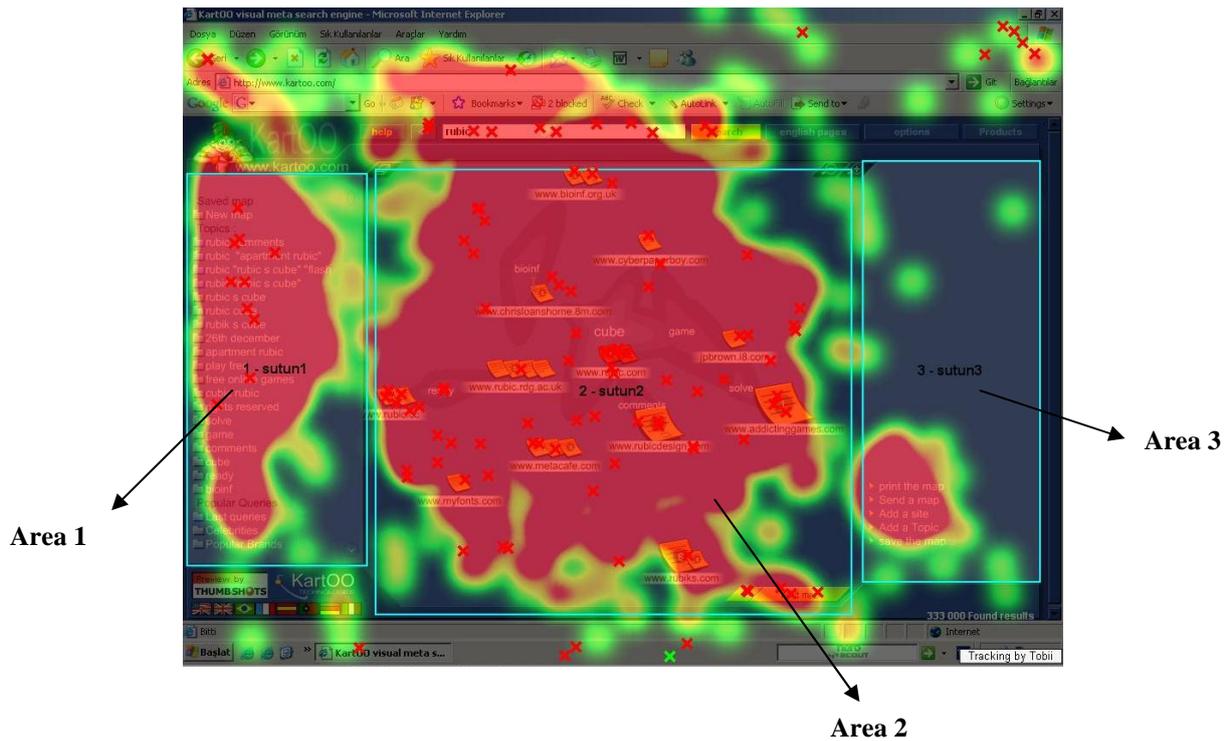


FIGURE 4. AREA OF INTERESTS (THREE AREAS WHICH WERE SPECIFIED BY THE RESEARCHER)

When we look at the hotspot data it was seen that participants mainly focused on the map structured area called “Area2”. Participants fixated on this area while searching for the related information they secondly fixated to the first column called “Area1” which was designed in a vertical way for listing the related links and options for previewing the icons content in self. Lastly, participants explained the reasons for looking to the third column called “Area3” that they were just looked at this part for understanding the purpose of this column. Also these results were supported with the fixation duration data like all the participants focused on these three areas on the screen. This data also supported that the participants were more focused on the Area2 than the other areas.

“How much time do the users spent on the search engine’s three specified parts while completing the tasks? “

TABLE2. THE TOTAL FIXATION DURATION TIME AND AVERAGE FOR ENTIRE PARTICIPANTS

Place	Fixation Duration (total time)	M
Area1	1203,9 msec	133,66
Area2	7293 msec	810,33
Area3	153 msec	17

The transitions numbers were analyzed for every participant for each task separately and the results were given below. The transition number mainly gives an idea about the

learning process of the participants while searching information in an unfamiliar search engine. The mean scores showed that participants while searching for a specific keyword on this search engine they had a tendency to focus on mainly Area 2 and their transition numbers increased from Area1-Area2. Although the numbers were high, this was a learning process and the participants explained that when they understood the purpose of the left menu (Area 1). Moreover, the decreasing of the transition numbers between tasks may be an evident for learning of the search engine in this searching process. Participant's comments on the web site also showed that they had a tendency to focus on the center more than the other parts of the screen. The left menu had an option like previewing the web pages, however many of the participants could not realize it very quickly. Also the biggest icons and colored icons were more attractive and they had a tendency to look at these icons.

TABLE3. THE MEAN OF TRANSITION NUMBERS FOR EVERY TASK FOR ALL PARTICIPANTS

Transition numbers	Task1		Task2		Task3		Task4	
	A1-A2	A2-A3	A1-A2	A2-A3	A1-A2	A2-A3	A1-A2	A2-A3
	28,5	7,6	17,8	5,3	9,5	4,3	10,1	3,7

Participant's comments on the web site also showed that they had a tendency to focus on the center more than the other parts of the screen. Also, the biggest icons and colored icons were more attractive and they had a tendency to look at these icons. The table showed below also gave information about the participants' comments about the icon design.

TABLE3. PERCENTAGE AND NUMBER OF THE PARTICIPANTS' COMMENTS ON ICONS

Icons	Number of participants	Percentage
Colorful icons	6	67 %
Big /Small Icons	3	33 %

Moreover, some of the participants stated while explaining the process, the keyword based approach and links between keywords made it easy to find the information in this search engine. The keywords and the links based approach are very beneficial for participants and it may be improved for meeting the needs of the users properly. The table showed the percentage of the satisfaction of participants with the keyword based design and also showed the percentage of the participants who discovered the preview option of the left menu.

TABLE 4. THE PARTICIPANTS' SATISFACTION PERCENTAGE IN TERMS KEYWORD BASED DESIGN AND THE PERCENTAGE OF THE PARTICIPANTS WHO DISCOVERED THE PREVIEW OPTION OF LEFT MENU

Left Menu	Number of participants	Percentage
Preview option	5	55 %
Keywords	7	78 %

5. CONCLUSIONS and DISCUSSIONS

When the comments of the participants were analyzed and the video recordings were examined, it was seen that many of the participants tended to look at the big and colored icons than the small and uncolored icons. Colored links are beneficial aids in screen design to get users attention affectively. In order to design more effective search screen, color, space and icon based approaches need to be investigated with considering the users' expectations. "Also they added that the system of the map was not very easy to understand but very different than the other search engine structures. Especially, there was a keyword related map system and many of the web pages were linked to each other with these keyword. This was helpful if the user know the system well enough but not very suitable for the novice users and broad contents. Additionally, left menu may be improved for attracting the users' interest with this it may be possible to use this part of the search engine more effectively. Almost all participants stated that the left menu did not take their attention although; the left menu had an option like previewing the web pages, which were showed with icons on the center of the screen many of the participants realized it very late but found it very useful. The transition numbers may be an evident for the researchers to find out more about the learning process of the users in an unfamiliar search engine.

The major limitation of the eye-tracking research is that they are usually conducted with a small sampling. Also this kind of studies sometimes may not give sufficient results because of the process structure that observing the participants with using the eye-tracking device and as Pan et al. (2004) commented on the limitations of the eye-tracking studies that they may give some answers about how the users behave and what is the ocular behavior but it is not very easy to understand the reasons that laid beneath of their behaviors. In order to complete our research's deficiency, we aimed to use different research methods like verbal protocol and videos of the participants to provide their facial expressions. With this it may be possible to make a connection between their behaviors and have additional information about their cognitive process.

Furthermore, there should be more researches on visual based search engines and their structures. In order to have more reliable data the sampling need to be increased and diversified from different departments and backgrounds. For gathering data for effective design there may be created different design possibilities and with this it may be possible to have information about the users' point of view on icon and keyword based systems. Also future studies mainly can focus on the possible areas for visual search engines and the effectiveness of their structure.

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