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Successful Web Searches: What Makes the Difference? An Eye-Tracking Study

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Resumen

Los datos de los archivos de registro de actividades Web (Web log data) han sido la base del análisis del comportamiento de los usuarios durante muchos años, sin embargo, estos datos tienen algunos defectos importantes, el principal es que no permiten saber con exactitud lo que el usuario está haciendo – si está mirando la pantalla o haciendo algo diferente? – Hemos llevado a cabo un estudio de seguimiento ocular para analizar la forma en que los usuarios realizan búsquedas en la Web. El objetivo es obtener información más precisa acerca de la estrategia de búsqueda del usuario. ¿Qué factores son relevantes en el proceso de búsqueda para los usuarios? ¿Qué características hacen la diferencia entre las búsquedas exitosas y no exitosas? En los experimentos, cada usuario ejecutó tres sesiones de consulta diferentes para encontrar tres objetivos de información predefinidos y al final de cada experimento se preguntó a los usuarios si encontraron sus objetivos de información. Esta investigación presenta los resultados centrados en el número de consultas formuladas por sesión , los documentos cuyos enlaces fueron seleccionados mediante un click del mouse, el número de fijaciones oculares y el tiempo de duración de estas fijaciones, y la distribución de la atención del usuario en las diferentes áreas de la pantalla, entre otros aspectos. El estudio encuentra tendencias interesantes relacionadas con las áreas de la página de resultados del buscador y de los documentos visitados, en las que se fijan los usuarios, y otros factores derivados que diferencian a los usuarios que tienen éxito en su búsqueda de información de aquellos que no logran su objetivo.

Palabras clave: *Eye tracking, web log, sesiones de consulta, éxito en búsquedas.*

Abstract

Web log data has been the basis for analyzing user behavior for a number of years, but it has several important shortcomings, the main one being that we don't really know what the user is doing – is s/he looking at the screen or doing something else? We have conducted an Eye-Tracking study to analyze how the users are searching the Web. The goal is to obtain more precise information

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about the search strategy of the user. Which factors are relevant in the user search process? Which characteristics make the difference between successful and unsuccessful searches? In the experiments, each user conducted three different query sessions to find three predefined information objectives, and at the end of each experiment the users were asked if they found their information objectives. This research presents results focusing on the number of formulated queries by session, documents clicked, the fixation durations on the documents, and the distribution of the attention in the different areas of the screen, among other aspects. We find interesting trends, in terms of where users look on the results and contents pages, and other derived factors which distinguish users who are successful in their information search from those who are not.

Keywords: *Eye tracking; web log; query session; search success*

1. Introduction

Eye-tracking is a state of the art technology which recently has become much more manageable, economical, and user friendly. Web logs have been used widely in the web search analysis community to reach conclusions about search categories, user types, document categories, and so on. However, anonymous web log data is nothing more than an approximation of what the user is really doing. Also, the eye movement patterns on the screen are completely unknown: browsing over the results before deciding which one to click on, reading through a document to decide if it is relevant or not and to find a key piece of information. This is the information which we can now evaluate in the current work and in this paper. Also, the behavior of users who are successful or unsuccessful in their searches may vary in terms of eye movement and fixation points on the screen. We propose that the evaluation of successful and unsuccessful query sessions is an indicator which is sensitive to differences in user activity in general (elapsed time, number of docs clicked, etc.) and eye activity in particular (number of fixation points, time spend on fixation points, eye movement patterns on the screen, in a document, and over the results list). That is, users who find what they are looking for will behave differently from those who do not find it, and we can quantify these factors from the Web log and eye-tracking data together, and analyze the differences statistically.

On the other hand, we have the problem of how to help more users be successful in their query searches, in terms of user support and guidance. In this paper, we consider these three aspects: (1) profiles of the user queries in terms of Web log + eye-tracking data; (2) the differences between successful and unsuccessful users in terms of these profiles; (3) how to offer the users appropriate help, such as query recommendation and automatic error correction, when we detect possible 'failure' scenarios.

2. State of the Art and Related Work

In this section we look at the state of the art and related work in the following areas: **(i)** query log analysis without eye tracking; **(ii)** eye tracking; **(iii)** evaluation of eye movement on the computer screen; **(iv)** user studies; **(v)** mapping of gaze data to Web content pages; **(vi)** mapping of gaze data to the results page: "the Golden Triangle"; **(vii)** mapping of eye movement to results and content pages: the "F-shaped pattern".

(i) Query log analysis without eye-tracking. In recent years, web search behavior has been analyzed in detail by different research groups in the Web mining community using query logs collected by search engines. Previous work of Baeza-Yates [1][2] and Nettleton [11][12] has been based on statistical analysis of web-log data, such as "hold times" of documents, number of results clicked, ranking of clicked documents, and so on. One deficit, we could say, of web log analysis, is that we do not know if the user is really looking at the screen, or what s/he is looking at or doing.

(ii) Eye-tracking. The technology of "Eye tracking" has been in use for several decades in a diversity of domains, such as neuroscience, psychology, industrial engineering and human factors, marketing/advertising, and computer science [6]. Work applying Eye Tracking to web search, such as [4][8][15], tends to focus on specific aspects of the page content. For example, in [4], Cutrell et. al. carry out a study to evaluate the effect of snippet length on how people use Web search, by studying eye tracking data from results pages in various configurations. They found that adding information to the contextual snippet significantly improved performance for informational tasks but degraded performance for navigational tasks. In contrast with [4], in the present study we allow users to formulate queries on their own, instead of providing a ready-made set of queries for each task.

(iii) Evaluation of eye-movement on a computer screen. In the context of evaluating user eye movement on a computer screen with respect to displayed information on that screen, different specific methods have been adopted [10]. Three of the main representation methods for user ocular activity are **(i)** the definition of *'areas of interest' (AOLs)* (eg. Cutrell [4]) by marking generally rectangular shapes predefined on the area to be studied and the relating the user ocular movement and focus to those areas; **(ii)** the generation of *'heat maps'* which show, using a given color scheme(typically the red end of the spectrum indicates 'hot' high user focus and the blue end of the spectrum indicates 'cool' low user focus activity), where the user focuses most often and for the most time; **(iii)** the generation of *'gaze* *maps'* which show as circles on the screen image, the points where a user has focused. The bigger the circle, the more time a user focused on that point. The circles are joined by directed lines/arrows which indicate the path a users' vision has taken and in what order the points have been visited. Modern eye-tracking equipment can generate these visual representations from relatively simple statistics of frequencies and time measurements with respect to the *x, y* coordinates of the screen.

(iv) User Studies. Eye tracking has been shown as very useful in ergonomic user studies and studies of how the user behaves with respect to specific objects or characteristics within an image on the computer screen or a web page[5][7][14][16][17]. For example, in [14], Pan et. al., carry out an eye tracking study of 30 subjects on 22 web pages from 11 popular web sites, with the objective of exploring the determinants of ocular behavior on a single web page: whether it is determined by individual differences of the subjects, different types of web sites, the order of web pages being viewed, or the task at hand. Their results indicate that gender of subjects, the viewing order of a web page, and the interaction between page order and site type, influence online ocular behavior.

(v) Mapping of gaze data to web content pages. Buscher [3] carried out a study mapping gaze data to web page content, and presented a model for predicting the visual attention that individual page elements may receive. Buscher divided the screen into 10 regions, and for each region the following statistics were calculated: median time to first fixation, viewing frequency, median fixation impact (entire task duration), median fixation impact (first second of task). The task was subdivided into two subtasks: (i) information foraging, and (ii) page recognition. The study was carried out with 20 users and 361 web pages. With respect to work related to eye movement analysis on web pages, two key recent findings are the *'Golden Triangle'*, presented by Hotchkiss in [9], and the '*F-Shaped pattern'* presented by Nielson in [13]. We will now briefly describe these two phenomena.

(vi) Mapping of gaze data to the results page: "the Golden Triangle". In a series of user studies, Hotchkiss [9] identified a triangular region (the so called "Golden Triangle") of maximum visibility on the search results page. With reference to Figure 1, the golden triangle is a right-angled triangle aligned along the top of the first search result and the left side of the results page. It extends from the left top of the results page over to the top of the first result, then down to a point on the left side about three quarters of the way down the page. However, we must take into account that their study was based on a sample size of only 48 subjects, made up of university undergraduates and graduates, 52% female, 48% male, and 83% with age less than 40 yrs.

Fig. 1. Heat Map: “Golden Triangle” pattern shown by the 'heat map' of how users focus on a search results page.

Hotchkiss related the “Golden Triangle” tendency to how a search engine (Google) works and presents results. In general, the search engine places the best listings at or near the top. Therefore, users have the tendency, at the beginning of a search session, to restrict ocular scan activity to the area of the page most likely to have the best listings. This area has been termed the “Golden Triangle”. Users tend to start reading information in this area with a typical upper left orientation. The users tend to scan listings and the majority (approx. 72 percent according Hotchkiss) click as soon as they see something of interest. Thus, if the search engine is presenting the results correctly, there is a high probability that the most relevant result will be the first one seen by the user, because the best result has been located in the first place where users tend to look (top left). The user may also check the validity of the results by scanning the title and description.

(vii) Mapping of eye movement to Results and Content pages: the “F-shaped pattern”. Nielsen's [13] eye tracking research showed that users read web content in an F-shaped pattern. The F-shape reading pattern refers to a viewing order in which users commence by reading across the top line and then look down the page a little and read across again and then continue down the left side. With reference to Figure 2, the 'hotspot map' shows the general “F” pattern of eye movement. It can be seen that most of the fixations are concentrated in the top left hand corner of the page. The image is from an e-commerce site with a picture in the middle of the page. The second line is lower than normal because it moves to the text below the picture. The top right hand corner contains the price. The implications of the F-shaped tendency confirm that users do not read all of the content on a Web page. The most important information should be contained in the first two paragraphs [13], and paragraphs and bullet points should begin with words that have a high information content, which will be noticed when the users scan the left side. Again, we must take into account the small sample size of this study: twenty undergraduate students (17 female, 3 male) of whom 65% were between the ages of 18 and 26 yrs. The eye-tracking system used was the Tobii 1750 system. However, more recent studies question the F-shaped tendency for modern content pages which contain a mix of images and text in different relative positions on the screen.

Fig. 2. Heat Map. F-Shaped pattern of how users read web content.

Summary. Much of the current work in the literature tends to present results using 'heat maps' and 'gaze plots' (to show special interest areas), for static predefined user experiments In this paper, we employ some data mining techniques such as neural clustering and rule induction, to contrast this way of interpreting the data with the heat maps and gaze plots, which we also generated from the Tobii Eye-tracking System. We also give the user freedom for formulate their own query (for a specified objective) and then carry out a "query session" (that is, one or more related queries and corresponding reading of results and content).

3. Experimental Design

In traditional Web Search Engines users submit a set of keywords and are then given a list of results with descriptions of documents that possibly contain the answer to their information needs. Some of the results shown by the Search Engine will be irrelevant and just few of them will contain links to pages with the correct answers to the users' query. Our experimental setting to evaluate eye movement data was designed to simulate a natural web search session. Users were asked to search as they normally would, and the study focused on unconstrained web search by allowing users to navigate multiple pages and to formulate and reformulate all the queries that they want, while searching for information to resolve a specific question. The aim of the research is to discover as many differences as possible among people that are successful in their web searches compared to those that are not.

3.1. The Questions

We designed three questions for the web search experiment. The idea was to create general questions in a non specialized topic and with a unique answer in order to reduce the ambiguity of the results. Each question is distinct and there is no relation o connection between the questions.

The designed questions are:

1. *"Name of a mechanical machine (not electrical) for calculating, of German origin, which fitted in the palm of a hand"*: The correct answer to the question is "*Curta*" [Curta]
2. "*Name of the wife of the author of "The Jungle Book"* ": The correct answer to the question is "Carrie Balestier"
3. "*Name of a Catalan NGO which works in India and whose founder was recently hospitalized*": The correct answer to the question is: "Vicente Ferrer Foundation"

Throughout this paper the terms Q1, Q2 and Q3 will be used to make reference to the questions 1, 2 and 3 respectively.

3.2. The Participants

Fifty seven (57) people participated in the study, 24 men and 33 women. The average age of the participants was 28 years in a range of 18 to 61 years. The participants had a diverse range of professions, background and education levels. All the participants were moderately experienced at Web search, reporting that they searched the Web for information at least once a week, and all were familiar with several search engines. None of them had experience using an eye-tracker.

3.3. Apparatus

The device used for measuring eye movements was the Tobii[3] 1750 Eye Tracker[18]. The eye tracker is integrated into a 17" TFT monitor. The tracker illuminates the user with two near infrared projections to generate reflection patterns on the corneas of the user. A video camera then gathers these reflection patterns as well as the stance of the user. Digital image processing is then carried out for extracting the pupils from the video signal. The system tracks pupil location and pupil width at the rate of 50 Hz. The system allows free head motion in a cube of 30x15x20 cm at 60 cm from tracker. The resolution of the tracker is 1280x1024, and the recommended distance of the user from the display is 60 cm. In Figure 3 we can see the screen of the interface of the Tobii software showing a participant's 'scan path' map.

3.4. Procedure and Design

At the beginning of the experiment the users were informed about the purpose and the procedure of the study. Users were asked to perform the search tasks using the web search engine, as they would normally do. Each participant conducted two task searches corresponding to two of the designed questions of this study. When starting the search task, a description of the question was shown to the users. After reading the question description, the participants clicked a start button and were taken to a search engine page to start the search task. The users had to find the correct answer to the question by searching the web through a commercial Search Engine. Participants were free to click links and scroll page-up/page-down as needed, this navigation freedom adding to the study a high degree of reality to the search tasks. Users were told they should continue the task until completed or until 5 minutes had elapsed.

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[3] http://www.tobii.com/corporate.aspx

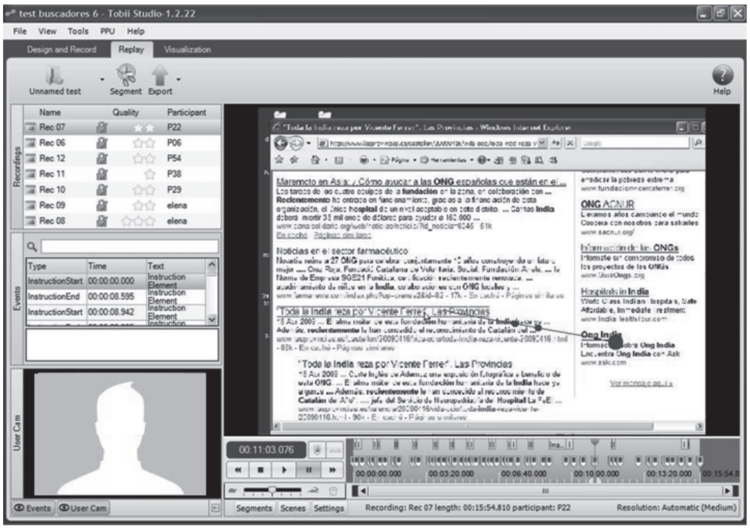

Fig. 3. Screenshot of Eye-Tracker Software.

4. Results

In this section we analyze the characteristics of the Web searches performed by the participants of this study. In all the analysis, we distinguish the page type, where "SERP" refers to the search engine result page and "CRP" refers to the clicked result page.

The results are presented in three Sections: in Section 4.1 a statistical analysis is made of the available data to identify trends, which distinguish, successful from unsuccessful searches. In Section 4.2, a study is made of successful and unsuccessful searches using neural clustering of the X,Y fixation coordinates. Finally, in Section 4.3, we evaluate the heatmaps and gaze plots in order to determine the existence of a structured (non random) gaze pattern on the screen. In all of the studies, we distinguish the page type, where page type 1 is the search engine results page and page type 2 is a clicked results document.

4.1. Successful and Unsuccessful Searches

Almost all the participants (56) completed the two task search that they had assigned; only one of them completed half of the task and performed just one of the two query sessions. In total, 57 users performed 67 successful searches and 46 unsuccessful searches.

The results of the general statistics (see Table 1) show clear trends for successful and unsuccessful searches. On average, users who are successful formulate fewer queries per session and visit a smaller number of documents than unsuccessful users. We conducted ANOVA tests with independent variable type of user (successful, unsuccessful) and with dependent variables number of queries formulated and average number of documents selected. Significant effects were found for both cases: number of documents ($F=153.309$, $p<0.001$) and average number of queries ($F=229.053$, $p<0.001$). These initial trends suggest that successful users have a more focused search behavior. We can contrast this assumption by evaluating the variables derived from the eye tracking methods, fixation frequency and fixation duration (see Table 2). Fixation frequency refers to the number of times that the user fixes his attention in some specific point of the screen. Fixation duration is related to the duration of a fixation [8]. The results show that the time and number of fixations that unsuccessful users invest in SERP and CRP is almost the double of the time that successful users invest in the same pages. If the web search engine is able to detect this behavior, it has the possibility to bring to the user a more effective service: more clear and intuitive interfaces or highlights on the key information SERP that allows these users to make a better selection of documents.

	Successful	Unsuccessful	All
Avg. number of queries	1.86	3.26	2.5
Avg. number of pages selected	4.36	8.32	6.34

Table 1. General statistics by query session.

	Successful	Unsuccessful	All
Fix. Frequency on SERP	25.41	49.40	37.41
Fix. Frequency on CRP	29.47	56.96	43.22
Fix. Duration on SERP (sg)	16.11	28.6	22.36
Fix. Duration on CRO (sg)	17.82	32.39	25.1

Table 2. Eye tracking statistics of successful and unsuccessful query sessions.

Analysis of web search behavior in terms of task difficulty: Another aspect to consider in the analysis of web search behavior of the users is the difficulty of the task. The percentage of successful searches to each question is a good indicator of the difficulty level of the task search: Q1 (yes=20% / no=80%), Q2 (yes=77% / no=33%)and Q3 (yes=88% / no=12%). By observing these success percentages we can clearly identify question Q1 as the most difficult task search. The general statistics obtained from the query log data, average number of queries formulated (Q1=2.7, Q2=2.5, Q3=2) and average number of document pages selected (Q1=7, Q2=6.3, Q3=4.3), suggest that the search activity of the users is proportional to the difficulty level of the search task. However, the results for fixation frequency and fixation duration of successful and unsuccessful searches suggest that the time that a user spends in SERP and CRP is related with the strategy of search of the user and not with the difficulty of the task. In general, the fixation frequency and fixation duration of successful users for SERP is homogenous for the three questions (see Figure 4). Successful users find the answers for the questions approximately in the same time and with the same number of fixations. It is not the same situation for unsuccessful users, this kind of user does not have a homogeneous search behavior. The fixation time and fixation duration is different for each question and in any case their behavior is less effective in time and number of fixations when compared with successful users. The gap in the attention that satisfactory and unsatisfactory searches paid to SERP and CRP suggest that these two kinds of search behaviors need different types of service or help from the web search systems. Figure 5 shows some examples of the unsuccessful and successful users, respectively, when they search for information in the SERP.

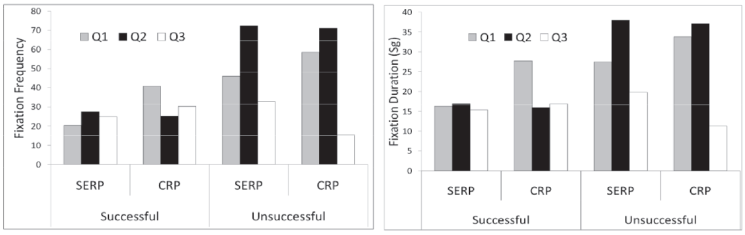

Fig. 4. (left) Fixation frequency and (right) Fixation duration for successful and unsuccessful searches by type of question and type of page.

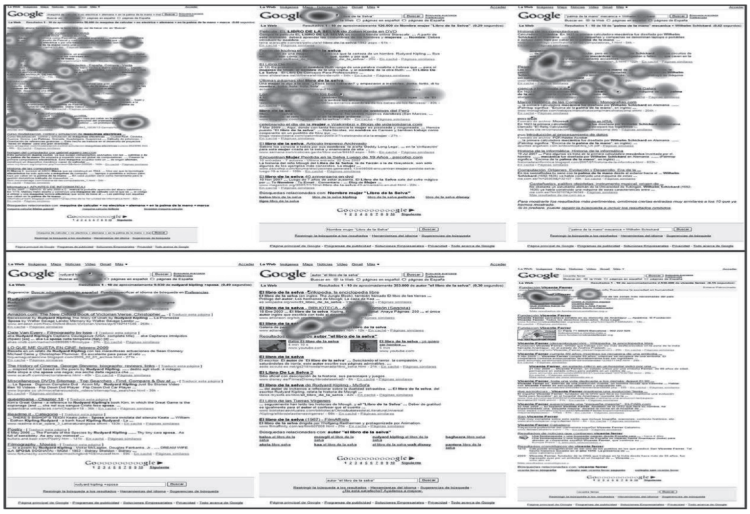

Fig. 5. Heat Maps. Screen images on top show SERPs of unsuccessful searches. Screen images on bottom show SERPs of successful searches.

4.2. Neural Clustering of X, Y Fixation Coordinates

For this analysis, we have used the Neural Clustering algorithm of the IBM Intelligent Miner for Data software [19]. We have divided the data by page type (search engine results page or clicked document) and by the flag success=yes/no which indicates if the user was successful or not in finding the required information. We note that this cluster analysis does not take into account the duration of the fixation; this has been studied separately in Section 4.1. Moreover, we can say that the clusters represent the frequencies in which users' fixations in general fell within a given region.

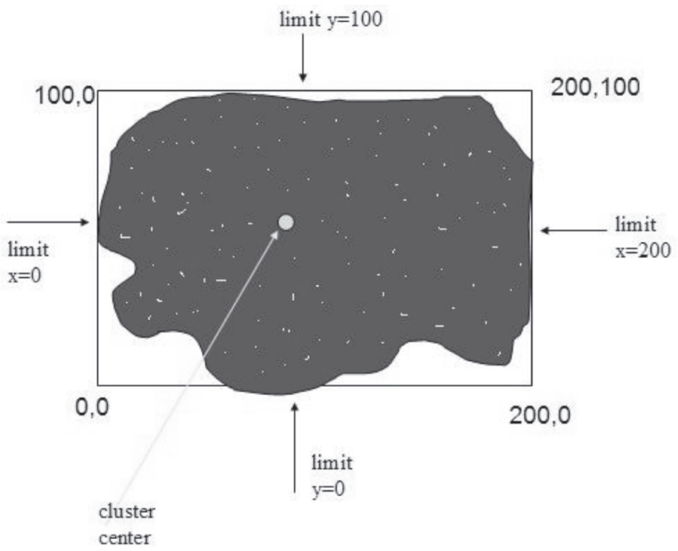

Fig. 6. Example of the association of a rectangular area of the screen with a data cluster generated by the neural clustering.

Data Processing. The following steps were taken to generate the clusters and associate them with rectangular areas on the computer screen: **(i)** create two data files, one for users who were successful and another for users who were not successful; **(ii)** for each file, give the X,Y coordinates to the clustering. The clustering algorithm generates N clusters from the data; **(iii)** for each cluster generated, calculate statistics to identify max/min values for X and for Y; **(iv)** based on the values from step (iii), relate clusters to rectangles on screen, defined by max/min limits of X,Y values; **(iv)** Check that the area is represented by a well defined cluster and not a disperse set of points (this is given by the clustering results statistics indicated by the clustering algorithm, such as the clustering density and location of the cluster center). For example, if a cluster has Xmin=0, Xmax=200, Ymin=0 and Ymax=100, this defines a rectangle limited by the corresponding X,Y coordinates on the screen: {(0,0); (200,0); (0,100); (200,100)}.

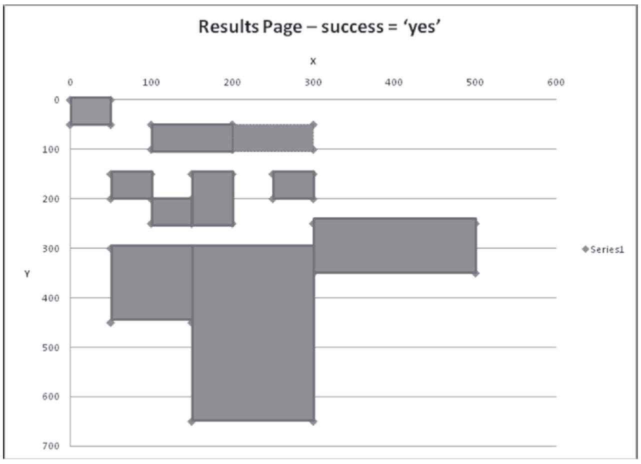

Fig. 7. Neural Clustering of X,Y coordinates.
Results Page – success = 'yes'.

Page type 1 (search engine results page)- If we compare the cluster regions (areas of interest), for success='yes' (Figure 7) and success=no (Figure 8), we can clearly observe the difference between the areas covered by the user's vision in each case. In Figure 8 we observe that the user has covered a much wider area, missing out a small region above and to the left of the screen (the y axis is reversed). On the other hand, in Figure 7 the user has focused on specific regions lower down the screen and towards the center.

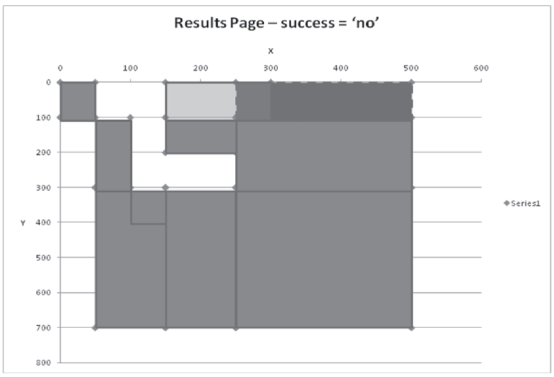

Fig. 8. Neural Clustering of X,Y coordinates. Results Page – success = 'no'.

With reference to the fixations on the area where the query box is located, we see in Figure 7 (success='yes') it is much more clearly defined (users focused more specifically on that area). The query box focus area in Figure 7 is defined approximately, as within the rectangle defined by the four X,Y coordinates {100,50; 100,100; 300,50; 300;100}. On the other hand, in Figure 8 (success='no') we see that the focus of users was not so evident in the query box area, and was more dispersed.

Page type 2 (clicked document) - In Figure 9 we show the regions which were heavily biased by the question itself. That is, the reply to the question was in a specific zone of a given clicked document (for example the Wikipedia page for the German calculator question, Q1). These regions/clusters were excluded from Figure 10, in order to only have clusters which could be generalized (independent of the question). If we compare Figures 10 and 11, we again see that the fixation areas of special interest are distinct, for users who found the reply to the question, and those who did not. However, the areas shown in Figures 10 and 11 have a greater coincidence (overlap) with respect to those of Figures 7 and 8. We can highlight the region defined by "y < 750" as having a greater scrutiny for those who did not find the answer (Figure 11).

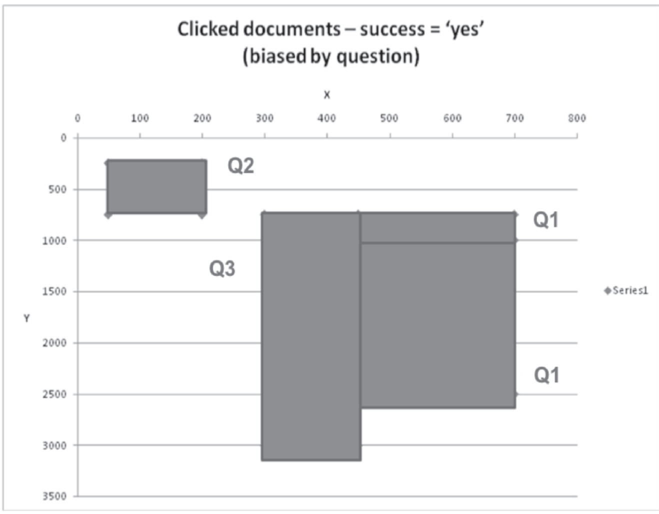

Fig. 9. Neural Clustering of X,Y coordinates. Clicked documents – success = 'yes' (clusters biased by question).

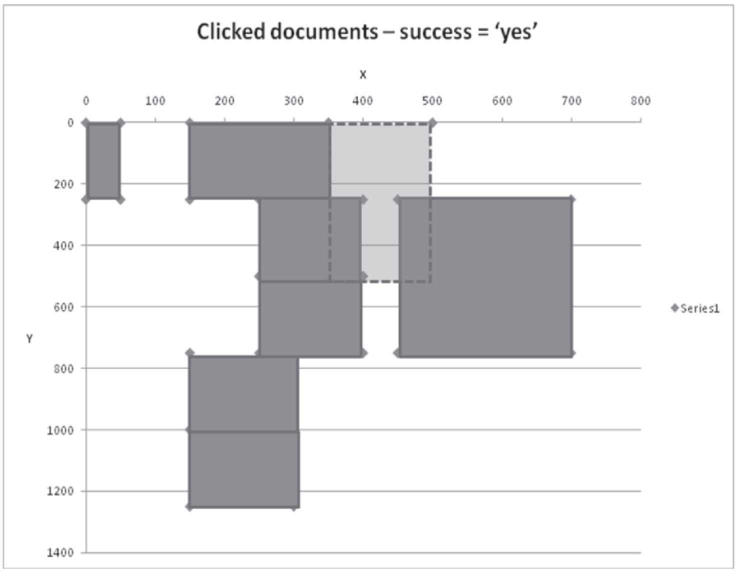

Fig. 10. Neural Clustering of X,Y coordinates. Clicked documents – success = 'yes' (clusters not biased by question).

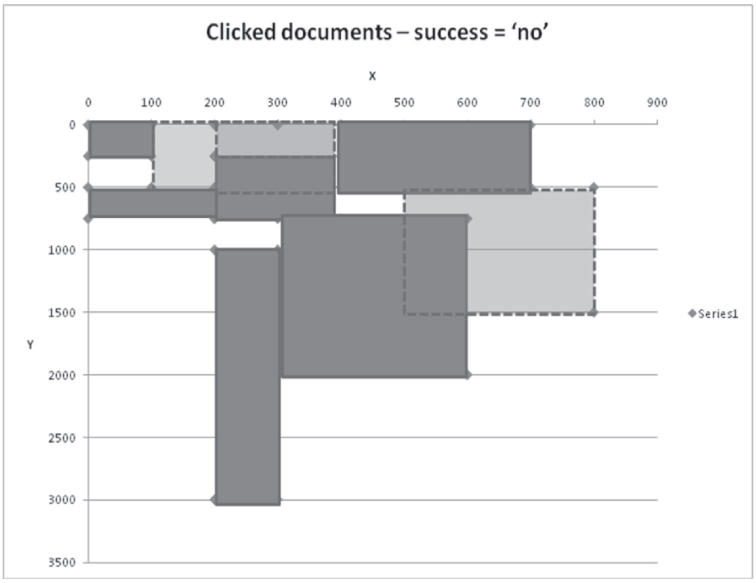

Fig. 11. Neural Clustering of X,Y coordinates.
Clicked documents – success = 'no'.

4.3. Identification of Tendencies in Heat Maps and Gaze Plots

We evaluated the Tobii heat maps and gaze plots of results pages and content pages of the users, using a scale from 0 to 5 to indicate the presence of the golden triangle and/or a structured (non random) gaze pattern on the screen. The scale was: {0:None, 1:Very little; 2:Little; 3:Some incidence; 4:Quite evident; 5:Very evident}. In Table 3 we see the compiled results for all the SERPs and CRPs. We manually inspected each screen individually, using the evaluation scale of 0 to 5 for the presence of the "golden triangle" and "structured" trends. The values in Table 3 are the average values for all pages and users. We observe that for all cases, the values for the successful users are higher than those of the unsuccessful users, ranging from a 20\% difference for CRP/structured-pattern to a 124\% difference for the SERP golden triangle.

	SERP		CRP	
Outcome of search	Golden triangle	Structure trend	Golden triangle	Structure trend
Success=YES	2.98	1.93	2.51	2.02
Success=NOT	1.33	1.45	1.56	1.69
% of difference between YES and NO indexes	124	33	61	20

Table 3. Incidence of patterns for different page types and successful/unsuccessful users.

We can conclude from this data that successful users tend to follow more predefined patterns (such as looking in the golden triangle and being systematic in their eye movement). This is most evident for the SERPs, and for the golden triangle. With reference to Figure 12 (left) we see an example SERP (results page) for a successful search, and in Figure 12 (right) we see an example SERP for an unsuccessful search.

In Figure 12 (left), we can see quite clearly a more systematic search concentrated in the upper part of the screen which agrees with the heat map results (see Figure 5), that successful searchers focus in the "Golden Triangle" for SERP pages. On the other hand, in Figure 12 (right, unsuccessful search) a different path is displayed which seems more chaotic, covering a greater area of the page and involving more time and effort (shown by the greater number of gaze points). This again agrees with the heat maps results for SERP (Figure 5). As a final comment to this section, we mention that as the experiments have dealt with real web pages, 'noise' may be introduced into the gaze statistics by the presence of embedded images, scroll options, and other features/functionality of the web pages.

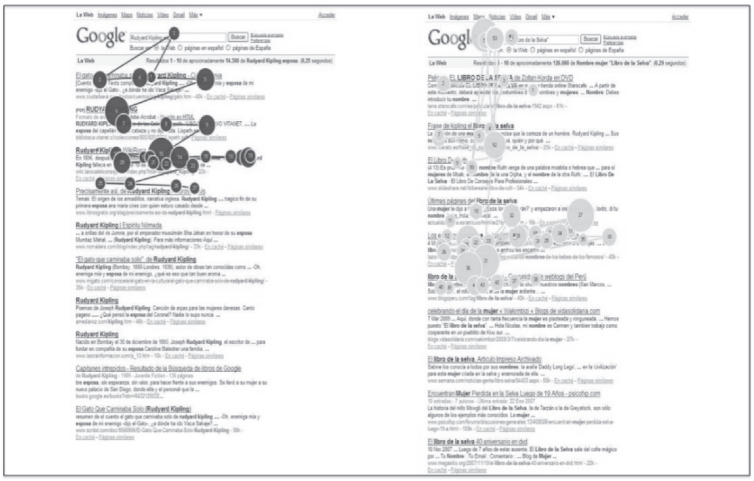

Fig. 12. Gaze Plot: SERPs (Result Pages). Gaze plots for question Q1 and search success (Yes on the left; No on the right).

5. Conclusions

In this study we have analyzed different types of factors which profile the users and query sessions in terms of successful and unsuccessful searches, taking into account the page type which can be the search engine results page (SERP) or a clicked results page (CRP). The results of the analysis of user search behavior have identified several trends, which distinguish between successful and unsuccessful searches. On average, users who are successful formulate fewer queries per session and visit a smaller number of documents than unsuccessful users. The results for fixation frequency and fixation duration of successful and unsuccessful searches suggest that the time that a user spends in SERP and CRP is more related with the strategy of search of the user than with the difficulty of the search task. Based on the scanning behavior of the SERPs and CRPs we have shown that the search strategies of the successful users are more focused and systematic that the search strategies of unsuccessful users. Now the open question is how Search Engines should react with unsuccessful users? How can Search Engines help this type of users to achieve successful searches? There are some suggested actions that can be derived from this study, for example, Search Engines could detect if a user is spending more time than the established average for a successful search and try to help the user in his task: suggestion of better queries, different presentation of the results and so on. Another important conclusion that we can derive from the eye tracking analysis of the unsuccessful users is the high cognitive effort required to select the results from the list presented by the Search Engine. Through the fixation frequency and fixation duration we can establish that it is not easy for this kind of user to select good results that lead them to the desired information. One suggestion is to enrich the snippets of the search results: if the users spend too much time evaluating the results it could be because they don't find the results sufficiently informative, so Search Engines need to consider this factor and try to offer more descriptive results.As future work we propose conducting a new experiment, with two versions of the results pages, one with enriched search result snippets, and the other with the default result snippets. Also, by programming an API to the results page, we can detect when the user is spending too much time evaluating the results or showing unstructured search patterns, and offer help at that moment.

References

[1] Baeza-Yates, R., Hurtado, C., Mendoza, M. and Dupret G., 2005. Modeling user search behavior. In Proceedings of the Third Latin American Web Congress 2005, p. 242 – 251. Buenos Aires, Argentina, Oct. 2005.

[2] Baeza-Yates, R., Calderon-Benavides, L., Gonzalez-Caro, C., 2006. The Intention Behind Web Queries. Lecture Notes in Computer Science, Springer. String Processing and Information Retrieval, Volume 4209/2006, pages 98-109.

[3] Buscher, G., Cutrell, E., Ringel Morris, M., 2009. What Do You See When You're Surfing? Using Eye Tracking to Predict Salient Regions of Web Pages Proc. 27th Int. Conf. on Human Factors in Computing Systems, Boston, USA. Session: Understanding information. Pages: 21-30, 2009.

[4] Cutrell, E., Guan, Z., 2007. What are you looking for? An eye-tracking study of information usage in Web search. Conference on Human Factors in Computing Systems, Session: Gaze & eye tracking. Proceedings of the SIGCHI conference on Human Factors in Computing Systems, San Jose, California, USA. Pages: 407 - 416, 2007. ISBN:978-1-59593-593-9.

[5] Dogusoy, B., Cagiltay, K., 2007. Evaluation of a Visually Categorized Search Engine. Department of Computer Education and Instructional Technology, Middle East Technical University, Ankara,Turkey. http://hal.archives-ouvertes.fr/docs/00/19/00/50/PDF/EvaluationofaVisually-CategorizedSearchEngine.pdf

[6] Duchowski A. T., 2002. A breadth-first survey of eye-tracking applications. Behavior Research Methods, Instruments, and Computers, Vol. 34., p.455–470 ,2000.

[7] Gaze-Based Interaction Group (Univ. Tampere, Finland), 2010. http://www.cs.uta.fi/hci/gaze/links.php

[8] Goldberg, J. H., Stimson, M. J., Lewenstein, M., Scott, N., & Wichansky, A. M., 2002. Eye tracking in web search tasks: design implications. In Proceedings of the 2002 Symposium on Eye Tracking Research & Applications (pp.51-58) New Orleans, Louisiana, March. ETRA '02. New York, NY: ACM.

[9] Hotchkiss, G., Alston, S., Edwards, G., 2005. Eye Tracking Study: An In Depth Look at Interactions with Google using Eye Tracking Methodology. White paper released by Enquiro, EyeTools and Did-It. Available at: http://pages.enquiro.com/whitepaper-enquiro-eye-tracking-report-I-google.html

[10] Lorigo, L., Haridasan, M., Brynjarsdóttir, H. Xia, L., Joachims, T., Gay, G., Granka, L., Pellacini F., Pan, B., 2008. Eye Tracking and Online Search: Lessons Learned and Challenges Ahead. Journal Of The American Society For Information Science and Technology, 59(7):1041–1052, Wiley Interscience, 2008.

[11] Nettleton, D.F., Baeza-Yates, R. "Web Retrieval: Techniques for the Aggregation and Selection of Queries and Answers". International Journal of Intelligent Systems. Wiley Interscience Publishers. Volume 23, Number 12, December 2008, pages 1223-1234.

[12] Nettleton, D., Calderon, L., Baeza-Yates, R., 2007. Analysis of Web Search Engine Query Session and Clicked Documents. Lecture Notes in Computer Science, Springer. Advances in Web Mining and Web Usage Analysis. Volume: 4811/2007, pages 207-226.

[13] Nielsen, J., 2006. F-Shaped Pattern For Reading Web Content. Alertbox. Available at: http://www.useit.com/alertbox/reading_pattern.html

[14] Pan, B., Hembrooke, H. A., Gay, G.K., Granka, L.A., Feusner, M.K. and Newman, J. K., 2004. The Determinants of Web Page Viewing Behavior: An Eye-Tracking Study Proceedings of the 2004 symposium on Eye tracking research & applications. San Antonio, Texas, Pages: 147 - 154, 2004. ISBN:1-58113-825-3

[15] Pan, B., Hembrooke, H., Joachims, T., Lorigo, L., Gay, G. and Granka, L., 2007. In Google We Trust: Users' Decisions on Rank, Position, and Relevance Journal of Computer-Mediated Communication, Vol. 12, Issue 3, April 2007. http://jcmc.indiana.edu/vol12/issue3/pan.html

[16] Poole A, Ball L.J., 2006. Eye tracking in human-computer interaction and usability research: current status and future prospects. In: Ghaoui C, ed. Encyclopedia of Human-Computer Interaction. Pennsylvania, PA: Idea Group Inc, 2006. Available from: http://www.alexpoole.info/academic/Poole&Ball%20Eye-tracking.pdf

[17] Salojärvi, J., Puolamäki, K., Simola J., Kovanen, L., Kojo, I. and Kaski, S., 2005. Inferring Relevance from Eye Movements: Feature Extraction. Helsinki University of Technology, Publications in Computer and Information Science, Report A82. 3 March 2005.

[18] Tobii Whitepaper Studying Web Pages Using Eye Tracking, 2009. http://www.scribd.com/doc/20321480/Tobii-Whitepaper-Studying-Web-Pages-Using-Eye-Tracking

[19] "Using the Intelligent Miner for Data V8 Rel. 1". IBM Redbooks, 2002, SH12-6394-00.