Eye-Mouse Coordination Patterns on Web Search Results Pages

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Abstract

We analyzed the patterns of coordination between users' eye movements and mouse movements when scanning a web search results page, using data gathered from a study with 32 participants. We discovered 3 patterns of active mouse usage: following the eye vertically with the mouse, following the eye horizontally with the mouse, and using the mouse to mark a promising result.

ACM Classification Keywords

H.3.3 [Information Storage and Retrieval]: Information Search and Retrieval – search process, selection process.

Keywords

Web search, user studies, mouse usage, eye tracking.

Introduction and related work

Researchers have explored the potential of analyzing users' click patterns on web search engines, e.g. [5]. This data is extremely valuable, especially because it represents the behaviour of users in their own environments, doing their own tasks – but it still has limitations. For example, it does not indicate which other results the user considered, before deciding where to click. Eye tracking can provide much more

detailed insights, but only on a small scale, in studies where the user is physically present. In contrast, mouse movements on web pages can be collected accurately, easily, remotely, and on a large scale, using Javascript. We therefore set out to explore the potential usefulness of tracking mouse movements on web search results pages.

Previous studies on the relationship between eye movements and mouse movements on the web [1][3][6] have found that some users will use the mouse pointer to help them read the page, or to help them make a decision about where to click. Other studies have considered the task of locating and selecting a given target item from graphical user interface menus of various lengths, e.g. [2][4].

Our goal in conducting this laboratory study was to investigate eye-mouse coordination in the specific context of web search results pages. In a previous paper [8] we reported summary statistics from the study; here we concentrate on patterns of behaviour.

Study method

Apparatus
We inserted Javascript code at the top of every Google search results page visited by the participants. This captured the user's mouse coordinates at 100ms intervals, and regularly submitted the gathered data into a MySQL database. To capture eye movements, we used a Tobii 1750 eye tracker running Clearview software, with a 17-inch screen at 1024x768.

Participants
We recruited 32 participants (14 male and 18 female; age range 24-61), with a wide range of occupations and web searching experience. All were familiar with Google. We excluded the data from 7 of them because of calibration problems with the eye tracker.

Tasks
We used a set of 16 Google web search tasks. Most were closed fact-finding questions with a specific correct answer, although we also included 3 tasks where it was up to the user to make a decision based on his or her own preference. We provided initial queries for each task, to ensure that each user would see the same page of results at first.

Procedure
To begin a task, the participant followed a link to a fake Google home page, with the initial query pre-filled in the search box, and the task description inserted underneath. Participants were instructed to press the "Google Search" button once they had read and understood the description and query. Once they reached the results page, it was up to them to do whatever they thought they needed to in order to complete the task – e.g. reading text on the results page itself, clicking on links, or changing the query.

Results: Coordination patterns

For each visit to a search results page, we generated two visualizations of the paths followed by the user's eye and mouse (see examples in Figures 2-4):

1. the eye fixations (as circles, with area proportional to the fixation duration) and the mouse data points were overlaid on a screenshot of the results page.

2. the Y coordinates of each data point were plotted against time. This style of visualization was proposed by Räihä et al [7] for eyetracking data, as

a way to clarify the order in which the user scans the search results. Adding the mouse data made it much easier for us to understand the relative timings involved, i.e. how each user was coordinating their eye and mouse movements over time. It also exposed an interesting phenomenon: users often continue to scan the results page after they have clicked, while they are waiting for their selected page to load.

Two of the authors then manually inspected these visualizations. In general, the usual starting position of the mouse pointer corresponded to the position of the "Google Search" button on the previous page – at the beginning of a task, users were forced to click on this button. This is also the most common starting point for the eye. After this point, there are a number of possible patterns. Users may simply keep the mouse relatively still until they have decided which action to take, for example to click on a particular result (as in Figure 2). We referred to mouse usage like this as *incidental* – i.e. cases where users move the mouse only for its usual purpose of clicking somewhere on the page, or manipulating the web browser.

In *active* mouse usage, on the other hand, the user seems to be making use of the mouse pointer to help with the task of processing the search results and deciding which one to click on. We found three distinct patterns of active mouse usage:

- *Following the eye horizontally*: the user moves the mouse pointer horizontally across or below the text they are currently reading – as in Figure 1.

- *Following the eye vertically*: the user moves the mouse pointer down the page so that it remains either touching or roughly level with the region the user is currently reading. This is illustrated in Figure 4, and may be a way to help the user keep track of their current place on the page.

- *Marking a particular result*: In this pattern, illustrated in Figure 3, the user leaves the mouse pointer on or near the result that seems to be the most promising one they have read so far, while their eyes continue to check more results. Often, the mouse pointer is left hovering over the title of the promising result – ready to click if the user eventually decides to select it. If another result seems more promising, the user will move the mouse on to that result, and so on. The difference between this pattern and the previous one is that the mouse seems to be used for the purpose of marking an interesting result, not simply to keep the user's current place on the page while reading.

We noted that many of the visualizations involved only incidental mouse usage – that is, the user made a quick decision to click on a result at or near the top of the page, and did not use the mouse otherwise. In part, this was because many of our tasks were very specific and had a particular target result, usually at the top of the page. It seems that the mouse does not become actively used until the user has moved past this first part of the page.

Because we were particularly interested in analyzing cases of active mouse usage, we chose to look in more detail at the 7 tasks that did not have a particular target result – e.g. a fact-finding task where the correct answer is present on many different pages, or a shopping task where it is up to the user to make a selection that appeals to his or her own tastes. We then manually classified the visualizations from these 7 tasks. In each task, we chose to use only the first visit to the first search results page, which was the same for all users. In total, then, we classified 7 tasks x 25

Figure 1: Example of the mouse following the eye horizontally. (The red dots show the eye fixations and the black line shows the path of the mouse). This user ran the mouse pointer over part of the snippet, containing the answer to the task ("The actress with the most Academy Awards for 'Best Actress' is Katharine Hepburn"), and then ended the task, without clicking.

Active behaviour	# of visits (/175)	# of users (/25)
Following eye horizontally	18	9
Following eye vertically	56	19
Marking a result	28	14

Table 1: Incidence of active mouse behaviours in the 7 tasks we analyzed. Each visit may contain multiple types of behaviour. The right column indicates the number of users who exhibited the behaviour in at least one task.

users x 1 visit = 175 visits. The results for active mouse behaviours are shown in Table 1. Overall, 78 of the 175 visits involved one of the "active" mouse usage patterns.

Although the "Following the eye horizontally" behaviour was generally quite rare, 9 users exhibited it in at least one task, and 2 users exhibited it in most of the tasks we analyzed – one for 5/7 and the other for 4/7. In most of these cases, the user was moving the mouse pointer over the answer to a fact-finding question, when that was visible on the results page, but there were also instances where it seemed that the user was simply using the mouse to help them read.

The "Following the eye vertically" behaviour was the most common of the active behaviours, and was exhibited at least once by all but 6 of the participants. 3 participants exhibited it in 5/7 tasks, and 3 in 4/7 tasks. From the visualizations of these visits, it seemed that participants were using the mouse to keep track of their current place on the page.

The "Marking a particular result" behaviour was exhibited at least once by more than half of the participants. From inspection of the visualizations, and based on previous work on selection from menus, e.g. [4], we believe that users are more likely to exhibit this pattern when they are finding the task difficult, and it is not obvious to them which result is best – especially as they move further down the page. More studies are required to confirm this.

The counts reported here apply specifically to the 7 tasks we chose to analyze, where there was no particular target result. If we had analyzed all of the tasks in the study, the overall prevalence of the active behaviours would have been lower, but the number of *users* who exhibited each active behaviour would be the same, or higher. It is not yet clear how to evaluate the representativeness of any set of web search tasks, so it is difficult to know how prevalent these behaviours would be in users' everyday web searching.

Further work
Controlled experiments, systematically manipulating the search results or the result order according to relevance, would help to confirm some of the findings presented here. Findings from such experiments would assist in generating reliable and valid metrics from mouse data. Such metrics would be a prerequisite to conducting larger-scale studies where only mouse data can be collected, e.g. by deploying mouse-tracking code on a web search site. With larger samples of data, it would be possible to use machine learning techniques to attempt to automatically identify the patterns of active mouse behaviour.

Conclusions
We discovered several different patterns of coordination between eye and mouse on web search results pages. Often, users move their mouse only to click, especially in cases where a highly relevant target result is visible near the top of the page. However, we identified three behaviours that seemed to indicate *active* usage of the mouse, to help the user process the content of the search results page: following the eye vertically, following the eye horizontally, and marking a particular result. Further work is required to enable reliable identification of these behaviours from mouse data alone.
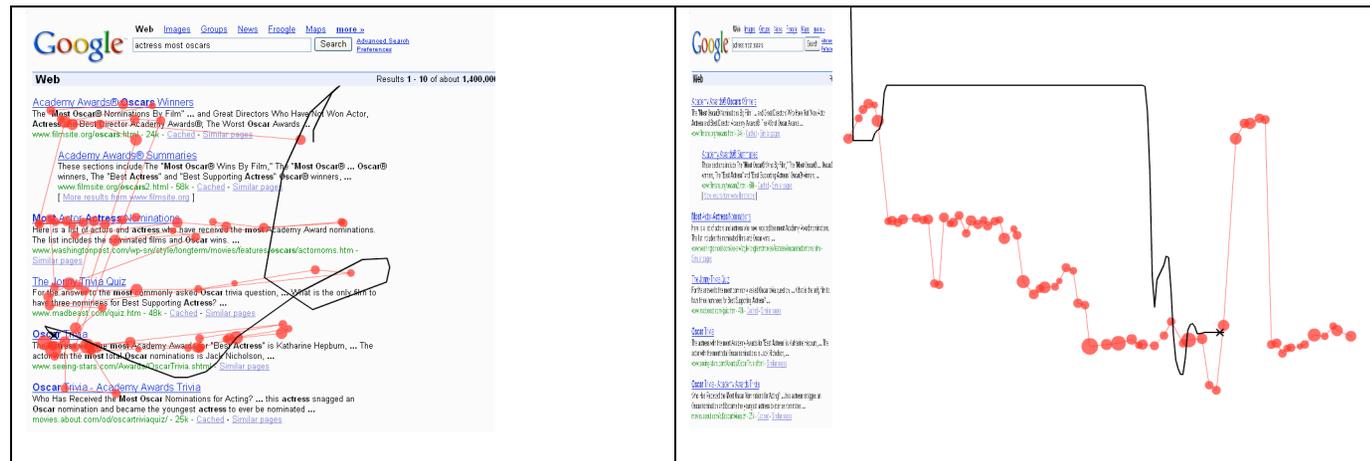
Figure 2: Incidental mouse usage – the user keeps the mouse mostly still, only moving it after reading down to result 5 and deciding to click there. In the visualization on the left, the eye fixations (red dots – with area proportional to duration) and mouse path (black line – with X for click) are overlaid on the original page. On the right, the Y coordinates of the eye and mouse are plotted against time, revealing their relative locations.
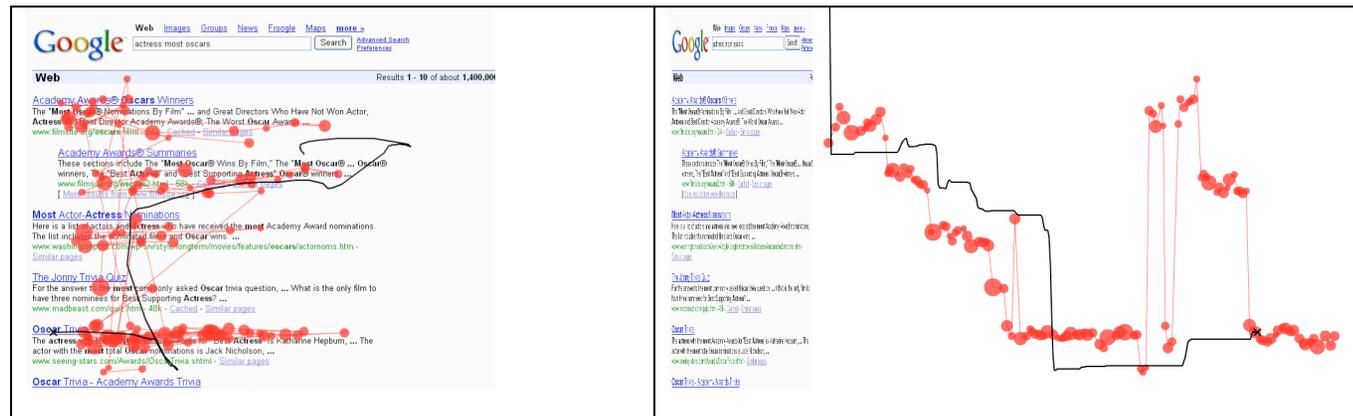
Figure 3: Example of using the mouse to mark a promising result while continuing to check others with the eyes. In this case the user left the mouse hovering over the title of result 3 while reading results 4 and 5. He then moved the mouse just below result 5 while rechecking results 1 and 2, before finally deciding to click on result 5.
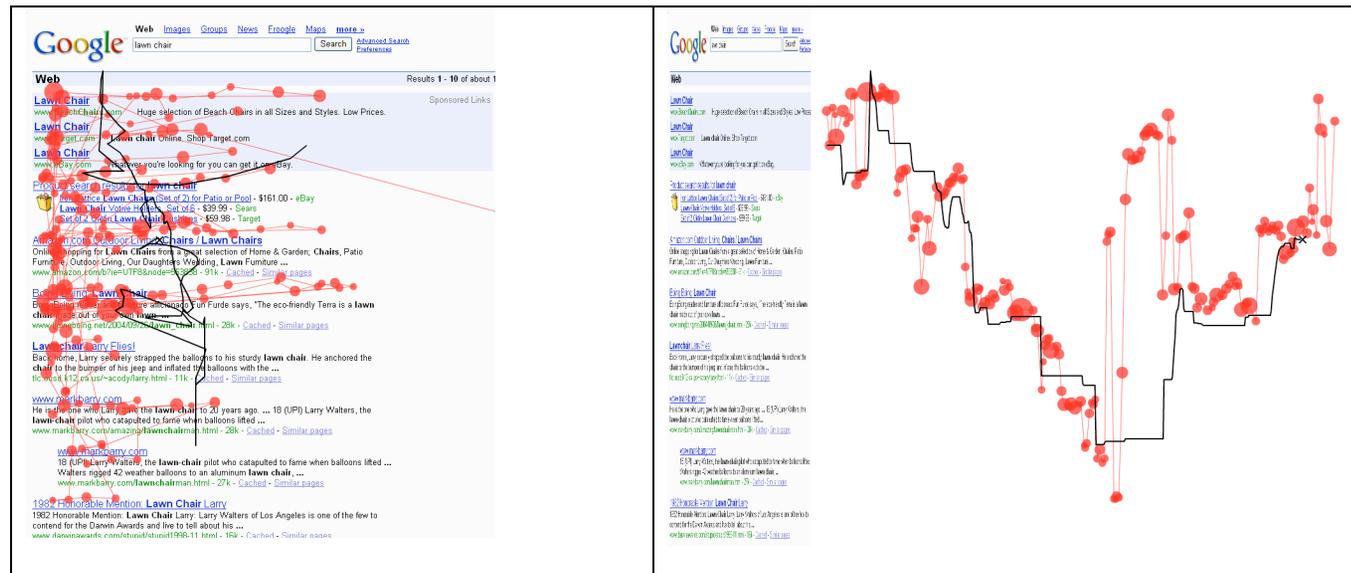
Figure 4: Example of the mouse following the eye in the vertical direction. Plotting the Y coordinate against time, in the visualization on the right, makes clear a pattern that is hidden in the visualization on the left.

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