Is the Mouse a "Poor Man's Eye Tracker"?

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How often do mouse movements match eye movements? To answer this research question, ten participants' eye and mouse movements were tracked as they performed four search tasks on a web site. From videos of participants' onscreen performance, descriptive transcripts were produced and analyzed for matches between eye and mouse movement. The findings indicate that, to a certain degree, the mouse can be considered a "poor man's eye tracker." Because of the exploratory nature of this study, additional research in this area is suggested.

INTRODUCTION

Eye tracking has recently received attention within technical communication as a method to gain insight into user behavior during usability testing. Preliminary research indicates that when eye tracking is used as an additional data collection during usability testing, it can reveal behavior that is not verbalized during concurrent think-aloud protocol (1).

A review of eye tracking studies within the fields of human-computer interaction (HCI), usability, and technical communication demonstrates how eye tracking has been used to study how users search for information on Web pages and PDAs (2). Analysis of scanpaths (the sequential representation of eye fixations and saccades), for instance, suggests that people develop different searching/scanning strategies based on the function and genre of the Web site (3). Such a finding indicates a universal web page design may not be the most functional strategy in terms of usability. Eye tracking research of PDAs by Krull and his research team (4) also suggests that people have developed scanning strategies for working with small screen user interfaces.

Drawbacks to Using Eye Tracking in Usability Testing

Although eye tracking offers technical communication and usability practitioners and researchers an additional way of learning about user behavior, the method also has its drawbacks. First, the equipment and software are still relatively expensive, despite continual price decreases. While a basic remote-mounted eye tracking system can be purchased from Arrington Research for under $8,000, a more sophisticated remote system that offers greater data collection precision is sold by Tobii Technologies and retails for around $24,400 (5). Eye tracking software, sold separately from the equipment, typically costs between $2,000 and $8,000, depending on the vendor and analysis capabilities.

The other drawback to using eye tracking in usability testing is the ability to link eye movement to specific cognitive processes. As Jacob and Karn note, "… relating eye tracking data to cognitive activity is probably the single most significant barrier to the greater inclusion of eye tracking in usability studies" (6, p. 586). As a first step in addressing this issue, Goldberg and Kotval (7) have identified several search patterns related to visual search efficiency and visual representation meaningfulness. However, these patterns have not been triangulated with verbal data collected from users. Therefore, any link between users' eye movements and their cognitive processes remain speculative.

Can the Mouse Serve as an Alternative Eye Tracker?

Until researchers explore the link between eye movement and cognitive processes, eye tracking may be better suited for research purposes than for usability testing in industry. While large companies may be able to attribute the expense of eye tracking equipment and software to the cost of doing business, smaller companies may have a more difficult time budgeting for these items.

Meanwhile, it is useful to examine data that is typically collected during usability testing — mouse movements — and explore whether the mouse can serve as an alternative eye tracker. Although this may seem like an obvious topic to address, little research has been conducted in this area. Chen, Anderson, and Sohn's (8) eye tracking study indicated that when participants use the mouse, 75% of the time the mouse and eye will move to the same region of the screen. This finding suggests that there is a fairly high correlation between eye and mouse movement. However, the study is limited because screen regions were broadly defined, and this increased the likelihood that eye and mouse movement would overlap. (Of six regions, one region consisted of the navigation menu, another region contained all onscreen text, and a third region contained all graphics.) Nevertheless, the researchers have asked an interesting research question—is there a relationship between eye

and mouse movements?—that warrants further investigation.

METHOD

This study addresses the research question: How often do mouse movements match eye movements? In this study, participants performed four short search tasks on the Washington State Department of Licensing web site. As participants worked, they verbalized their thoughts while their eye and mouse movements were recorded. The study was conducted at the University of Washington's Laboratory for Usability Testing and Evaluation. Eye movement data was collected using the remote-mounted Eye-gaze Response Computer Aid (ERICA) system and GazeTracker software, which sampled eye gaze at a rate of 60 Hz.

Participants

Ten people affiliated with the University of Washington's Department of Technical Communication participated in the study. Because of limitations with the eye tracking equipment, only participants who did not wear glasses or contacts were recruited for the study. All participants had taken part in at least one usability study, and four of the participants had taken part in at least one eye tracking study.

Tasks

Each participant performed the same four tasks on the Washington State Department of Licensing web site (www.dol.wa.gov/). All participants performed the following tasks in the same order:

1. Find the web page that gives you information about getting a motorcycle permit.
2. Find the web page that tells you how to register the trade name for your business.
3. Find the web page that tells you how many days a person who has failed the exam for becoming a private eye must wait before taking the exam again.
4. Find the web page that tells you how to get a personalized license plate.

Participants spent no more than four minutes on any given task. In most cases, task completion occurred in less than two minutes.

Data Collection and Analysis

Eye movement data were represented in "real time" where participants' eye movements appeared onscreen as an animated red "X." (Participants could not see the red "X" on the computer screen during the test.) This video also contained mouse movement, making it possible to view both eye and mouse movement on the same screen. The second video, which contained participants' verbalized thoughts, was then synchronized with the eye/mouse movement video. Time-stamped transcripts were first made of participants' verbalizations and then supplemented with descriptions of eye movement and mouse movements. A portion of a descriptive transcript appears below after the information key.

Key <Time> Verbalization produced during concurrent think-aloud protocol {Eye movement description │ Mouse movement description}

Sample Descriptive Transcript <0:29> So I'm gonna go to professions cause I remember vendors and employment, no, doesn't seem okay. {Eyes quickly move to the navigation bar. Reads navigation bar names. │ Mouse hovers over "Professions" link on the navigation bar.}

<0:34> Professions. {Eye fixates on "Professions" link. │ Mouse clicks on link.}

<0:36> Private investigators. It's already highlighted. Hmm. {Eye immediately fixates on "Professions" link under the "Professional Licensing" heading in main content panel. │ Mouse moves over to the link.}

<0:40> Let's go there. {Fixates on link. │ Clicks on link.}

<0:42> Private investigator principal and/or certified trainer exam study guide. {Reads heading/link under the "Private Investigators" link in the main content panel. │ Mouse hovers above link.}

<0:47> So this could be a red .... since somebody just highlighted it already. But... {Rapid up and down scan of the first four sections on the screen in the main content panel. │ Mouse not visible.}

<0:53> Let's look down. Renewal fees, nothing, nothing, nothing, okay. {Scans vertically down the page, reads "Renewal fees" heading. │ Mouse scrolls down screen.}

<0:58> Let's go back up here. {Eyes go back to the top of the page.│ Mouse scrolls vertically up the page.}

<1:00> Private investigator, principal and/or certified trainer state exam study guide. So that's the study guide. {Reads this link. │ Mouse moves over the words in the link as she is reading.}

<1:04> How many days she must wait before she can take the exam again? {Reading the task prompt. │ Mouse clicks in prompt window and stays there as she is reading.}

Transcript Analysis Each time-stamped unit of the transcripts was examined for matches in qualitative descriptions of eye movement and mouse movement. If necessary, verbalizations were consulted for additional detail.

Eye and mouse movement were considered to be matches in the following instances:

- Eye fixates on link name. | Mouse hovers/clicks on link name.
- Eye scans up/down to the top/bottom of the page. | Mouse scrolls vertically up/down the page.
- Eye reads words. | Mouse moves over words.
- Eye slowly scans down navigation bar. | Mouse moves down the navigation bar at same rate.

Eye and mouse movements were not considered matches in the following instances:

- Eye scans the bottom portion of the Quick Links column. | Mouse hovers over specific link on the navigation bar.
- Eye continues to scan down and then up the navigation bar. | Mouse hovers over specific link on the navigation bar.
- Eye scans first heading at the top of the main content panel. | Mouse does not move at the bottom of the main content panel.

If the mouse was not visible on the computer screen, this was noted in the transcript and the time-stamped unit was not included in the calculation of onscreen mouse time. Total times were then calculated to determine matches between eye movement and mouse movement.

RESULTS

Because of file corruption or loss of eye tracker calibration, the number of individual task sessions for analysis was reduced from 40 to 27. The eye and mouse movement data collected from these tasks totaled 34 minutes and 2 seconds. The mouse appeared on the computer screen 29 minutes and 22 seconds. In the text below, Match Time refers to the percentage of time the eye movement matched the onscreen mouse movement.

An ANOVA test was run to determine whether Match Times differed—in terms of statistical significance—across the four tasks. This step was necessary before the Match Times for all four tasks could be added together. Since Match Times were represented as percentages, mean percentage scores were converted to arcsin values (9). (Using percentage data would have violated the assumption that data are normally-distributed.) Table 1 shows the Match Time mean percentages and arcsin values for each task.

Using the converted arcsin scores—and assuming a Type 1 Error set at $p \leq .05$—the ANOVA test showed no significant difference in Match Times across the four tasks, $F(323) = 1.25$; $p = .313$. The small sample size limits the statistical power of this test; however, it is reasonable to conclude that task content did not significantly affect Match Times in the study.

Task	Number of Participants	Mean Percentage	Arcsin Value
1	6	59%	.533
2	7	74%	.633
3	7	67%	.587
4	7	69%	.596

Table 1. Mean Match Time and converted arcsin values by task.

DISCUSSION AND CONCLUSION

In terms of total task completion time across all four tasks, the mouse appeared onscreen 86% of the time. This finding suggests people are active mouse users as they search for information. While some participants used the mouse more than others during task performance, none of the participants set aside the mouse for the entire task and only used the mouse in a functional manner (clicking on links or scrolling).

For all tasks, eye movement matched mouse movement 69% of the time the mouse appeared onscreen. This finding indicates the mouse can, to a certain degree, be considered a "poor man's eye tracker."

Because of the small sample size used in this study, the results should be viewed as exploratory. (Therefore, a larger, follow-up study is recommended.) Nevertheless, when the findings from this study are examined in light of the findings from Chen, Anderson, and Sohn's (8) eye tracking study, mouse movement appears to be a fairly accurate reflection of eye movement.

Do these findings indicate that eye trackers do not belong in usability testing? Not necessarily. Eye tracking still provides a means for capturing information about user behavior that would be difficult to obtain through other methods, including mouse movement tracking. In this study, participants still looked at parts of the screen

without ever placing their mouse in the same area. For usability researchers and practitioners who need this type of information, eye tracking is still the best way to obtain it.

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