Using eye tracking for usability testing

a research note by Namahn

Introduction

The purpose of this research note is to explore how and if eye tracking should be used for usability testing on intranets and Internet sites.

Definition

Eye tracking is a technique allowing testers to determine eye movement and eye-fixation patterns of a person.

Eye tracking can be used in both passive and active modes (3). In usability testing, eye tracking helps software designers to evaluate the usability of their screen layouts. It is an example of **passive**, "monitoring" use of eye tracking, because the eye-tracking devices simply monitor eye activity for later study and analysis. Other examples of passive mode are:

- Behavioural scientists can monitor what pilots or control room operators look at when given certain tasks or placed in certain situations.
- Reading specialists can use eye tracking to recognize when a person is reading and when he/she has fixated on a word longer than normal, in order to create a highly individualized reading aid.
- Marketing researchers can determine what features of product advertising and packaging attract buyer attention.

Eye tracking can also be used to actively direct a computer through the motions of the eyes (**active**, "control mode"). Examples are:

- Disabled people who cannot use their hands to operate a computer can do so with their eyes, using on-screen keyboards and mouse controllers.
- Hospitals can provide an eye-aware communication program to people who have lost their ability to move and speak, either temporarily or permanently through a traumatic accident.

Eye-tracking technology

There are different ways of determining the direction of a person's gaze (1). The "pupil-centre/corneal-reflection" method is probably the most effective and the most commonly used one.

The method is based on the idea that the direction of a person's gaze is directly related to the relative positions of the pupil and the reflection of an object off the cornea. This remote eye-tracking method does not require physical contact with the user's eye or eye socket. It uses reflector trackers: a beam of light is projected onto the eye, after which a sophisticated camera picks up the difference between the pupil reflection and known reference points to determine what the user is looking at.

So, this method involves the following procedures:

1. A calibration procedure, enabling the eye-tracking system to learn about several physiological properties of the tested person's eye
2. Illuminate the eye in order to reach the bright-pupil effect (cf. red-eye effect in flash photography), an effect necessary to locate the centre of the pupil
3. Measure the locations of the pupil centre

4. Locate the relative position of the corneal reflection
5. Calculate the direction of gaze (through image processing algorithms)

Other eye-tracking methods make use of equipment such as skin electrodes or marked contact lenses. The “electro-oculography” method, for instance, involves measuring electric potential differences between locations on different sides of the eye. However, remote eye tracking seems to be the most widespread method.

Eye tracking in usability testing

Eye tracking versus traditional usability testing techniques

>> © Eyetracking, Inc.: an eye-tracking session

At present, **traditional usability testing** still is widely used to determine the quality of web site and intranet design. Traditional testing usually involves participants having to perform a number of tasks while being observed by the experimenter. The following is measured:

- Time to complete the task
- Percentage of participants succeeding
- Type and number of errors
- Subjective ratings of ease of use

Supporters of eye tracking claim that certain types of questions about usability are difficult to answer efficiently via traditional techniques. Suppose a user is spending longer than expected looking at an interface of a web site, without making the appropriate selection to reach his goal. A “think aloud” protocol or an interview afterwards won’t always reveal the reason for this failure. Different possible explanations will puzzle the experimenter:

- Did the user overlook the hyperlink or button?
- Was he distracted by another visual element in the interface?

- Did he see the link or button, but fail to understand its purpose?
- Did he look at the company branding elements?

It is obvious that different answers to these questions would lead to different design solutions: e.g. in case of distraction, an unnecessary animated gif could be omitted. Without knowing the answers to these questions, design recommendations however would have to be implemented by trial and error. In such cases, supporters of eye tracking claim, user's eye movements can offer additional insight (4).

Eye tracking: benefits

So what relevant information can we get out of **eye tracking**? Eye movement recording can provide a record of the following:

- The pattern of fixations (scan paths)
- The time spent looking at various display elements
- The deployment of visual attention

During the CHI 99 workshop "The hunt for usability: tracking eye movements" (4), a team of workshop participants focused on incorporating eye tracking in usability tests, and they came up with a "list of reasons for using eye tracking during usability tests:

- Support other types of data
- Help discriminate "dead time"
- Measure how long a user looked at an area of interest
- Capture a sequential scan path
- Evaluate a specific interface
- Extract general design principles
- Demonstrate scanning efficiency
- Understand expert performance for training
- Help to sell usability testing
- Provide a quantitative comparison of UI designs
- Provide domain specific benefits (web pages, cockpits, text design)
- Help explain individual differences"

Difficulties, constraints and unresolved issues

Constraints

What can be possible difficulties, **constraints** of the eye-tracking method (13)?

- Some persons cannot be eye tracked for physiological reasons: the pupil may not reflect enough light, or the iris may be too light in colour to be distinguished from the pupil reflection; the pupil may be too large or it may be occluded by eye lashes or eye lids, making the eye difficult to track; the person may have a wandering eye; etc.
- Other persons cannot be eye tracked, for external reasons, such as eyeglasses or hard contacts.
- Problems can occur during the eye-tracking process: a person's eyes may dry out during an experiment and become difficult to track. Sometimes a participant can be eye tracked one day

and not the next, or half way through a test the eye track degrades to the point that the data collected cannot be used.

- While using a remote eye-tracking system, head movement may cause a delay until the eye tracker reacquires the eye, and may also cause loss of calibration. Restraining methods to keep the participant's head stationary may cause the participant to feel awkward and the testing situation to become completely unnatural.

- Interpreting eye-tracking data isn't always easy, and can be an issue. Integrating eye-tracking data with data from traditional interviewing and observing methods can be even more challenging.

Negative consequences of these constraints are:

- Restricting participants to those for instances without glasses limits the participant pool and may affect how representative the sample is.

- The low success rate of gaining useful eye-tracking data from participants, and as a consequence the loss of participants (because of unacceptable data), means time and money wasted. Does the data collected from just a few participants justify the cost?

Unresolved issues

At the CHI 99 workshop "The hunt for usability: tracking eye movements", a team of participants discussed technical issues with the eye-tracking technology. It suggested a number of issues that were considered to be "the most significant unresolved issues in the area of incorporating eye tracking in usability testing:

- How to handle excessive volume of data

- Correspondence of eye position and deployment of attention

- Integration of multiple cameras

- Fuse eye, mouse, facial expression, voice input, other data

- Standardize definitions of derived data (e.g. fixations)

- Taxonomy of dependent measures and applications

- Reduce complexity of equipment use and data analysis

- Techniques to deal with spurious data."

Study results

A few examples of eye tracking illustrate what can be learned from eye tracking as a usability testing method. The first example is an example of commercial use of eye tracking, the second a scientific research on eye tracking, the third a case study for a customer service site. Some of the most striking results of both studies are listed.

UIE, a User Interface Engineering company (1)

What did usability testers of UIE learn about interface design via eye tracking?

- Users typically look first in the centre, then to the left, then to the right of a web interface.

- New and experienced web users scan essentially the same way. At first, the new user scans pages from left to right, as if reading a book. But he quickly changes to the centre-left-right sequence.

- Users rarely look at the bottom of the page section that is visible, i.e. the area just above the browser's status line.

- Peripheral vision plays a significant role in what users see.

The Stanford-Poynter Project (9)

The Poynter Institute released an eye-tracking study of how people read news on the Web, mainly focusing on newspaper websites. The study led to conclusions such as:

- Text attracts attention before graphics: headlines, briefs and captions get eye fixations first. Often, users only look at images during the second or third visit to a page.
- Banner ads do catch online readers' attention. For the 45 percent of banner ads looked at all, the tested people fixated on them for an average one second.
- Users frequently alternate between multiple sites (interlaced browsing). So users are not focused on any single site.

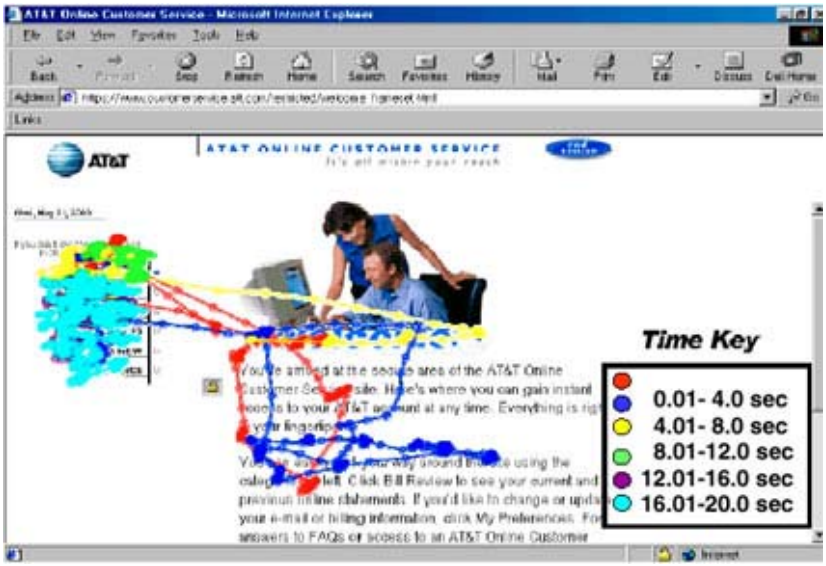
>> © Stanford-Poynter Project: illustration of the fixation order:

Case study: the AT&T Customer Service Site (6)

This study was based on new and existing users of the online service provided by AT&T, and illustrates an approach of usability testing that integrates state-of-the-art eye-tracking techniques with traditional interviewing methodology (integration of qualitative and quantitative approach). It focused on the functionality and usability of the home page of the site.

Three essential characteristics of a website are usability, visibility, and optimisation. The eye-tracking analyses focused on measures of these three features:

- Usability was measured by the time to succeed a task, the rate of success and the degree of confusion shown by the participants. Especially the degree of confusion (as displayed by new users) could be deducted from the eye gaze patterns.
- Visibility: a second measure derived from patterns of eye movements indicates the extent to which all relevant regions of a display are noticed. Eye tracking enables experimenters to determine if some regions were attracting too little attention while others are attracting too much.
- Optimisation: eye tracking enabled the researchers to determine the number of non-page-changing extraneous menu items that were inspected (and then rejected) by the user. This number was used as a measure for efficiency: with optimal performance, a user would make few or no extra clicks on the menu items.



>> © Eyetracking, Inc.: gaze-trace, indicating a high rate of confusion

The conclusion of the researchers was that the "combination of eye tracking with in-depth interviewing produced strong corroborative results. Through this process, we were able to verify that what we interpreted as "confusions" were indeed confusions, and we were able to probe why these confusions occurred. This integration provided the research team with a richer interpretation than either technique alone. The result is a set of strong, detailed recommendations for site improvement that have both statistical and qualitative bases."

Should we use eye tracking for usability testing? Some opinions…

S. Schnipke and M. Todd, George Mason University, Virginia (13)

"We believe (eye tracking) is still not a practical tool for most usability laboratories. The loss of participants due to eye-tracking constraints requires the experimenter to allow more time for usability testing. This may place unacceptable constraints on a usability laboratory faced with a limited budget and a tight schedule. Because there are many different tools and methods available for researchers to collect data, we recommend that eye tracking only be used if there is no alternative method for collecting the necessary data.

Any laboratory that is considering a major purchase of an eye-tracking system should be aware of the ramp-up time associated with eye tracking and the likely data-collection success rates. Due to the absence of "failure" data, it is important for researchers to report their rejection rates and let the community know the problems they can expect to encounter if they decide to use an eye-tracking system. The experiences described in this study are typical of other tests we have conducted using eye tracing equipment. We do not believe that we are a unique case or our equipment is an exception and are the only ones to achieve such a low success rate. However, we do believe we are a unique case in reporting the challenges we have encountered with collecting eye-tracking data."

Jakob Nielsen, usability engineer, as quoted by Hakim (11)

The level of usability testing reached in using eye tracking "is incredibly, exceedingly rare," said Jakob Nielsen. (…) He said that while usability testing was common in many industries, he had heard of eye-tracking tests being conducted only at universities like Stanford, for Internet-related research, and by the Navy and a few technology companies.

"There's no doubt it pays off dramatically, particularly for a site where people do a huge amount of transactions," Mr. Nielsen said. "Errors are a disaster for that type of system. The return on the investment is so huge that you can't even discuss the cost of building a lab. It's trivial."

Will Schroeder, Principal of UIE, User Interface Engineering (2)

Schroeder has used eye tracking in several recent usability studies. He believes that “eye tracking does some things well – and others not at all”.

According to Schroeder, eye trackers **can**:

- Tell whether users are looking at the screen or not.
- Differentiate reading from scanning for particular words or phrases.
- Learn the relative intensity of a user’s attention to various parts of a web page.
- Determine whether a user is searching for a specific item. Pupil diameter appears to increase when users are not sure what words they are looking for.
- Compare users’ overall scan patterns.

Eye trackers **can not**:

- Let you know whether users actually “see” something.
- Prove that users did not see something (Users can acquire information through peripheral vision).
- Determine why users are looking at something.
- Test everybody (there are certain constraints which make certain persons unfit to be tested).

Alexei Oreskovic, journalist (10)

“Many people associate usability testing with high-tech labs complete with two-way mirrors and fingernail-size audio-video equipment. All that's nice, but it's hardly essential. (…) High-tech eye-tracking equipment, which pinpoints exactly where a person's eyeball gazes on an individual Web page, is another unnecessary luxury. It can be useful (a recent study by the Poynter Institute found that online newspaper viewers looked at text first and images later), but it's usually excessive. Frankly, it's more worth my while to go to the Web and read somebody else's research than it is to spend $50,000 and start an eye-tracking lab.”

Karn, Ellis and Juliano, authors of a report on the CHI 99 workshop “The hunt for usability: tracking eye movements” (4).

Karn, Ellis and Juliano believe that “incorporation of eye position recording into product usability evaluation can provide insights into human-computer interaction that are not available from traditional usability testing methods.” It also helps “reduce trial and error in user interaction design.” “All group members (of the workshop team that focused on incorporating eye tracking in usability tests) agreed that it is worth the time and effort to collect eye tracker data when the domain is well understood.”

Commercial eye-tracking applications – prices and deliverables

Some eye-tracking companies

Eyetracking, Inc (ETI) is a provider of eye-tracking services. EyeTracking's patented technology can evaluate a user's experience while interacting with applications and Web sites. The company’s web site offers information about deliverables and prices. It also has an interesting press corner.

Veritest, a testing service provider, offers eye-tracking usability tests. It has several labs in North America and Europe (Ireland, France), and has an alliance with Eyetracking, Inc.

Eyetools, Inc. uses patented eye-tracking technology developed at Stanford University to produce improvements in web site design.

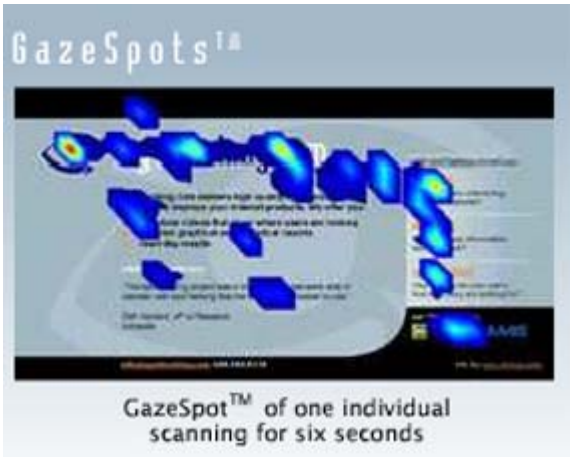
Applied Science Laboratories (ASL) is an American provider of technology and systems for eye tracking, with distributors in Europe. They offer complete eye-tracking sets for usability testing. Such sets consist of a remote eye tracker, a magnetic head tracker, a camera with separate remote control, a portable computer, Asl software, etc. The set comes in a carry case that is light (under 15 lbs.) and that can easily fit in the overhead of an airplane.

The Dutch company Testusability offers usability testing using an eye-tracking system called "EyeCatcher". Other eye technology companies are: Erica Inc., LC Technologies Inc. and Fourward Technologies Inc.

Example 1: Eyetracking, Inc sells eye-tracking usability testing:

Deliverables are:

- Real-time videos that show what users saw/missed: the videos show the point-of-gaze that is superimposed on the display images, providing a clear view of where the user was looking at every instant.
- PowerPoint presentation of graphs and analyses:
  - "GazeSpots" show the relative amount of time spent by one or more users across a visual display. The intensity of use over the visual display is reflected by colour variation.



  - "GazeStats" provide percentages of time spent in predefined regions of interest.

  - "GazeTransitions" show the transitions of the gaze from region to region (using numbers to indicate the order)

– "GazeTraces" display the gaze of a single user over time as he or she works through a particular part of an interface (different colours indicate the amount of time spent on each part)

- DVD recording of all data and results
- Written summary with recommendations

Pricing:

- ETI Concept Testing - $ 7500/Day
- ETI WebCheck - $ 9500 (report available in 48 hours)
- ETI Custom Website Evaluation – starting at $ 12,500
- Pricing excludes travel-related expenses, respondent recruitment & incentives, and use of professional moderator for exit interviews

Example 2: LC Technologies, Inc. sells complete eye-tracking sets:

LC Technologies, Inc. produces the "Eyegaze Development System". Cost of such a Basic Development System in June 2001: $17,900 in U.S. Dollars. It consists of the following components:

The first component is the Eyegaze **Software** Development Tool Kit: Calibration Program, Gaze Tracking Demonstration Program, Fixation/Saccade Analysis Function, Windows 2000 Professional, Microsoft Visual C++ Professional Edition Compiler, etc.

The second component is the Eyegaze System **Hardware**:

- Computer System (Modified for Integration with Eyegaze): Intel Pentium 3 Processor, 128 Megabyte Memory, 15" LCD Flat Panel Monitor (1024x768), Floppy Disk Drive, Hard Disk Drive (10GB), CD-ROM Drive, Video Frame Grabber Board
- Monitor Support Arm with Camera Bracket

- High-Speed Infrared Sensitive Camera and Lens (RS-170 or CCIR)
- Infrared LED, Power Source and Filter
- Eye-Image Video Monitor (Monochrome)
- Power Surge Protector, Cables and Connectors
- Optional: Portable Computer (in place of desktop computer): $1250 extra

Eye tracking in Belgium

In Belgium, as an initiative of Hogeschool Antwerpen (Departement Ontwerpwetenschappen), Viewlab currently studies the usability of products, using the eye-tracking technique.

>> © Viewlab: a head tracker (left) and the “I-scene system” (right)

Siteview, a continuation of Viewlab, focuses on the usability of interfaces. Though still in a research phase, the Siteview project has already provide usability testing for two external clients. It uses the remote eye-tracking system called SMI (Sensomotoric Instruments) and can offer the following deliverables:

- Videotape with the interface and a cursor overlay, indicating eye movements
- Scan paths, the duration of fixations, the time spent in certain predefined “areas of interests”: this information is based on x-y-coordinates data.
- Analysis of the eye-tracking data, resulting in a limited set of recommendations

Conclusion

The conclusion of Namahn is that generally it considers the use of eye tracking as a method for usability testing to be a case of “**overkill**”. For a commercial web site for instance, it is in most cases exaggerated and even unnecessary. Usability testers will reach the same results simply by spending time on studying the current eye-tracking material available (research, studies, conferences) on the one hand, and other, general usability literature on the other hand.

However, using eye tracking can be a good strategy if it is combined with traditional techniques and in very specific cases only. First, there is a **quantitative** argument in favour of eye tracking: it is worth the investment in case of very large usability testing budgets, of sites of which revenues depend largely on placing of advertising and type of advertising, and of systems that allow (or depend on) large transactions. In such cases, a minor improvement in usability will save a company a lot of money, and it is a fact that a usability tester does get additional information when using the eye-tracking method and not limiting him to traditional testing methods.

Another argument in favour of eye tracking is that it **helps to sell usability testing**. The eye-tracking method results in a series of numbers. It provides a quantitative, “scientific” basis for evaluating user behaviour; traditional usability testing is often reproached to lack such a basis. Thus, an integrated approach, an approach that combines traditional interviewing and measuring techniques and eye tracking, is in some cases useful and advisable.

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