Printed in: Empowering Software Quality: How Can Usability Engineering Reach These Goals? Usability Symposium 2005: pp 141-152, OCG publication vol. 198.

Eye tracking in usability research: What users really see

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Abstract:
This paper discusses how eye tracking can be used to supplement usability testing and intends to identify best practice about eye tracking in its scientific and practical sense, especially as applied to commercial usability engineering practice.

Keywords: Eye Tracking, Usability Evaluation, User Interfaces, User-centered design.

1. Introduction

Recently eye tracking is becoming a popular method in the context of the usability research. With the help of an Eye tracker the users pupils and their position on a screen are tracked and thus provide detailed data about the users visual attention on user interface elements. It can be used as a valuable source of information about users behaviour. This paper discusses how eye tracking can be used to supplement usability testing and intends to identify best practice about eye tracking in its scientific and practical sense, especially as applied to commercial usability engineering practice.

2. History of eye tracking in usability research

Eye tracking has a long history in usability research but has not widely been used. Reasons for this are that eye tracking technology was complicated to use and thus was rather expensive for using it in commerecial projects.

Early eye trackers were head mounted or forced subjects into fixed head positions both of which affect the natural situation for the test subjects.

Remote eye tracking measurements are made unobtrusively via a remote video camera mounted below the computer monitor. It is discretely integrated into a monitor, providing a more natural user environment.

3. Visual perception

3.1. Foveal and peripheral perception

One can distinguish between foveal and peripheral vision, due to the physical construction of our eyes. The central one or two degrees of the visual angle (the fovea) provide the bulk of visual information; the input from larger eccentricities (the periphery) is less informative. The purpose of the peripheral perception is mainly the guidance of the gaze. Eye tracking systems are capable of recording the foveal vision exclusively.

3.2. Fixations and saccades

Ocular movements are divided into fixations and saccades. Fixations appear, when the eye gaze pauses in a certain position - normally lasting between a quarter to a half of a second. Most information from the eye is made available during a fixation. The main goal of a fixation is to identify the fixated object.
Saccades are the jumps of the gaze between fixations.

3.3. Reading

The perceptual span, that is the size of the visual window, where the reading occurs, is asymmetrically. We need 3 to 4 letters to the left and up to 15 letters to the right of a fixation for reading a text. The asymmetrical alignment of the perceptual span depends on the language we read (e.g. it is reversed in Hebrew). Reading does not happen in exact linear saccadical movements, sometimes we need control fixations, that move towards the text directions. Control fixations are necessary if a word or a phrase is not understood by itself or in the connection with the framing phrase. Words we do not encounter frequently will more probably need control fixations to be perceived correctly. 10 to 15% of all fixations are backward fixations.

The fixation of words is not randomly – it is left to the center of the words. But while reading not every single word will get a fixation. Frequently used and short words (e.g. “the”, “and”, “or” etc.) will normally encounter no fixations. The average length of a forward fixation is 7 to 9 letters in the English or German language. It is shorter in languages like the Chinese, where a sign contains more information.

4. Eye tracking Metrics & Data Visualization

4.1. Live-Observation and Video

Modern eye tracking systems allow live-viewing of the eye-movements of an object. The moderator of a usability test can watch the gaze of the test user, in combination with the screen, the test person looks at (see fig. 1).

Figure 1. Live observation showing gaze trail on website, test subject and subjects pupils.

Live-Viewing makes eye tracking a highly useful observation instrument. The moderator can immediately react on the behaviour of the test person. E.g. when a test person examines an object repeatedly the moderator can directly ask what the test subjects thinks about that object.

4.2. Scan Path – Gaze Plot

The resulting series of fixations and saccades is called a scan path (see fig. 2). The blue points mark the fixations in numeric order. The blue lines are the saccades. Gaze plots are useful in providing a snapshot image of attention during a test. However, for long recordings, this view quickly becomes cluttered and the dynamic gaze replay or the hotspot visualization described below becomes more suitable.

Figure 2. Scan path and fixation visualization.

4.3. Hot Spot

Hot spot maps show aggregate eye fixations and viewing of a screen (see fig. 3). It summarizes the gaze positions received from multiple sessions and users, and creates a hotspot map based on this data. This map is superimposed on the stimuli used in the test. Depending on the type of eye tracking software being used, hot spot visualizations can be applied for slide shows and web pages or even for scenes within a screen movie.

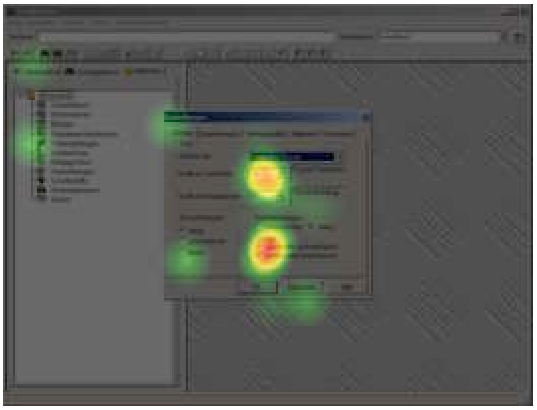

Figure 3. Hot spot visualization.

4.4. Area of interest

The area of interest analysis allows to define areas within a page and to compare eye tracking data for those areas, e.g. number of fixations, fixation duration etc. Fig. 4 shows the definition of areas on a webpage. Such areas could be the menues, the pictures, the searching opportunities, the content or other points of interest. Fig. 5 illustrates a comparison of gaze time the users spent in each area.

Figure 4 .Definition of areas of interest.

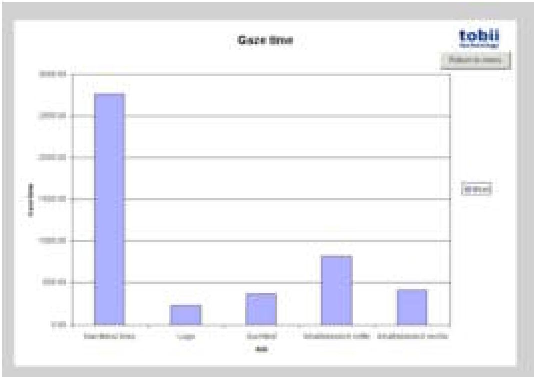

Figure 5. Area of interest data visualization.

5. Usage of eye tracking in a usability lab

In our usability lab we use a remote eye tracker. The system is non-invasive, there is no physical contact between the user and the system. The eye tracker is integrated in a standard TFT monitor which lets users easily forget that their gaze is being recorded. Fig. 6 shows a test subject in an eye tracking situation. The system allows the subjects to move their heads freely within a cylinder of appr. 30 centimeters in length and with a radius of 10 cm. Both eyes are tracked. As eye tracking does not work with all sorts of human eyes, e.g. eyeglasses, contact lenses or small pupils reduce the precision, test persons have to be chosen carefully.

Each test starts with a short calibration phase of appr. 10-30 seconds that teaches the eye tracking software how the eyes of a particular subject look and behave at certain screen positions.

Figure 6. Test person in an eye tracking situation.

Usability testing covers a range of methods for identifying how users experience an interactive system [4]. A typical method is the thinking aloud method: A subject performs typical tasks according to a previously designed test script. The test person is requested to “think loud” and talk about what she thinks about the elements she finds on the screen and her user experience. It is also typical practice that usability engineers sit in the same room with the test person and ask questions to get the information they need about the user´s mental model of the system.

Not all questions regarding the user experience can be answered extensively by the method of thinking aloud. In addition to this method eye tracking data can provide valuable input to get more information about certain situations in usability testing [7].

From the set of metrics that are provided by eye tracking systems certain metrics may be more suitable for certain situations than others.

6. Identifying and solving usability problems

6.1. Users don´t read, they scan

Users of interactive systems most probably will not read text, instead they scan for useful information. When watching eye tracking videos this fact immediately gets obvious: there is a large number of fixations on different separated parts of the screens. It seems the gaze wanders more or less randomly and extremely fast across the screen. Eye tracking clearly shows if subjects read texts or if they just scan for information.

Fig. 7 shows a gaze plot of a scene comparing reading and scanning: the subject read the text in the marked area and scanned the rest of the screen. While scanning only single words and some images received fixations.

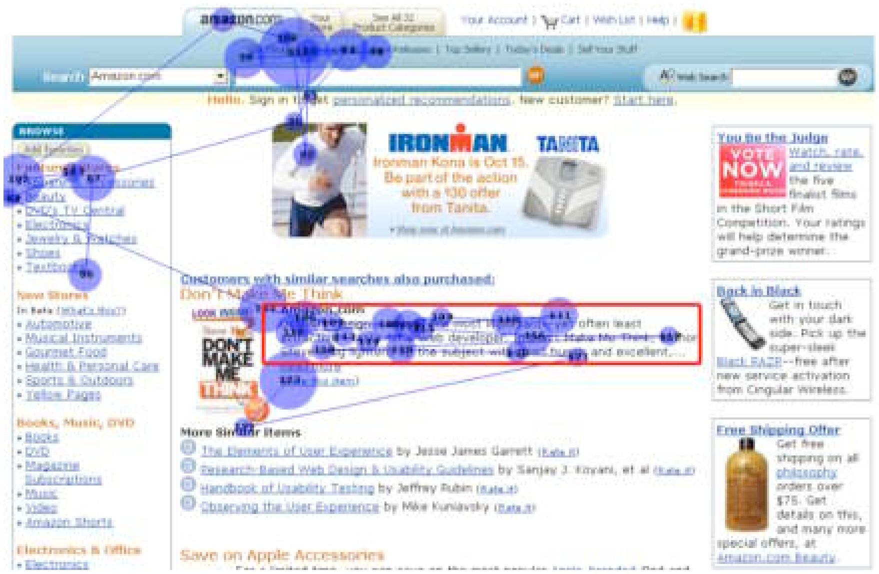

Figure 7. A gaze plot shows that the user read the text in the marked area.

Eye tracking data clearly reveals which textual information is read. Furthermore it shows which information subjects scan to fulfill a certain task.

E.g. people typically scan down a list of headlines, as shown in Fig. 6, and often don't need more than one fixation to decide if the headline is important. On average, a headline has less than a second of a site visitor's attention [6].

For usability engineering purposes it is very important to find out which text parts, people read on the screen. Eye tracking is the most effective method to figure this out. Alternatives for finding this out would be the thinking aloud method or by interviewing the test subjects after the testing.
All these methods are highly dependent on the individual subject: her memory and her ability of introspection. Eye tracking is a more objective method to detect if a subject is reading or not.

The following study shows an example where reading would be required to fill out a form correctly (see fig. 8). The text above the entry fields states that the user has to use a password of a certain length. Most of the users in the study had problems filling out the form and got at least one error message. Eye tracking data shows the reason for these usability problems: users don´t read the form filling information. The recommendation to solve this problem is to present information concerning the password length next to the password field, as consistently postulated by the “law of proximity” in Gestalt theory [5].

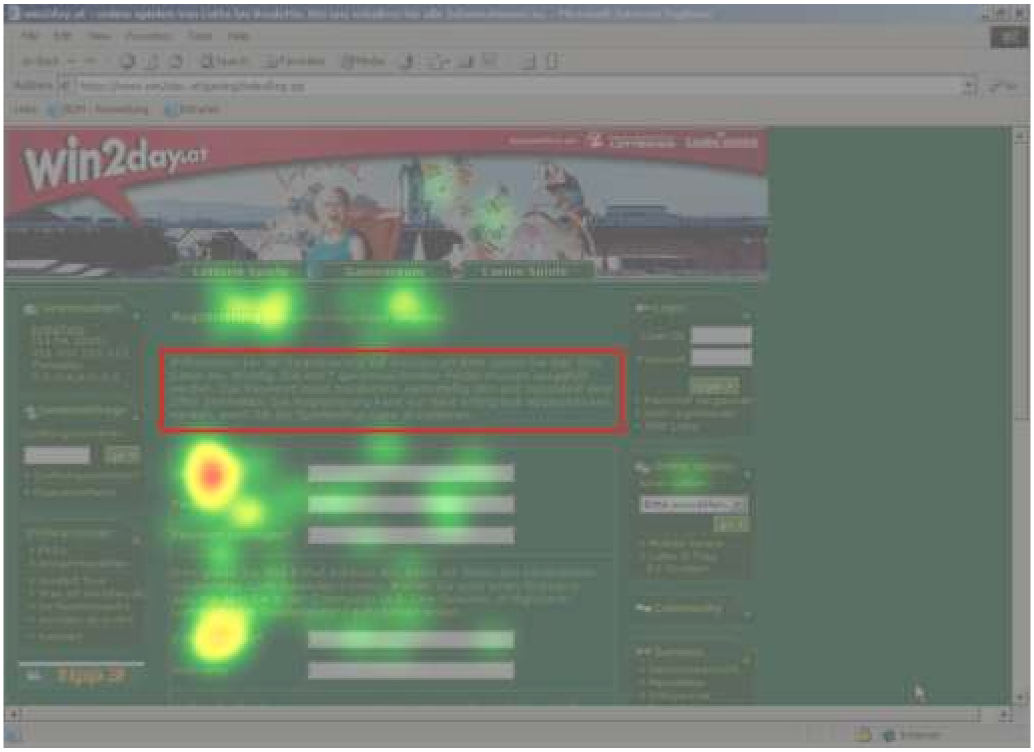

Figure 8. Eye tracking study hotspot picture that shows that users ignore text above an entry form, which contains important information about the password format.

6.2. Wording problems

Incorrect wording is a reason for a large amount of usability problems. If a link on a webpage has a wording the user does not understand, she usually does not click that link. In general users do not want to spend an extensively amount of time on web pages. They will rather ignore a link they do not understand, than finding out what is behind that link. An important finding in a usability test is, whether correct wording is consistent with the target audiences expectations.

Eye tracking without a controlled usability testing situation (i.e. the subject has no concrete task) could not give a clear answer to that question. If a user focuses a word longer than other words or has more fixations on it, it is still unclear whether this is due to the fact she is figuring out what the word means or simply because she finds it amusing [3,8].

Whenever eye tracking is used while a test subject searches for a concrete information, the interpretation of the eye tracking data is much easier: e.g. a test subject that examines a link with several fixations and finally does not use it or click it - although the link would lead to the correct information - will most possibly have a different expectation about the suitable wording.

6.3. Web standards

Certain design practices are so common, that they are de-facto standards. In the case of web sites for example, users expect to find the logo in the top left corner of the page [1,2]. Standards enhance usability because users do not have to learn new interaction paradigms when switching between applications or web sites or even other media like newspapers or books.

For the positioning of screen elements eye tracking can show where users expect certain elements. In a study to compare different types of navigation menues we were interested where users looked for primal orientation (see fig. 9). Users were shown a website and were asked, which site it was. Subjects most commonly concentrated on the left top side of each site – no matter where the main navigation was actually positioned.

The implication for design of navigational aids is, that the left-top position is the most important position to show users where they are located.

Figure 9. Eye tracking study picture that shows were users looked for primal orientation.

6.4. Lack of affordance

Affordance is a desirable property of all user interface elements. It describes a situation where an object's sensory characteristics intuitively imply its functionality and use. E.g. a button in 3D look suggests the idea of pushing it. Affordance naturally leads people to take the correct steps to accomplish a goal.

Fig. 10 shows an example where lack of affordance leads to usability problems. In this study of a data warehouse software the users had to go through a wizard with several screens that had a left side navigation that additionally should show the users where they were.

It turned out that the test persons had problems in navigating the wizard. The gaze plot shows a testing situation of a single person. The navigation does not get any attention. It obviously lacks the affordance of a navigational menu, so users do not look there for navigation possibilities.

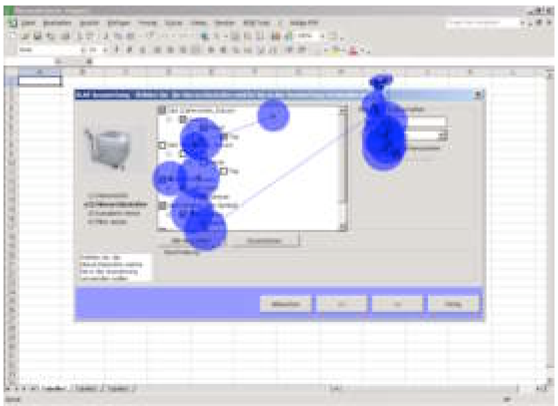

Figure 2. Low affordance of a navigation menu makes it unattractive to the users eye.

6.5. Bad information design

In a study of an online banking system users were shown the entry page of the system and asked what they could do there. Figure 11 shows a hot spot visualization of a left side navigation of this situation. Eye tracking data clearly shows that the links underneath the text "UNSERE ANGEBOTE ONLINE" get much less attention than the links above it. The reason is, that the text does not look like the other menu items, but looks like a heading. It does not follow the "Law of Similarity" of the Gestalt theory, which states that objects that appear to be similar will be grouped together in the learner's mind [5]. In this case similarity includes font style and size. Because users are not too much interested in this "heading", they ignore the text underneath the "heading" as well.

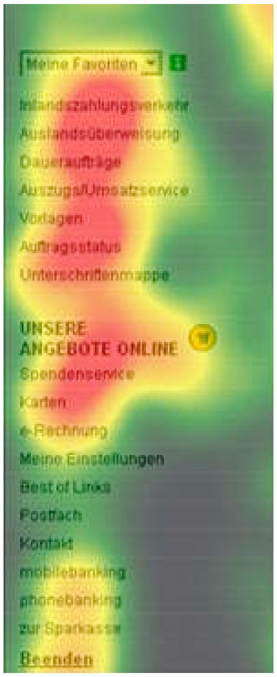

Figure 3. In this left-side navigation of an online banking system the text "UNSERE ANGEBOTE ONLINE" looks like a heading. Because users read it as heading, and they are not too much interested in online offerings, they ignore the links underneath it.

6.6. Wrong eye catchers and vampire effect

Sometimes usability problems arise from placing eye catchers on a page that distract the user from interaction elements that are important for them to complete a task. The eye catchers cause a so called "vampire effect": they draw away and consume the users attention completely. Vampire effects can easily occur when emotional pictures, banners or animations are used extensively, but also, if the difference between important interaction elements and less important elements is not visualized correctly.

Fig. 12. illustrates an example, where such an eye catcher was used. The marked areas are the most important areas where the user decided about the type of product she wanted to order and a very small button for completing the shopping process. A large amount of the user´s attention is drawn away by two links in blue boxes that lead to other offerings and a word in pink. Several of the test users clicked the links in the boxes, with the effect that they were driven away from the order form and thus were interrupted during the ordering task.
Most site owners would agree that it is rather counterproductive to disturb the user´s intentions of buying a product.

Solving the problem does not imply much effort. It is enough to use a confirmation button that obviously looks like a button and to downgrade the less important links in their visual affordance.

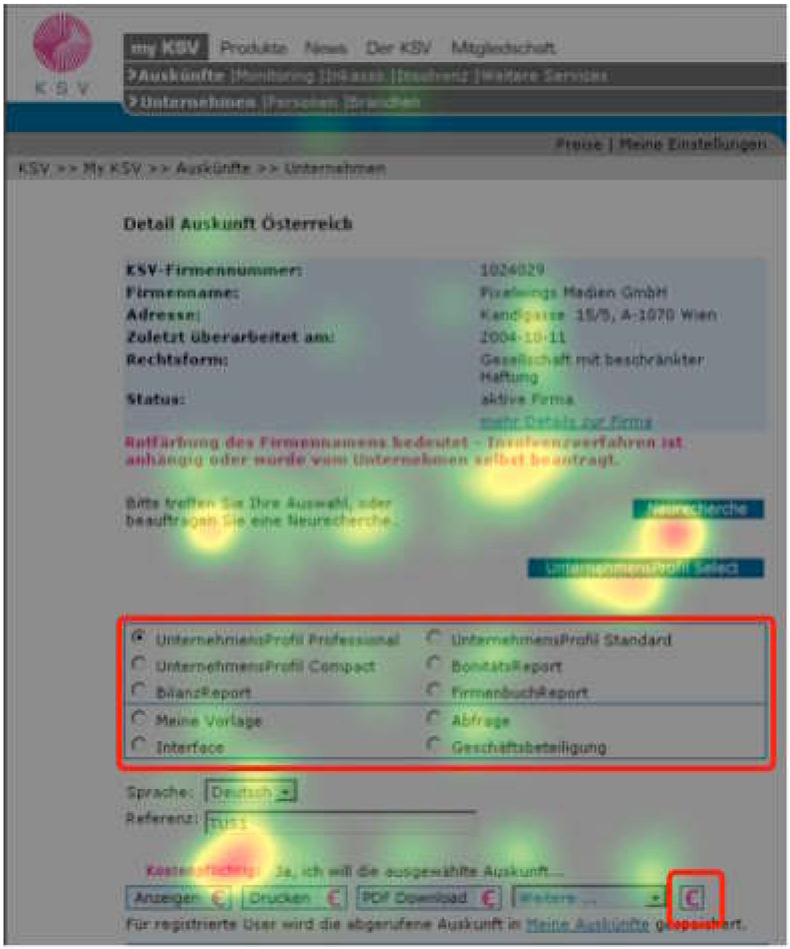

Figure 4. Elements that are not important drag away the user's attention from the main page elements in the marked areas.

7. Conclusion and future directions

Eye tracking is presently a valuable instrument to enhance the findings of qualitative usability testing. The experiences emphasize the importance of interpreting eye tracking data within the context of the user interface being evaluated.

Still there is a great need for studies that analyze the utility of eye tracking as an additional source of information in usability evaluation.

Eye tracking technology should still be further developed from a technical point of view, aiming at more precision, less failure and more usability for the usability engineer. It will be a challenge to develop remote, i.e. non-invasive eye tracking methods for ubiquitous computing like mobile phones and all kind of user interfaces that are not displayed within a typical computer monitor.

8. About the Authors

Martina Manhartsberger and Norbert Zellhofer are CEOs of Interface Consult (Vienna, Austria). Founded in 1994, Interface Consult is a usability consultancy & lab that offers usability support for all kind of user interfaces. More information can be found on: www.usability.at.

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