Chapter 7

The application of eye tracking in business

Eye tracking is a method of study allowing for the verification of how humans perceive objects in front of them (e.g. Internet websites on the computer screen). This method consists in tracking the movement of eyeballs with the help of a specially designed video camera which is capable of registering even the most minute eye movements. Thanks to this method we can learn what people look at, which elements are perceived by them and which are omitted. It allows to check whether a particular graphic design, e.g. for an Internet website or an advertisement, meets its marketing objectives – i.e. whether recipients see those elements of the message which are crucial to the seller [W13].

7.1. Introduction

This technology is especially useful when studying the behaviours of the clients of Internet shops. Thanks to eye tracking, website designers have the possibility to understand how consumers see and read websites created by them [NP10]. They may measure what way the gaze of potential clients crosses in order to accomplish the intended tasks, on which parts of the website their gaze stays longer, how they react to advertising (whether they look at it at all), whether the menu navigation is clear enough for the first-time visitors, how users react to the contents of both texts and images, as well as films and flash clips.

7.2. The work of eye tracker

The mode of action of an eye tracker is based on the observation of eye movements with the help of an Internet camera or specialist light emitting diodes placed in the corners of a screen. The camera detects the placement of eyeballs (or pupils, to be more precise), which are lit with infrared light invisible to the naked eye (fig. 1). Infrared is reflected in the eyes and creates reflections, which are known in physics as ‘Purkinje images’. Those reflections are well-visible reflexes in pupils (fig. 2). Those reflections may be tracked with a camera. By observing the reflection of the diodes on the eye, one may identify the place the person is looking at.

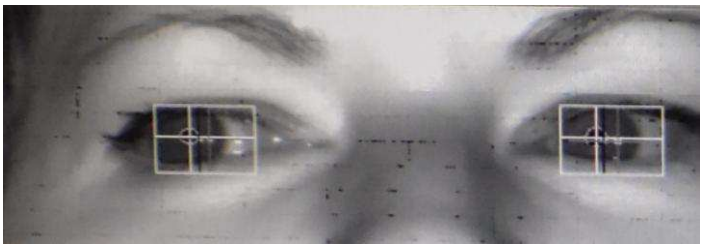


Figure 1. Pupil movement tracking by an eye tracker made by SensoMotoric Instruments (SMI)

Source: author's own materials.

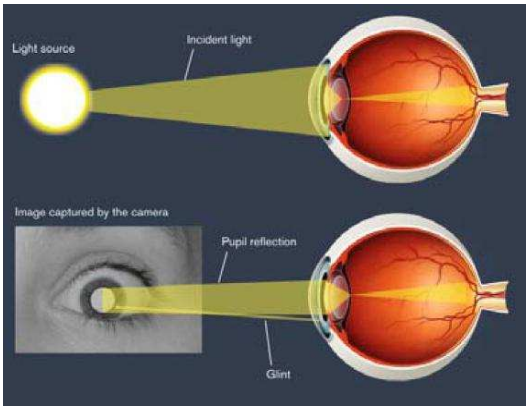


Figure 2. How a reflex in the pupil is created

Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o.

Both stationary eye trackers (integrated with a computer screen) and mobile devices (usually to be put on the head) are available on the market (fig. 3).
Stationary eye tracker does not differ in appearance from an ordinary monitor. During the test there is no need to connect the respondent to any external device. Hence the test is entirely non-invasive. During the test the respondent simply sits in front of the monitor and watches projected images. In the casing of the LCD screen there is a hidden miniature video camera which records images for both eyes. The control programme processes those images and in real time provides data on the current line of sight direction, i.e. which point of the screen is looked at by the respondent. The measuring process is done "in the background" and therefore does not limit in any way the natural behaviour of the respondents during their work

with any utility programme, particularly an Internet browsers and Web applications. The measurement provides precise information about which points of the screen are looked at by the respondent. The position of the eye is measured 60 times a second and hence one is able to record even really quick glances and reading process with high accuracy. The accuracy of the measurement is more than 1 cm on a 19-inch screen for a typical distance range for working with a screen, i.e. ca. 50-70 cm. The system used by us is dedicated for Human-Computer Interactions (HCI) studies.

a) b)

Figure 3. An example of
a) a stationary eye tracker - Tobii TX300, b) a mobile eye tracker - Tobii Glasses

Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o

A mobile eye tracker, on the other hand, allows the respondent to enjoy full freedom of movement in their natural environment, which allows the researcher to gather data regarding what has drawn the attention of clients in shops or whether they have noticed prominently displayed elements of interior design (fig. 4). It may also be used for the optimisation of the display of information and marketing elements. Eye movements of a respondent are recorded by the device and subsequently, thanks to using radio communication with the workstation, are sent to the workstation where they are digitally processed, analyzed and interpreted.

Figure 4. The study of shelf display with the use of a mobile eye tracker Tobii Glasses

Source: http://www.tobii.com/en/about/news-and-events/press-room/#/images/tobii-glasses-in-package-design-shopper-research-68340

7.3. Calibration of an eye tracker

Before eye tracking is recorded, each respondent undergoes a calibration procedure [D07]. During this procedure an eye tracker measures the characteristics of respondent's eye and uses them, together with an internal physiological 3D eye model, to calculate gazing data. The 3D model gathers data on the shape, refraction of light and the properties of refraction for different parts of the eye (e.g. cornea, the placement of the fovea, etc.). This is followed by sampling in points of calibration, which appear on the screen (fig. 5). On this basis samples for a chosen amount of points are gathered. The results are then integrated with the model (there is a moment of learning the model).

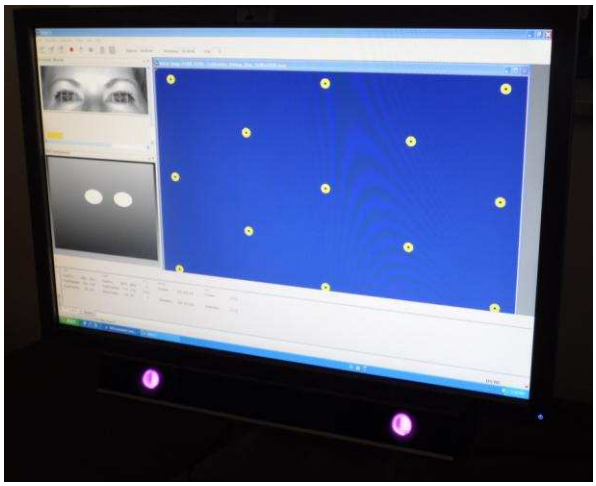


Figure 5. Calibration of a SensoMotoric Instruments (SMI) eye tracker

Source: author's own materials.

Once the calibration procedure is finished, its quality is illustrated e.g. by red and green circles (fig. 6), with red circles indicating where the calibration is not correct and the green ones where it is proper. Additionally, the accuracy ratio for the left and the right eye is calculated. By properly executed calibration this ratio should not be higher than 1. If it should exceed 1, the calibration procedure should be conducted again.

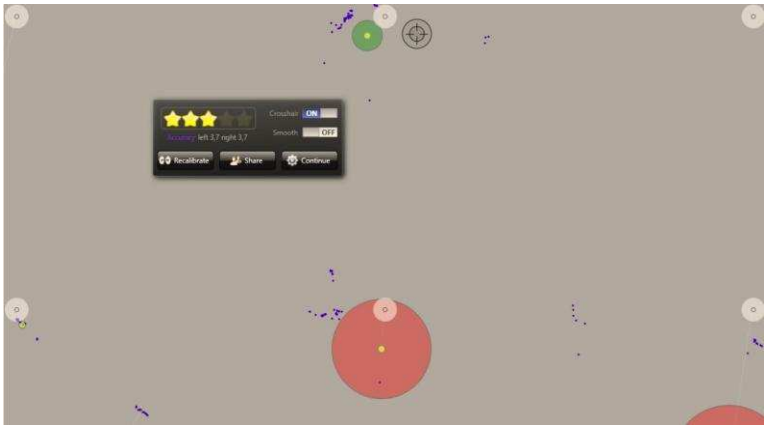


Figure 6. Calibration window in the ITU Gazer Tracker programme

Source: author's own materials.

7.4. The methods of analyzing and presenting the results

The majority of eye tracking data is analysed in the context of performing specific tasks, e.g. reading, searching information. The interpretation is done on the basis of the registered:

- fixations – the time the eye is focused on one element of the image,
- saccades – moving the eye from one focus point to another,
- residence time in a particular area of interest, calculated from the moment of making the decision to move to that are,
- mean time and total time dedicated to looking at particular elements of the test object,
- number of revisits – returns to a certain element (e.g. company logo, slogan, studied product),
- individual elements of an image depending on the type of material tested.

Tables 1 and 2 show various methods of presenting data obtained in eye tracking studies.

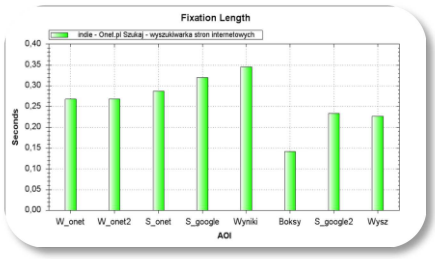
Table 1. Methods of presenting eye tracking test results – part I.

	Scanning path Presents the sequence of perceiving individual areas. It allows to specify whether the elements crucial for the Client are perceived first. It helps to identify elements distracting from the main contents.

	Heat maps Summary results of attention focus of a particular group of respondents. It allows to determine which elements of a service/advertisement drew the attention to the greatest extent and which were ignored.
	Blind zone maps More graphic presentation of a classic heat map. Highlights clearly for the Client which elements of a service/advertisement were noticed by a user.

Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o.

Table 2. Methods of presenting eye tracking test results – part II.

 	Statistics Averaged or summed up data concerning chosen issues, e.g. the duration of fixation on particular areas of interest, mean time necessary to find certain information, attention distribution according to respondents' sex, age, proficiency in navigation, etc. Separate areas with percentage record of attention distribution shown for example in the form of semi-transparent layers superimposed on the advertisement, containing the percentage description of how particular elements attracted the attention. Various statistic may be gathered for such areas.
	Videos of conducted studies Precise record of what the respondents did during the study. Where they looked, for how long and in what sequence, which contents escaped their attention. The film may be supplemented with a preview form a camera recording respondents' reactions. They allow to analyse user's exploration path of the material.

Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o.

7.5. The uses of eye tracking

Taking into account the fact that looking and cognitive processes connected therewith occur almost all the time and everywhere, eye tracking studies are not only used to study how useful particular applications and Internet services are. Modern eye trackers are becoming increasingly common in studies concerning many fields of life, starting at navigating in a real-life shops and looking at shelves, perceiving the urban space, through watching outdoor advertisements and television commercial, driving a car, up to sports games [WP06].

The analysis of human perception provides us with information not only to study where the gaze is directed but it also constitutes a basis for the studies of problem solving, reasoning, attention or mental images. Eye tracking allows to understand many aspects of human cognition and behaviour, and the range of its applications is still growing.

The main measures used in eye tracking are fixations, i.e. focusing the eye on one element, and saccades, which are fast movements of an eye, occurring in between fixations. One should, however, remember that eye tracking studies do not provide clear answers as to whether a user understands the perceived contents. Only data on how it is processed is obtained and such data may be variously interpreted.

The future of eye tracking are not only the studies of the Internet, but first and foremost other visual media, such as television, games, virtual environment and urban space. This will not only extend the range of studies, but also the knowledge about psychological bases of gazing, attention and remembering. This will be affected by technological development and more detailed measurements with ever less invasive apparatuses connected therewith. In Polish market analyses of such areas as urban space or television with the use of eye tracking are still rare. Current results of an eye tracking study may provide us with answers to the following questions:

- What attracts client's attention and what remains unnoticed?
- Is information included in the tested materials visible?
- Are the crucial elements of press and television advertisements noticed?
- Are the logo and the brand placed in the best possible place?
- Is the brand included in product placement appropriately located?
- Are Internet sites, instruction manuals or forms created correctly and clearly?
- Are there any distracters in the studied material?
- Is the product correctly displayed in the point of sale?

7.6. The areas of the use of eye tracking

Eye tracking in usability testing

This area is of key importance in studying Internet sites and applications. Not only for marketing purposes but also in studying interactions of the process with the application. Thanks to this we are able to check:

- the trajectory of the eyeball movement and the time of focus on particular objects,
- in what sequence objects attract client's attention ,
- distracting elements,
- frequently viewed elements,
- correct or incorrect display of modules on the website, by the sequence the objects are scanned.

The use of eye tracking to study ergonomics

From the point of view of a client, ergonomics is of key importance when choosing a product. Here it is measured how easy and intuitive a product is in use. Eye tracking studies of ergonomics are used in testing mobile phones, panels, cockpits, audio/video devices, household appliances and even working posts. Thanks to this study we can check:

- the clarity of the elements,
- what distracted the respondents,
- which elements were not found and why,
- whether their use and behaviour was predictable,
- whether the elements were in places the respondent expected them to be.

The use of eye tracking in psychology

Eye tracking studies increasingly often provide new possibilities in many areas of psychology. We owe it to the technological development and increased availability of equipment as well as the increase in analytical possibilities. Eye tracking may be used in:

- *cognitive psychology and cognitive science* – eye tracking studies of the perception of visual stimuli, relations between the form of information and the way it is perceived, the behaviour of people while driving vehicles and human-computer interactions;
- *developmental psychology* – eye tracking studies of the development of eye-hand coordination, the development of attention allocation skills, relations

between motion control system and text comprehension and the studies of autism;

- *experimental psychology* – eye tracking studies of face perception and recognition, visual perception of scenes and images and the differences in using visual and spatial functions in healthy people and people with damage to the nervous system;
- *psycholinguistics and reading* – eye tracking studies of recognising reading difficulties, training programmes supporting reading skills and the correlation between visual perception and reading proficiency;
- *neuropsychology and mental health disorders* – eye tracking studies of the analysis of the strategy of watching scenes and images by healthy and diseased people, correlation between EEG images and eye movements and the exploration of seeing mechanisms;
- *ophthalmology* – eye tracking studies of the properties of rapid eye movements, diagnostics of disorders of muscles moving the eyeball and the assessment of the effect of surgical and conservative treatment of, for example, strabismus for patient's eye and movement activity.

The use of eye tracking in advertising

The study of advertising creation aims at checking what the client really sees and what is totally ignored. Thanks to this we have the possibility to optimise the advertising message and choose the best design option. Eye tracking study allows to determine which elements were viewed most often and longest. The first seconds of client's contact with the advertisement are essential. Eye tracking shows which elements attracted the attention and which remained unseen. Therefore we have the full and detailed picture of the effectiveness of each advertisement. With the use of eye tracking we may study:

- press advertisements,
- video commercials,
- internet advertisements,
- outdoor advertisements,
- e-mailing.
- The use of eye tracking in studying the shelves in shops

Eye tracking has its use in modern commerce, where current methods have not provided satisfactory results. It concerns both macro- and micro-level navigation. Macro-level navigation refers to the layout of product categories in the entire area

of a shop or one shelf. It is connected with the communication of categories and sales sections. Eye tracking studies aim at suggesting appropriate layout of products in order for clients to freely move around the shop and at the same time to have all the informative elements within the reach of their sight. Micro-level navigation consists in building planograms, i.e. optimum layout of particular products on a shelf. This aims at adapting sale space in order for it to be as efficient as possible. Aside from sale in its value and quantitative approach, one should also take into consideration clients' needs, i.e. placing product on shelves according to their needs. Micro-level navigation also deals with the clarity of price and product labels.

Eye tracking is used during qualitative studies and supplements the process of studying shelves. In this part of the study various shelf arrangements, advertising materials, price labels, wobblers, etc., are tested. The behaviours of a respondents are examined with the use of an eye tracker in conditions which are as natural as possible.

Thanks to eye tracking systems our environments becomes increasingly clear, i.e. we will easily find our way to the underground station, cash point, or a particular shop in a shopping centre. Eye tracking is also used in assessing the evacuation and warning signs.

7.7. The examples of eye tracking use

Example 1

The study uses a stationary eye tracker X2. Respondents' task was to look at packages of mint chewing gums by various producers. The aim of the study was to check to what extent particular graphic elements attract attention. Figure 7 shows summary results of the attention focus of a group of respondents in the form of a heat map.

The heat map allows us to conclude that:

- central location and contrasting colours of the logo on the package of the "Trident White" gums strongly attracted respondents' attention,
- vertical lettering on the package of the "Dentyne Ice" chewing gums caused the respondents' attention to be spread all over the package,
- horizontally placed logo on the package of "Trident White" gums concentrated the attention in one place.[1]

[1] *Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o.*

Figure 7. Summary results of the attention focus

Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o.

Example 2

In a study with the use of a stationary eye tracker the respondents were asked to perform two tasks. The first one consisted in finding a chosen product, and the second one – subscribing to a newsletter. The commands were formulated in a general way. The eye tracking study was done on the basis of shop masks of an Internet shop in food industry (data on the basis of study report *Eye tracking studies of shop masks of Home.pl, IAI-Shop.com and Sote.pl* [*Badania eyetrackingowe masek sklepów Home.pl, IAI-Shop.com i Sote.pl*], http://blog.sote.pl/wp-content/uploads/badanie-ideacto-usability-sklepow.pdf). The results, shown in the form of a heat map, showed those elements of shop's website which require improvement and proven solutions (fig. 8).

The study showed that:

- the placement of the searching option was very intuitive – respondents did not have to waste time to find it,
- simple and clear layout of the page resulted in the fact that respondents had no difficulties in navigating the shop and finding options they needed (e.g. newsletter),
- the ordering process was intuitive and posed no difficulties for respondents,

- search option that did not search for alternative names of products impeded the completion of the task,
- incomprehensible categorising impeded finding products,
- they only action buttons on the product lists were the "add to cart" buttons – there was no action to go to the product card (one could go to the product card after clicking the picture),
- messages on the page were visually imperceptible, i.e. could not be distinguished from the rest of the website and therefore did not attract respondents' attention,
- no information on the measuring unit caused confusion, as respondents did not know whether they order products per item or per kilogram.

Figure 8. Heat map obtained during the analysis of an Internet grocery shop.

Source: http://blog.sote.pl/wp-content/uploads/badanie-ideacto-usability-sklepow.pdf

7.8. Conclusion

Eye tracking studies may provide many important conclusions about studied products. It is possible, for example, to offer a few designs of a particular website or application and to check in which case respondents do best. One may also check whether what people say about a product is confirmed by what they do. One should remember that study methods such as questionnaires or IDIs (In-Depth Interviews) can be purposefully falsified by respondents whereas their gaze cannot be that easily manipulated.

Eye tracking also provides answers to questions on whether respondents saw the elements key to the object of the study (logo, the "buy" button, etc.), where they expected to see particular contents, which contents were read. One may achieve really good results when combining eye tracking studies with usability tests. Thanks to this combination one may obtain information as to why people had difficulties in performing their tasks, which may not always be obtained during a regular conversation about the task. Eye tracking studies have also shed some light on the universal website designing. They helped to detect the so-called banner blindness, which shows that banner advertisements are completely ignored by respondents' gaze.

Since human sight is the most complex and the most significant way of perceiving the world by people, an eye tracker provides us with information that is impossible to obtain during any other study. It has been tested that human gaze follows the attention. This statement is the main assumption confirming the significance of eye tracking studies. There are, however, examples proving that this statement is not reversible, i.e. human attention does not follow the gaze. One of them is the so-called Ketchup Bottle Problem. It consists in the fact that people see certain elements – which is proved by eye tracking tests – but when asked about this element, they do not realise that it was displayed. This fact, hindering the interpretation of websites or applications tests, is a part of evidence that an eye tracker may be used for research for scientific purposes.

References

[D07] Andrew Duchowski. *Eye Tracking Methodology. Theory and Practice*. Springer, 8: 87 – 99, 2007.

[NP10] Jakob Nielsen and Kara Pernice. *Eyetracking Web Usability*. Copyright by Nielsen Norman Group, 2010.

[W13] Barbara Wąsikowska. *Contemporary data exploration technologies in marketing*. Studia Informatica 32/2013, 137 – 138, 2013.

[WP06] Michel Wedel and Rik Pieters. *Eye Tracking for Visual Marketing*. Foundations and Trends® in Marketing, vol. I, no 4, 231-320, 2006.

„Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o.

http://www.tobii.com/en/about/news-and-events/press-room/#/images/tobii-glasses-in-package-design-shopper-research-68340

http://blog.sote.pl/wp-content/uploads/badanie-ideacto-usability-sklepow.pdf