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## Eye-tracking in Cultural Studies

### ABSTRACT

Eye-tracking is a technology based on tracking the movement of eye-balls. The results of the study allow a detailed analysis of the path of sight, and provide answers to the questions: what are we looking at, what we focus on and what we ignore despite that the objects are located in our field of view. The eye movement tracking is not a new technology, but it is constantly improved and is gaining importance in many fields of science and consumer market research. Contemporary culture, oriented to image absorption, is a perfect surface for non-standard eye-tracking research.

**KEY WORDS:** eye-tracking, saccade, fixation, the gaze plot

### STRESZCZENIE

#### *Eye-tracking w badaniach kulturowych*

Eye-tracking to technologia, której działanie polega na śledzeniu ruchu gałek ocznych. Wyniki badania pozwalają na szczegółową analizę ścieżki wzroku, udzielając odpowiedzi na pytania, na co patrzymy, na czym skupiamy największą uwagę, a co ignorujemy i czego nie dostrzegamy, pomimo tego, że znajduje się w polu widzenia. Śledzenie ruchu gałek ocznych nie jest technologią nową, jednak stale udoskonalane, zyskuje coraz większe znaczenie w życiu codziennym, wielu dziedzinach nauki i w badaniach rynku konsumenckiego. Współczesna kultura, zorientowana na absorbcję obrazów, jest szczególnie doskonałą płaszczyzną, na której badania eye-trackingowe znajdują wiele często niestandardowych zastosowań.

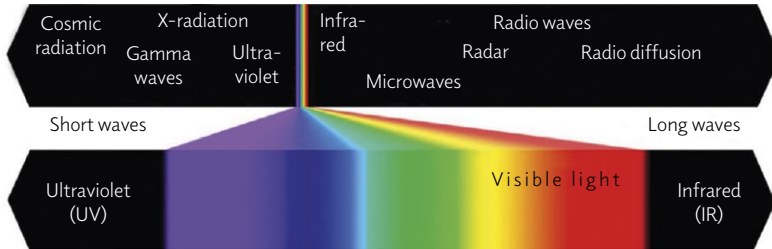
**SŁOWA KLUCZE:** eye-tracking, sakkady, fiksacje, ścieżka wzroku

## The new culture of vision

It would be difficult to argue with the thesis that modern culture is largely based on the absorption of images. Visual communication reigns in the world of new technologies and social networks. Image is a fast message, which influences the imagination to a greater extent than the written text and at the same time—stronger and more memorable. Nowadays, nobody has time for long, extensive narratives. A message should be short and quick in receipt. Image fits perfectly in this style.

Man receives most external stimuli through the organ of vision. However, although a human eye is a perfect and extremely precise organ, its capabilities are limited. From the wide electromagnetic spectrum, only a narrow band thereof is perceived by the human sense of sight. However, image perception and interpretation are not a simple process at all. It is so because not all images are absorbed in the same way. Moreover, recording images by the sense of sight depends not only on their qualitative features, but also on their location in space or on the monitor screen.

Figure 1. Spectrum of electromagnetic radiation



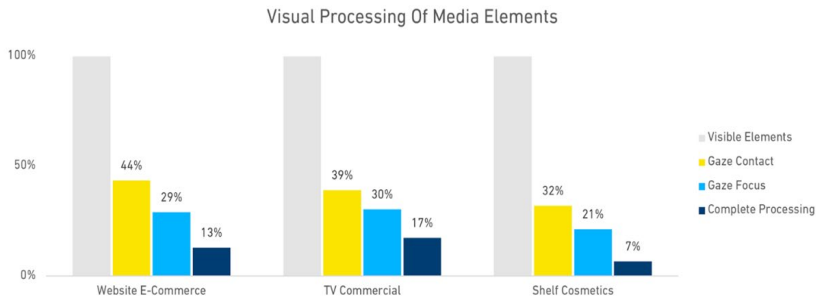
Source: P. Francuz, *IMAGIA. W kierunku neurokognitywnej teorii obrazu*, <http://new.after-imagia.pl/widzenie/>

The visual sphere of the modern world is so developed and diverse that it is not possible for all stimuli to be recorded and processed by man with equal intensity. As part of the activities of the *Eye Square* international market research institute, a series of studies have been conducted which have conclusively confirmed this fact. Tests carried out on groups of respondents from several countries have shown that they focus on less than one third of the visible elements of advertisements presented on television, on e-commerce websites and also when viewing product displays on store shelves (Fig. 2).<sup>1</sup>

1 A detailed description of the study is available on the website <https://www.eye-square.com/eye-tracking/> (access: 17.12.2018).

At a time when the human attention is focused on a selected visual point, their abilities to perceive further placed elements are very limited. The further away from the focus point, the less detail is recorded by the human brain.

**Figure 2.** Percentage graph of the absorption of elements on online store websites, on TV and on store shelves by eye-tracking survey participants



Source: <https://www.eye-square.com/eye-tracking>

However, this selective and very limited perception of the surrounding world is not the result of the human body's disability, but on the contrary, it happens for the good of man. By registering only, a part of the elements from the visual sphere within sight, the human brain defends itself against an excess of stimuli which it would not be able to interpret in real time.

It is worth having knowledge about what human registers in the process of perceiving reality, what elements draw their attention and which are omitted. The ability to trace the path of vision and subsequent focal points of visual attention allows for a deeper understanding of human behavior in everyday situations, when performing various types of tasks and also when making communication interactions.<sup>2</sup>

## Eye-tracking as a method of examining visual attention

On average, a human eye makes three to four movements per second. At this time, visual attention moves between the elements of the visual sphere surrounding the human being, and this is happening largely beyond

2 B.W. Tatler, C. Kirtley, R.G. Macdonald, K.M. Mitchell, S.W. Savage, *The Active Eye: Perspectives on Eye Movement Research*, in: *Current Trends in Eye-tracking Research*, eds. M. Horsley, M. Eliot, B.A. Knight, R. Reilly, Sydney 2014, pp. 3-9.

human consciousness. The path of visual attention can be traced using the so-called fixations and saccades. Fixation is a temporary stopping of the eyesight during visual activity of human. Very fast movement of the eyeballs, corresponding to the transfer of visual attention from one fixation to another is referred to as a saccade. The analysis of subsequent fixations and saccades explains many phenomena related to image perception and visual information assimilation.

Eye-tracking is a research method that allows to collect precise data describing the process of perceiving objects within the range of human sight. It is used to monitor eye movements and record focus points for analysis and interpretation. Eye-tracking allows to track changes in the focus of visual attention over time, based on the analysis of the path of vision, obtaining information about the perception patterns of visual stimuli.<sup>3</sup> This research enables access to various aspects related to cognitive processes and human behavior.

Eye-tracking research methods are constantly evolving and improving, but the techniques associated with eye path testing are not new. The first research based on eye movement tracking took place as early as the beginning of the 19th century. Back then, they were based on direct observation of eye movement of the participants. Therefore, they were not very accurate, which further limited the area of their application. The breakthrough came when the French ophthalmologist Louis Émil Javal discovered in 1879 that reading is not continuous, but the visual attention between words is shifted in steps. He was also the first to conduct empirical studies of eye movement and for the purposes of describing the results of the research he defined the concept of saccade. In subsequent years, the technology used to track the path of vision was successively improved, and in the mid-twentieth century the first mobile device for recording eye movements was designed.<sup>4</sup>

Since then, the area of application of the eye-tracking method has been successively expanded, and with the development of technology, the measuring precision of the testing equipment has increased, while the cost of production has decreased. Currently, the main areas of application of eye-tracking methods include cognitive psychology, medicine, marketing research and cultural research. Eye-tracking also plays an increasingly important role in the broadly understood interaction between human and computer. In this context, it is worth mentioning even the advanced work

3 A. Schall, J.R. Bergstrom, *Introduction to Eye-tracking*, in: *Eye-tracking in User Experience Design*, eds. J.R. Bergstrom, A.J. Schall, Waltham 2014, p. 3.

4 T. Opach, *Zastosowanie okulografii (techniki eye-tracking) w kartografii*, "Polski Przegląd Kartograficzny," 43, 2, 2011, p. 157. See also N. Wade, B. Tatler, *The Moving Tablet of the Eye. The Origins of Modern Eye Movement Research*, Oxford 2005, pp. 20-21.

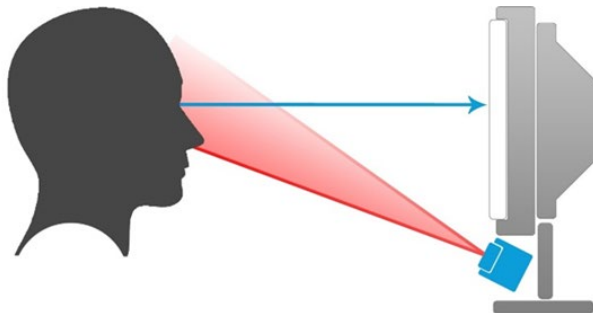
on the design of visual interfaces, where mouse control is replaced by eye movement. Eye-tracking can also be used e.g. in computer games as an alternative data input method.

Nowadays, eye-tracking offers new methods of data collection and analysis. Scientists keep extending their knowledge about the functioning of the human sense of sight in the context of focusing attention and recognizing reality. The ability to track eyesight and record the results of such tests with high accuracy has allowed asking new questions and raising scientific hypotheses, which can be verified using eye-tracking technology.<sup>5</sup> Researchers also see the practical application of eye-tracking technologies in cultural research.

Researchers choose the type of eye tracker, a device that monitors eye movement, according to the type of task to be carried out by its participants. Stationary eye trackers are devices used to examine attention with which the user views images on screens, working with multimedia such as images, films, computer games and when browsing websites. An eye tracker equipped with appropriate sensors, which is most often integrated with the monitor, scans the eyes of the examined person on average 50 times per second, recording areas at which the person's eyes are directed at a given moment (Fig. 3).

Mobile eye trackers allow free movement of the person. They allow visual attention tests to be carried out in a natural environment. This type of tests involves the analysis of behavior in stores, cultural institutions, in a car or in the urban space, for example when testing billboard ads.

**Figure 3.** Operating diagram of stationary screen eye-tracking technology



Source: <http://www.makinggames.biz/feature/use-your-eyes-interaction-through-eye-tracking,7117.html>

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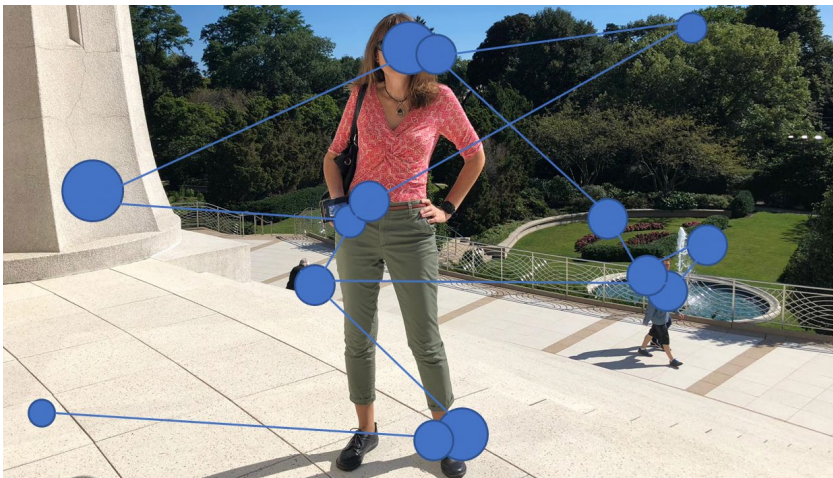
5 M. Horsley, *Introduction*, in: *Current Trends in Eye-tracking Research*, eds. M. Horsley, M. Eliot, B. A. Knight, R. Reilly, New York 2014, p. v.

## Presentation of eye-tracking test results

The data collected during eye-tracking research, before being subjected to analysis, are visualized, i.e. presented in a graphic, convenient to interpret form. Information visualization is a powerful tool for presenting data and information in order to learn and/or analyze them. Especially in recent decades, when scientific research is based on a huge amount of data, visualization has become almost a commonly used method in the world of science. Graphic presentation of data ensures transparency of the message and facilitates the understanding thereof. Weather forecasts, exchange rates, support for political parties are just a few examples of information we have already got used to being presented to us in a visualized form.<sup>6</sup>

One of the most common ways to present the results obtained through eye-tracking tests is gaze plot. It is presented as a series of consecutive fixations graphically marked as circles, the size of which is related to their duration (the longer the focus, the larger the circle) and saccades, sections connecting subsequent fixations (Fig. 4).

**Figure 4.** Simulation of recording the gaze plot by means of marking fixations as circles of varying sizes depending on the length of time the visual attention is focused and the saccades, as the sections between the circles representing subsequent fixations



Source: own study.

6 B. Fua, N.F. Noyb, M. Storeya, *Eye-tracking the User Experience—An Evaluation of Ontology Visualization Techniques*, <http://www.semantic-web-journal.net/system/files/swj770.pdf> (access: 17.12.2018).

This kind of visualization presents information about the areas where the person focused their sight, however, for more detailed analysis and interpretation, an additional parameter is often introduced, specifying the order of fixation. Owing to this kind of presentation, researchers can trace not only what and how long the subject looked at, but also what interested the test participant's attention in the first place and they looked at later on.

An alternative way of presenting eye-tracking research results is the so-called heatmap, which is graphics indicating the areas on which the test participants have focused their attention on.<sup>7</sup> Warm colors, from red through yellow to green, represent those areas that attracted more attention of the respondents. Greater precision in the analysis of areas perceived by respondents is obtained by including additional parameters, such as the time elapsed to the first fixation, the number of respondents and the average time spent on viewing particular focus areas, the number of repeated visits for a given area (Fig. 5).<sup>8</sup>

Figure 5. Heat map of urban space research results using a mobile eye tracker



Source: <http://neuorelay.com/2016/09/11/eye-tracking-in-neuomarketing-research/>

## Eye-tracking as a method of examining websites

In the information society, most diverse tasks are performed using a computer. Therefore, the usability of operating systems, user interfaces, applications and websites has recently been undertaken. Usability is a measure

7 The choice of eye-tracking test method and presentation method results are largely related to the number of users participating in the test. The presentation of results using a heat map is used for quantitative research, based on statistics. Therefore, at least 30 participants should participate in the test. K. Pernice, J. Nielsen, *How to Conduct Eye-tracking Studies*, Freeman, 2013, 1, p. 19, [https://media.nngroup.com/media/reports/free/How\\_to\\_Conduct\\_Eye-tracking\\_Studies.pdf](https://media.nngroup.com/media/reports/free/How_to_Conduct_Eye-tracking_Studies.pdf) (access: 17.12.2018).

8 *Eye-tracking in User Experience Design*, op. cit., Waltham 2014, p. 5. See also A. Duchowski, *Eye-tracking Methodology. Theory and Practice*, London 2007, pp. 15-16, 42.

of effectiveness, efficiency and satisfaction obtained when using a product in order to achieve the expected benefits in a given context of its use. In short, a product is useful if the handling thereof is not difficult and the use is intuitive.<sup>9</sup> Therefore, usability tests apply to goods used on a daily basis, all types of devices that require a specific method of operation, as well as websites that are an important source of information for the contemporary man. The results of eye-tracking tests give an idea of the patterns of receiving messages posted on websites.

An Internet user who, within the first ten seconds of browsing a website, does not find the information they were looking for, leaves it and proceeds to the next site. However, not finding the information that interests them does not necessarily mean that it is not available on the site. The reason may be the arrangement thereof in a place that is beyond the user's attention. In such cases, testing the websites prior to the publishing on the web proves to be invaluable help during tests.

One example of an unfortunate website design is the home page of a well-known international clothing brand published in 2012. Due to the start of the Summer Olympic Games, *Ralph Lauren's* home page has temporarily changed its appearance. In the central part there is a photo taken during the opening ceremony of the games, and in the lower part of the photo there was an inscription saying that all the clothes in which the athletes appeared at the ceremony were created by Ralph Lauren's designers (Fig. 6).

Eye-tracking tests have shown, however, that only one of all respondents got acquainted with this information. Other test participants focused their attention on the silhouettes of athletes, kept their eyes on the flag and logo of the Olympics, but ignored the statement below the photo. As one can guess, the main purpose of the inauguration of the temporary page was to convey the message, which was overlooked by website visitors due to the unfortunate placement thereof.<sup>10</sup>

The acquisition of information on websites is governed by its own laws. Frequent use of electronic publications has modified reading habits. This is not a linear and continuous reading, as is the case with printed texts, but a scan of text elements and images placed on the electronic display. Tests conducted in 2013 revealed that people of different cultural backgrounds differ in terms of style with the content on the search results pages. Groups of respondents from the Middle East and Western Europe took part in eye tracker tests. It turned out that the respondents from the first group spent more time familiarizing themselves with the content of the search results,

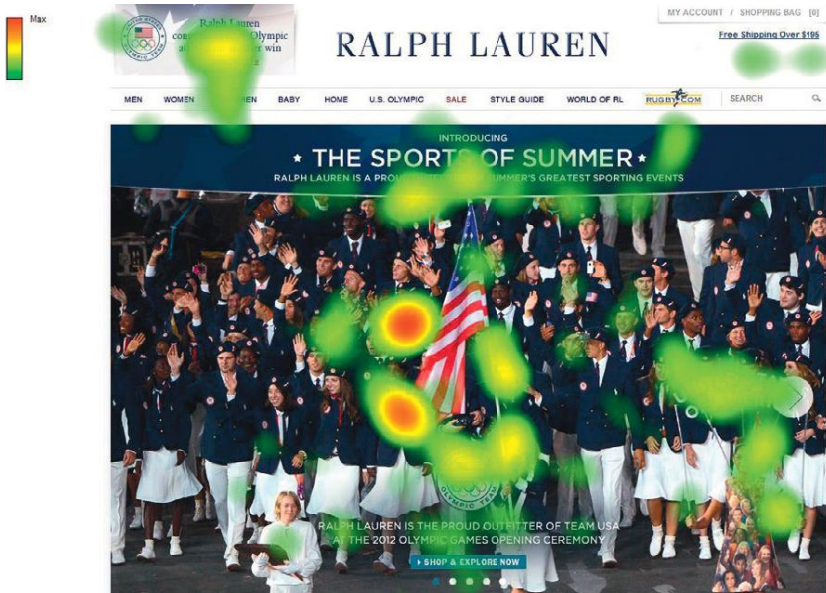
9 J. Andrzejewski, *Projektowanie użytecznych produktów*, Warszawa 2009, p. 4.

10 A.J. Schall, J.R. Bergstrom, *Introduction to Eye-tracking*, op. cit., p. 23.



while the participants of the second group paid less attention thereto, rather scanning the displayed content, instead of analyzing it longer.<sup>11</sup>

Figure 6. The results of the eye-tracking test of the Ralph Lauren website—heat map



Source: A.J. Schall, J.R. Bergstrom, *Introduction to Eye-tracking*, in: J.R. Bergstrom, A.J. Schall, *Eye-tracking in User Experience Design*, Waltham 2014, p. 23.

## Eye-tracking in marketing

Colorful advertisements, ubiquitous in urban space and on websites, fight for the attention of the recipient. Those that fail to attract the attention within the first few seconds will be ignored by them. An image, in order to be registered and remembered, and at the same time to evoke positive associations, should “catch the eye,” and although this is only a colloquial term, it perfectly describes the way the human perceives the world.

In recent years, cheap, commercial eye trackers have been developed, which accurately track and record the movement of human eyes. In this, as well as in the growing commercialization of culture, one should see the

11 M.C. Marcos, R. Garcia-Gavilanes, E. Bataineh, L. Pasarin, *Using Eye-tracking to Identify Cultural Differences in Information Seeking Behavior*, <http://www.ruthygarcia.com/papers/chi2013.pdf> (access: 17.12.2018).

reason that the method of eye-tracking is more and more often used in marketing, where it allows the study of consumer perception and response to advertising messages.<sup>12</sup> This is particularly important due to the fact that almost 90% of stimuli reach consumers through the sense of sight.<sup>13</sup> Market researchers agree that marketing is not a competition for products, but for perception, therefore it is one of the areas where it is particularly important to know what people are looking at and what they bypass, which catches their attention and what they ignore.<sup>14</sup>

It is obvious that an effective advertising message that meets the intended goals of the advertiser should attract the attention of consumers mainly on those elements that relate to the brand name and features of the advertised product or service. In addition, the recipient should read and interpret the message as intended by the sender.

Figure 7. The results of an eye-tracking test of a website with an advertising banner in its central part



Source: <https://www.tobiipro.com/fields-of-use/marketing-consumer-research/advertising/>

The internet is a great advertising space. Advertising messages on websites have become almost an indispensable element thereof long ago. However, once popular advertising banners are becoming less and less effective, because modern man has learned to defend against their intrusive

12 N. Scott, Ch. Green, S. Fairley, *Investigation of the use of eye-tracking to examine tourism advertising effectiveness*, "Current Issues in Tourism," 197, 2016, pp. 634-642.

13 E. Jerzyk, *Zastosowanie okulografii w badaniach uwagi wzrokowej konsumentów*, "Handel Wewnętrzny," 2, 371, 2017, p. 124.

14 A. Ries, J. Trout, *22 niezmiennie prawa marketingu*, Warszawa 1996, p. 33.

influence. Web users, in order to avoid the flood of useless content, have become resistant to the promotion of unnecessary products and services. When browsing the websites, they omit the advertising banners, focusing only on the page elements that interest them. This mechanism was called banner blindness.

Banner blindness is therefore a developed phenomenon, allowing the Internet user to save time that would be spent on learning content that is not of interest to them. Sometimes, however, as a result of the mechanism, which aims to protect against unnecessary information, the user of the page ignores content that could be relevant and valuable to them. This happens when they have been designed in the form, color and sizes usually used for advertising (Fig. 7).

## Cultural conditioning of image registration patterns

Scientists have been involved in the dependence of image perception patterns on cultural considerations for a long time, but it was only the development of eye-tracking technology that made it possible to conduct more serious research in this area. In 2015, researchers from the University of Arizona conducted an experiment that aimed to determine whether and to what extent visual attention patterns differ between Americans and those test participants who were born in China and raised in this country. It turned out that Asians pay attention to the context in which the message is placed, while people from Western culture focus more on objects that are the main element of the message.<sup>15</sup>

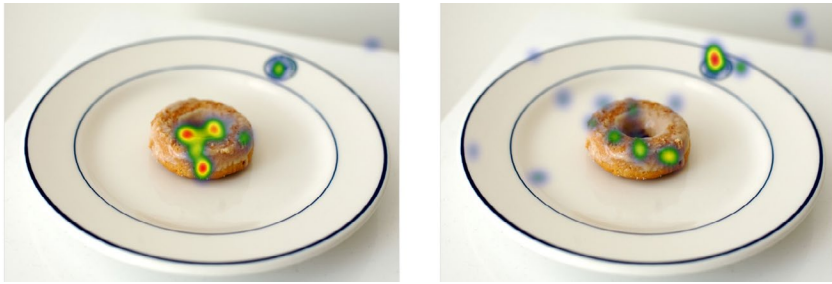
Eye-tracking allowed verification of many stereotypes that were formulated solely on the basis of observation. The opinion that men looking at the face focus mainly on the lips, while women focus their attention on the eyes has always been common. Eye-tracking of the test participants confirmed this, as well as the thesis that attention is most focused on the face when observing the human figure. In the same research, differences in perception patterns of the human figure were also indicated, resulting not only from the difference in sex, but also from cultural conditions. For example, when viewing photos of a young, attractive woman, the French women focused their attention on her neckline more than twice as

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15 B. Zhang, H.S. Seo, *Visual attention toward food-item images can vary as a function of background saliency and culture. An eye-tracking study*, "Food Quality and Preference," 41, 2015, pp. 172-179. For similar surveys see J.O. Goh, J.C. Tan, D.C. Park, *Culture Modulates Eye-Movements to Visual Novelty, Culture Modulates Eye-Movements to Visual Novelty*, "PLOS ONE," 4, 12, 2009, <https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0008238&type=printable>

intensely as ladies from Great Britain, while the proportion of focus on the ring on the hand of the photographed woman was exactly the opposite.<sup>16</sup>

**Figure 8.** Eye-tracking test results of visual attention patterns on a group of US and Chinese respondents—heat map



Source: B. Zhang, H.S. Seo, *Visual attention toward food-item images can vary as a function of background saliency and culture. An eye-tracking study*, "Food Quality and Preference," 41, 2015, p. 177.

Eye-tracking is a useful tool in researching ways of learning. People differ in preferences and, as a consequence, also in the way they process and remember information, they use different patterns of reading texts and assimilating the images they contain. It would be difficult to find a better methodology for researching cognitive preferences than tracking and analyzing the eyesight of test participants. The tests confirmed the theory dividing people into two groups: those whose visual cognitive style is characterized and those whose cognitive process is based on verbal communication.<sup>17</sup>

Eye-tracking method has also found widespread use in computer games in recent years, where it is used in two different ways. The first one is to evaluate the game design, assess the functionality and usability of the solutions used. In the second case, more interesting from the point of view of the game, the gaze is used as data input technique.

16 More about research results <http://miratech.com/> (access: 17.12.2018). The study was conducted in 2011 by the French consulting company *Miratech* in cooperation with partners from four European countries as well as from Brazil and the USA. Description of research related to the perception of the face and its elements, see also S. Seyda, J. Wiśniewska, *Czy twarz naprawdę postrzegana jest jako całość?*, "Lingwistyka Stosowana," 20, 5, 2016, pp. 119-125.

17 M. Koć-Januchta, T. Hoffler, G. Thoma, H. Precht, D. Leutner, *Visualizers versus verbalizers: Effects of cognitive style on learning with texts and pictures—an eye-tracking study*, "Computers in Human Behavior," 68, 2017, pp. 170-179. See also D. Leutner, T. Hoffler, M. Koć-Januchta, *More Evidence for Three Types of Cognitive Style. Validating the Object-Spatial Imagery and Verbal Questionnaire Using Eye-tracking when Learning with Texts and Pictures*, "Applied Cognitive Psychology," 31, 2017, pp. 109-115.

After the joystick and computer mouse, it is time to control the elements of a game with eyesight. Although this is not a common practice used to control a game, many games have gained new quality owing to the use of eye-tracking technology. In such games as *Flight Simulator X* or *Deus Ex: Mankind Divided* focusing the player's gaze on the edge of the image causes it to shift, which smoothly widens the perspective, creating the so-called *Infinite Screen Extension*. In games where the player's tasks are mainly to target and eliminate opponents, eye-tracking allows to choose a target with own eyes. Almost as fast as the human eye moves, the player can move between successive elements of the game or between the opponents they want to eliminate.

In some kinds of games in which the dark mood of horror prevails, compounded by the darkness that envelops the action scene, the areas to which the player directs attention at a given moment are recognized and only highlighted. In this way, the effect of using a flashlight is obtained, which builds the realism of the game allowing to get deeper into the course thereof.<sup>18</sup> Eye-tracking technology allows people with disabilities to use games, although it does not completely replace input devices such as a mouse or joystick.

## Conclusion

A popular saying is that the eyes are the mirror of the soul. Although this is only a beautiful metaphor, it would also be difficult to disagree with the fact that gaze is one of the most important non-verbal signals in interpersonal communication. Eye-tracking studies help to explain patterns of human behavior in face-to-face contacts, especially differences in the behavior of people from different cultural backgrounds.

The real strength of eye-tracking technology can be seen in its combination with techniques of visualizing human nervous system activity and analyzing the current biometric data. The results of comprehensive research include measurement of brain activity, heart rate and breathing, muscle response at the time of perception of particular image components. Comparing these data with the results of facial expression analysis not only provides information on what the participant looks at, but also what emotions are present in this process.<sup>19</sup>

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18 Examples of games using eye-tracking technology e.g. <https://www.spidersweb.pl/2016/08/eye-tracking-acer.html>; <http://www.makinggames.biz/feature/use-your-eyes-interaction-through-eye-tracking,7117.html> (access: 17.12.2018).

19 J.R. Bergstrom, S. Duda, D. Hawkins, M. McGill, *Physiological Response Measurements*, in: *Eye-tracking in User Experience Design*, eds. J. R. Bergstrom, A.J. Schall, Waltham 2014, pp. 93-95 i n.

Eye-tracking method in combination with the analysis of biometric parameters is presently a powerful research tool enabling the undertaking of various tests, including those for which the earlier scientific apparatus was lacking.<sup>20</sup>

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20 For example, in 2017, a group of researchers used the eye-tracking method extended by testing biometric parameters to assess a driver's visual perception and ability to recognize threat situations. Tests using eye-tracking have been integrated with the study of the driver's physiological responses, such as the galvanic skin reaction to an object appearing within their sight, accelerated heart rate or EEG recording. See more on: E. Kasneci, T. Kübler, K. Broelemann, G. Kasneci, *Aggregating physiological and eye-tracking signals to predict perception in the absence of ground truth*, "Computers in Human Behavior," 68, 2017, pp. 450-455.

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