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Eye tracking in research on perception of objects and spaces

Okulografia w badaniach postrzegania obiektów i przestrzeni

Abstract

The article is devoted to the visual perception of selected architectonic objects and urban space in the health resort in Rabka-Zdrój. Eye-tracking research was presented in its theoretical aspect, and then results of research carried out using a stationary eye-tracker were also presented. An analysis of experiment results allowed for determining the usefulness of eye-tracking research in learning the range and manner of perceiving architectonic objects and urban spaces by people looking at them. The usefulness of the discussed research in working out assumptions and activities related to protecting historic objects and spaces as well as educational activities was indicated.

Keywords: eye-tracking method, visual perception, architectonic objects and urban space

Streszczenie

Artykuł poświęcony jest percepcji wzrokowej wybranych obiektów architektonicznych i przestrzeni urbanistycznych w uzdrowisku Rabka-Zdrój. Zaprezentowano w ujęciu teoretycznym badania okulograficzne, a następnie przedstawiono wyniki badań przeprowadzonych z wykorzystaniem eye-trackera stacjonarnego. Analiza wyników eksperymentu pozwoliła na stwierdzenie przydatności badań okulograficznych do poznania zakresu i sposobu postrzegania obiektów architektonicznych i przestrzeni urbanistycznych przez osoby na nie patrzące. Wskazano na przydatność przedmiotowych badań przy opracowywaniu założeń i działań związanych z ochroną obiektów i przestrzeni zabytkowych oraz działań edukacyjnych.

Słowa kluczowe: metoda eye tracking, percepcja wzrokowa, obiekty architektoniczne i przestrzeń urbanistyczna

1. Introduction

The issue of learning the reasons why the very poor condition of historic objects is accepted in many, particularly small, historic Polish towns in which local communities do nothing or do too little to prevent degradation of those objects is important with regard to the effectiveness of revalorization and protection activity [1].

The aim of this work is presenting the usefulness of eye-tracking research in assessing what conditions social attitudes towards architectonic objects and urban spaces, especially indifference towards degradation of objects in the closest vicinity.

So far, eye-tracking research has been found useful in such disciplines as psychology, medicine, ergonomics, interaction man-computer or marketing [2–4]. Nowadays research has also commenced concerning man's perception of works of art, industrial forms and products and their packaging [5–7].

Applying the eye-tracking method in this new suggested area should allow for evaluating the range and manner of perceiving architectonic objects and urban spaces by people looking at them. Hence, it will allow for relatively objectively assessing the manner of perceiving diverse information reaching a man and affecting the way of building and the structure of his own knowledge and awareness.

An example of a town that struggles with a serious threat to its cultural landscape is Rabka-Zdrój, which is the subject of studies concerning urban-architectonic aspects of cultural heritage conducted by the authors of this work for many years. The undertaken research regarding assessing the visual perception of visualisations of selected objects and spaces in Rabka-Zdrój constitute the next stage of research aimed at finding the answer to the question whether one of the reasons behind the poor state of the cultural landscape of that health resort could be ignoring its cultural heritage and, consequently, lack of awareness of its value [8, 1].

2. Nature of eye-tracking research

The issue concerning the eye-tracking method has been addressed in work presenting scientific assumptions referring to conducting an experiment and indicating possibilities of its application. Among the most important volumes in the literature on the subjects are publications by D. Richardson [9], A. Duchowski [10] and K. Hoolmovist, M. Nystrom, R. Andersson and others [11], which constitute a compendium of knowledge about that research method. Other studies worth mentioning are: a publication by A. Bojko [12] and the work edited by M. Horsley, M. Eliot, B. Knight and R. Reilly [13]. Among Polish publications indirectly concerning the application of the eye-tracking method also in the research on the perception of space one should point out the publication by R.Wawer [14], as well as by R. Wawer and M. Pakuła [15]. So far, the issue of usefulness of the method in the research on historical architectonic space has only been addressed in the work by M. Krupa [8] and in the work by B. Kabaj and M. Krupa [16]. In the world the issues connected to eye tracking in the research on architecture and space have been discussed by the team: Ch. Lebrun, A. Sussman, W. Crolius, and G. van der Linde

from the Institute for Human Centered Design in Boston [17], and D. Junker and Ch. Nollen from the University of Applied Science in Osnabruck [18].

It is worth mentioning that although the application of the method in the architecture-related research is innovative, the method itself was invented in the 19th century, or more precisely in 1878, by Louis E. Jave, who had a fluorescent gauge fixed to the eye cornea, which allowed him to record and analyse eye movements. Another step in the development of the method was made by R. Dodge and T.S. Cline who created the first eye-tracker, which took place in the United States in the year 1901 [9]. In the following years, both the method and the device were improved. Around the mid-20th century, H. Hertridge and L.C. Thomson devised an eye tracker in the form of a helmet, thanks to which the research yielded even better effects. In the year 1958, A. Mackworth improved the method by combining the recorded information with the changing image [14]. In time computer work was added to the eye tracking method, thanks to which its results are even more precise and, first of all, can be analysed and examined from multiple angles [14, 15].

Nowadays, in the literature of the subject eye tracking is presented as a method for measuring, recording and analysing data about the position and movements of eye balls within a given time bracket. The functioning of eye trackers is based on the method called the corneal reflection. A high-resolution camera tracks the position of pupils which are illuminated by infrared light invisible to man. The infrared light is mirrored in the eyes creating reflections (known in physics as Purkinje reflection) clearly visible in the pupils, which serve to identify the place which the viewer is looking at in a given moment [12, 2, 3].

Thus it is possible to precisely present the eye movements of the research participant.

A typical measurement involves the analysis of:

- fixation – eye movements that stabilise the retina above an immobile object (they are very short; last between 100 and 600 milliseconds),
- saccade – a rapid shift from observing one focal point to another (they take between 20 and 40 milliseconds),
- total or average time devoted to observing given elements,
- number of revisits – repeated viewing of given elements [10].

It is assumed that the cognitive process occurs during the fixation, i.e. information reaches the brain and is consciously processed. On the other hand, during the saccade stimuli reaching the brain are not analysed and the cognitive process does not take place [14].

Eye movements are recorded in the form of quantitative data. Additionally, measurements are created that allow for interpreting the way of perceiving elements presented on the screen. Eye tracker software makes it possible to generate data visualisations. Input data include identification of places at which the research participant looked, the time spent viewing the material and marking the path that his eyes followed. The most frequently used forms of graphic presentation of the data obtained during the research are: heat maps, a scan path and an analysis of areas of interest [13, 10, 4].

A heat map allows for determining which of the presented elements attracted the research participant's attention. In the case of each material presented on the screen, it is possible to use different colours to show places where the research participants fixed their eyes while

presenting concise results for attention focus in each group of research participants. Focusing attention in one point for a longer time is marked by an intensive warm colour, while cool colours indicate a shorter focusing time. Places devoid of colouring indicate fragments that were completely ignored by the viewer. A specific example of a heat map is the reversed version showing exclusively the spots on which research participants focused their attention. Other areas remain darkened [12, 2].

The second form of graphic presentation is a scan path that indicates the order in which particular areas were noticed while observing a given image. Circles indicate subsequent spots on which the viewer focused his attention (fixations). The bigger the diameter of the circle, the longer the viewer kept his eyes on a given object. Numbering within the circle shows the order of viewing, and lines symbolise saccade movements indicating the scan path the eye followed to the next focal point [10, 11, 9].

The third form of graphic presentation is the AOI – Area of Interest. An analysis allows here for selecting those looks, from among a large number of them, which refer to specific places presented on the screen. AOI can be designed independently by the leader of the research (in the shape of a rectangle, an ellipsis or a polygon) or generated automatically with a percent recording of the distribution of focus. The advantage of areas of interest over heat maps lies in the possibility of obtaining concrete Figures that allow for carrying out a thorough quantitative analysis of focus and using parametric measurements. The applied so called statistics vary depending on the aim of the research.

While analysing the areas of interest it is standard to determine the following measurements:

- the time that passes until the first fixation in the given AOI (TTFF – Time to First Fixation); allows for determining how much time the viewer needs to find a given area significant from the viewpoint of realisation of the research goal,
- the number of fixations within a given AOI during observation for one of all research participants; it is assumed that a larger number of fixations confirms a more intensive interest in a given area,
- the time all the fixations within a given area last,
- the number of visits within a given area during observation for one or all research participants; it is assumed that the larger number of visits within an area, the more interesting it is from the perspective of the viewer (can present interest in a novelty or difficult content, hence the return to them in order to understand information) [12, 13, 10, 2].

In each area or photograph considered in the research, after determining AOI there is usually an area that remains unclassified (Not on AOI). That latter area, though uninteresting from the viewpoint of measuring the degree of perception of objects constituting an AOI, can also be included in an analysis taking into account the possible occurrence of other attractors (elements attracting attention) and distractors (elements distracting the viewer) [14, 15].

Summing up, the main advantage of the eye-tracking research is the fact that it allows for objectively assessing the perceptive activity of the research participants. Tracking eye movement allows for reflecting those elements in the analysed image of the object to which a viewer really pays attention. Therefore results are based on facts, and not declarations or assumptions [11, 16, 8].

3. Research on perception of selected objects and spaces in Rabka-Zdrój

The research using the above described method (ET) for perceiving architectonic objects and urban spaces in Rabka-Zdrój was carried out in a group of 100 people. Research participants were selected at random. The number of research participants was sufficient from the perspective of methodological assumptions; moreover, it considerably outnumbered the populations taking part in the research concerning other disciplines [5, 3, 6, 14, 15]. The group of participants differed in respect of age, education and sex. The structure of population regarding the sex of the examined inhabitants of Lesser Poland included: 60% females, and 40% males.

Every research participant was informed about the research procedure, though it was not stated what the aim of the research was or how the scan paths would be analysed. This information was deliberately concealed, so as not to suggest the participants which areas to focus on or pay attention to. Research participants declared that their eyesight was not impaired, which is imperative for this method [3]. 4 photographs of urban spaces in the health resort of Rabka-Zdrój were selected. Such shots were selected which showed both historical and modern objects, in good and poor technical condition, as well as additional objects not related to architecture but occurring in that space. The photos considered in the research and analysed presented the buildings along Poniatowskiego Street on the south-east side (2 shots) and Orkana St. on the south-west side (2 shots). Each photograph was shown to the viewer on the screen for 15 seconds. The research was carried out using a stationary device Eye tracker Tobii X2-30 Compact with special software [19].

An analysis of the results obtained from the conducted research began by generating heat maps as visual data indicating places on which the participants' attention was focused, as well as places ignored i.e. unobserved. The distribution of heat maps constituted a basis for determining Areas of Interest with regard to research goals. The determined areas of interest concerned objects and architectonic space, as well as other elements e.g. commercial banners, information boards, objects in the public space which were attractive to viewers.

The analysis determined areas of interest for each photographic material was carried out using the so called statistics, i.e. such parameters as: the average time till the first fixation, the number of fixations during observation, an average number of fixation per research participant, the total time of all fixations, the number of visits during observation and an average number of visits per participant. The generated numerical data for each area of interest took into account the sex difference between participants.

The first photo (Fig. 1) shown to research participants presents the initial fragment of Poniatowskiego St. viewed from the south-east (Fig. 1). The buildings along that street developed at the beginning of the 20th century. From that period several wooden villas representing the health-resort style have survived until the present. The most historical objects have been preserved at the beginning of the street. Dilapidated or ruined buildings are adjacent to well-maintained modern architecture which, however, does not allude to traditional models of spa architecture [8]. On the left side of the picture in the background there is an area of non-historical buildings, while on the right side in the street frontage one can see a modern house

and, slightly further, historical buildings. The foreground of the photo shows the street with parked cars further back. A visualisation of research results in the form of heat maps (Fig. 2) indicated that the cognitive process among participants did not concern the whole view of objects on the left side of the image, or the whole view of the contemporary object, or the farther historic buildings. In the case of buildings the cognitive elements were mainly porches, not whole elevations. The focus of participants' attention and warm colours (red), confirming a longer observation time, referred mainly to the street with the cars parked along it. The above analysis allowed for determining three areas of interest: area 1_AOI1 comprises the non-historical buildings on the left side of the photo; area 1_AOI2 includes the contemporary house and farter historic buildings; and area 1_AOI3 is not related to architectonic objects i.e. the road surface. The indicated areas (Fig. 3) did not include the part of building development screened by greenery. Numerical data, so called statistics (tab. 1), were generated for the indicated areas of interest. The analysis of obtained results indicates that the road with cars parked on it seemed to have the greatest ability of focusing viewer's attention, and making the first impression, then the contemporary house and further historic buildings, while the anonymous non-historic buildings on the other side of the street were the least attractive. It is confirmed by mainly such parameters as the average time until the first fixation, the number of fixations during observation or the total time of all fixations. The number of visits during observation for all research participants and for each participant, with an analogical distinction regarding sex and other parameters, could be evidence of both interest and difficulty in understanding the information contained in the objects and space.

The next photo (Fig. 4–6) shown to research participants also depicts the buildings along Poniatowskiego St. photographed from the south-east (Fig. 4). In the frame selected for research there are both historic buildings in the shape of historical villas, as well as contemporary buildings, namely an apartment block. The heat map distribution (Fig. 5) indicated the occurrence of a cognitive process in relation to architectonic details in both kinds of buildings. In the apartment block those were windows and balconies, and porches with columns in the area of historic villas. Those objects without the greenery screening them were attributed areas of interest: the apartment block was 2AOI1, and historic villas were 2_AOI2 (Fig. 6).

So called statistics were generated for selected areas (tab. 2). An analysis of obtained results allows for stating that the area with historic buildings was perceived as more attractive than the one with contemporary buildings (an apartment block). It concerns mostly the first impression where attention drawn most quickly, which is confirmed by lower value of time until the first fixation for 2_AOI2 in comparison with 2_AOI1. It is also related to the fact that architectonic details in historical objects aroused more interest than those in the apartment block, the evidence of which is the larger number of fixations by over 50%, as well as a greater number of visits during observation by over 20%. And in this case, the cognitive process did not refer to the entire historical area, but only its fragments.

Next shots presented to research participants display views of two fragments of Orkana Street. It is the main street in Rabka-Zdrój along which were built health-resort villas and public utility objects, constituting significant elements of the cultural landscape of the town [8].

Photo no. 3 (Fig. 7–9) shows a built-up fragment of Orkana Street in the vicinity of the church dedicated to St. Mary Magdalene on the south-west side (Fig. 7). The church was erected at the beginning of the 20th century in the neo-Gothic style. Its fence, built from brick at the same time as the church, is divided into spans with posts. The brick fence with the main entrance gate to the church yard is visible on the left side of the photo. On the other side of the street one can see non-historic buildings with a large number of advertising boards of varying size. In the foreground of the photo there is a road with pavements. An analysis of the distribution of generated heat maps (Fig. 8) indicated that research participants showed little interest in either the historic wall surrounding the church or the buildings on the other side of the street. Warm colours implying the longer period of observation concerned mainly the street and advertisement and information boards put up along the street. Areas of interest were established in order to analyse the cognitive process among participants. The area including the historic object (the wall surrounding the church) was marked as 3_AOI1, while the areas of interest linked to architectonic objects comprising attractors drawing viewers' attention were marked as 3_AOI2 (larger board) and 3_AOI3 (smaller advertising board). The largest area of interest included in the analysis was the area outlined by the street and marked as 3_AOI4 (Fig. 9). Then, data was generated concerning parameters for the established areas of interest (tab. 3). Values of all parameters showed that the process of learning concerning the first impression and arousing interest during observation referred mainly to the message conveyed by elements of road infrastructure and parked cars, as well as by the large advertising board located by the side of the building.

The next shot (no 4) is a view of another fragment of Orkana Street from the south-west (Fig. 10). The central place in the presented shot is taken by objects situated on the right side of the street, including a historic villa of high cultural value [8] ant a contemporary market pavilion. Further back, behind the historic object there is anonymous non-historical architecture with advertising boards (see Fig. 3). A considerable section of the elevation of the historic villa is hidden behind a hanging advertising banner. The ground floor and the first floor of the market pavilion have many advertising signboards. Generated distributions of heat maps (Fig. 11) allowed for establishing areas of interest. It was assumed that 4_AOI1 will denote the elevation of the historic villa not screened by the advertising banner, 4_AOI2 – the area of the advertising banner on the villa elevation, 4_AOI3 – the ground floor of the market pavilion with shop-signs, 4_AOI4 – the first floor of the pavilion with advertising boards, and 4_AOI5 – the advertising board visible behind the historic villa (Fig. 12).

Generated numerical data for the parameters describing the cognitive process (tab. 4) allow for stating that a large advertising banner could be an attractor determining the first impression on the part of a viewer observing various objects and spaces, and the cognitive process with memorised information content. The banner located on the elevation of a historic object strongly affects the process of visual perception of the value of historic objects, which is confirmed by numerical data.

For the 4_AOI1, namely the historic villa, the time to the first fixation was 5 times longer, the number of fixations during observation was lower by 60%, the length of time of all fixations was 3 times shorter, and the number of visits lower by 40% than in the case of the

Fig. 1. View of the built-up fragment of the early section of Poniatowskiego St. from the south-east (photo no. 1)

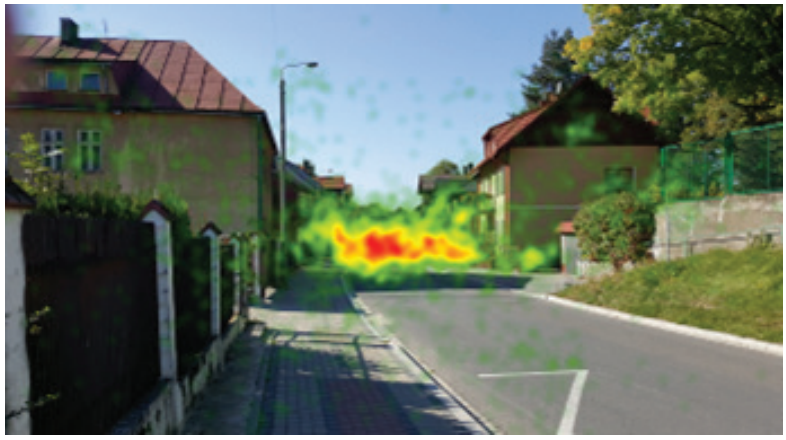

Fig. 2. Visualisation of results in the form of heat map for all participants (photo no. 1)

Fig. 3. Established areas of interest (photo no. 1)

Table 1. Research results for photo no. 1 (Fig. 1–3)

Statistic (parametr)	Research participants	1_Aoi1	1_Aoi2	1_Aoi3
Average time to first fixation [s]	Women	1.89	2.02	0.94
	Men	1.43	1.69	1.2
	Total	1.69	1.87	1.05
Number of fixations during observation	Women	387	487	652
	Men	351	357	507
	Total	738	844	1159
Average number of fixations per person	Women	6.24	7.85	10.52
	Men	7.63	7.76	11.02
	Total	6.83	7.81	10.73
Length of time of all fixations [s]	Women	156.46	187.24	265
	Men	137.64	133.17	215.33
	Total	294.1	320.42	480.93
Number of visits during observation	Women	243	285	309
	Men	185	201	232
	Total	428	486	541
Average number of visits (in proportion to number of research participants)	Women	3.92	4.6	4.98
	Men	4.02	4.37	5.04
	Total	3.96	4.5	5.01

Fig. 4. View of the built-up fragment of Poniatowskiego St. from the south-east (photo no. 2)

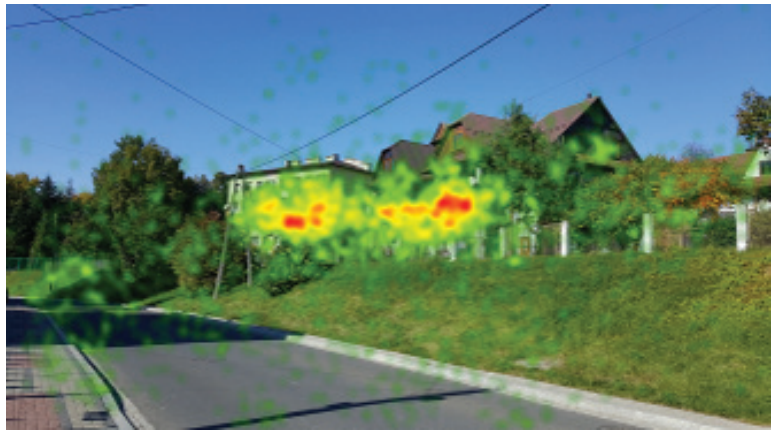

Fig. 5. Visualisation of results in the form of heat map for all participants (photo no. 2)

Fig. 6. Established areas of interest (photo no. 2)

Table 2. Research results for photo no. 2 (Fig. 4–6)

Statistic (parametr)	Research participants	2_Aoi1	2_Aoi2
Average time to first fixation [s]	Women	1.16	0.61
	Men	1.04	1.33
	Total	1.11	0.93
Number of fixations during observation	Women	368	584
	Men	287	414
	Total	655	998
Average number of fixations per person	Women	5.94	9.42
	Men	6.24	9
	Total	6.06	9.24
Length of time of all fixations [s]	Women	150,28	248.46
	Men	131.22	182.56
	Total	281.51	431.02
Number of visits during observation	Women	241	298
	Men	184	226
	Total	425	524
Average number of visits (in proportion to number of research participants)	Women	3.89	4.81
	men	4	4.91
	Total	3.94	4.85

Fig. 7. View of the built-up fragment of Orkana St. in the vicinity of the new church from the south-west (photo no. 3)

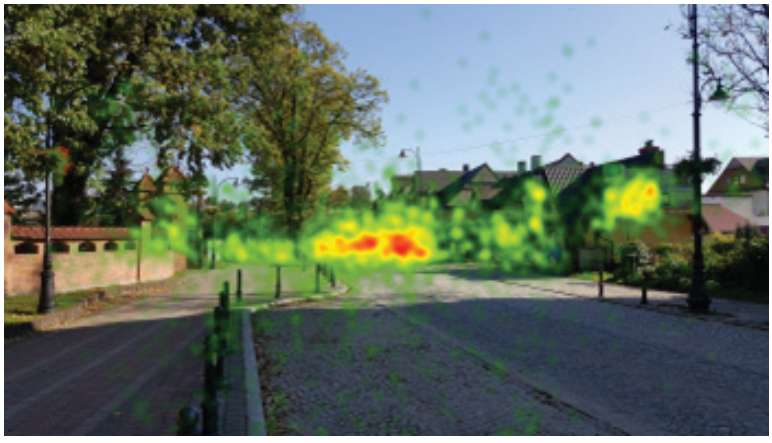

Fig. 8. Visualisation of results in the form of heat map for all participants (photo no. 3)

Fig. 9. Established areas of interest (photo no. 3)

Table 3. Research results for photo no. 3 (Fig. 7–9)

Statistic (parametr)	Research participants	3_Aoi1	3_Aoi2	3_Aoi3	3_Aoi4
Average time to first fixation [s]	Women	2.95	3.13	4.48	0,93
	Men	3.06	2.15	6.51	0,89
	Total	2.99	2.67	5.33	0,92
Number of fixations during observation	Women	161	148	30	879
	Men	105	153	18	654
	Total	266	301	48	1533
Average number of fixations per person	Women	2,6	2,39	0,48	14,18
	Men	2,28	3,33	0,39	14,22
	Total	2,46	2,79	0,44	14,19
Length of time of all fixations [s]	Women	57,42	66,5	13,21	347,2
	Men	38,74	73,73	9,9	267,55
	Total	97,16	140,23	23,12	614,75
Number of visits during observation	Women	100	99	29	325
	Men	68	84	17	233
	Total	168	183	46	558
Average number of visits (in proportion to number of research participants)	Women	1,61	1,6	0,47	5,24
	Men	1,48	1,83	0,37	5,07
	Total	1,56	1,69	0,43	5,17

Fig. 10. View of the built-up fragment of Orkana St. from the south-west (photo no. 4)

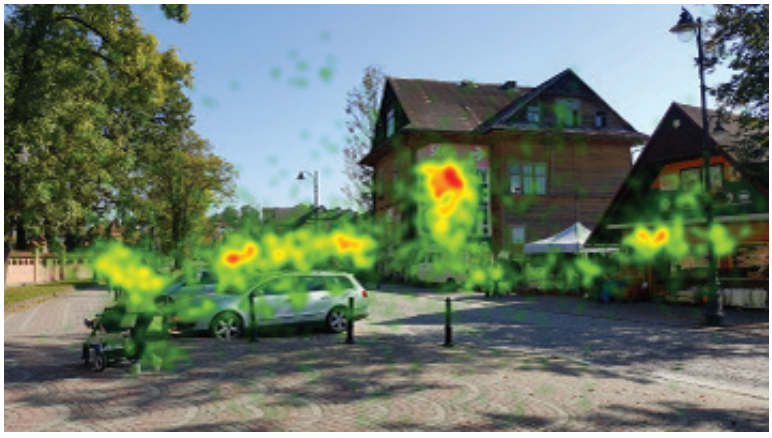

Fig. 11. Visualisation of results in the form of heat map for all participants (photo no. 4)

Fig. 12. Established areas of interest (photo no. 4)

Table 4. Research results for photo no. 4 (Fig. 10–12)

Statistic (parametr)	Research participants	4_Aoi1	4_Aoi2	4_Aoi3	4_Aoi4	4_Aoi5
Average time to first fixation [s]	Women	4.94	0,86	3,99	4,51	7,97
	Men	3.12	0,58	4,95	4,96	6,62
	Total	4,15	0,74	4,34	4,73	7,35
Number of fixations during observation	Women	139	380	218	80	56
	Men	145	311	140	86	40
	Total	284	691	358	166	96
Average number of fixations per person	Women	2,24	6,13	3,52	1,29	0,9
	Men	3,15	6,76	3,04	1,87	0,87
	Total	2,63	6,4	3,31	1,54	0,89
Length of time of all fixations [s]	Women	47,07	158,79	76,01	26,21	22,66
	Men	48,73	120,43	52,04	29,64	17,38
	Total	95,81	279,21	128,05	55,84	40,04
Number of visits during observation	Women	100	173	91	61	47
	Men	100	171	67	63	37
	Total	200	344	158	124	84
Average number of visits (in proportion to number of research participants)	Women	1,61	2,79	1,47	0,98	0,76
	Men	2,17	3,72	1,46	1,37	0,8
	Total	1,85	3,19	1,46	1,15	0,78

4_AOI2, i.e. the advertising banner located on the object. The other attractors of advertising character were of varying cognitive attractiveness to viewers, with the area of interest including the farthest advertising board being the least effective in conveying the message, which is confirmed by the values of parameters related to the occurring fixations.

To sum up, the carried out experiment allowed for stating that the historic or contemporary character of an object or a space had no bearing on drawing attention or perception by individuals participating in the research. Architectonic objects were not seen as a whole by participants. Fragments of buildings, mostly windows and balconies, were the architectonic elements attracting attention and consciously noticed and remembered. Therefore, the character and style of an object were not identified by research participants. Hoardings, signboards and information boards were the elements associated with objects, because of being mounted on their elevations, which focused viewers' attention. The attention-drawing elements occurring in the space around the analysed architectonic objects were primarily parked cars and road infrastructure. Like advertising elements on elevations of buildings, elements in the public space also interfere with the perception of objects valuable for our cultural heritage.

4. Conclusion

Both studies of literature and the empirical research confirmed the effectiveness of the eye-tracking method in the research on visual perception of architectonic objects and urban spaces. Applying the eye-tracking method allows for learning the range and manner of perceiving objects and spaces by people looking at them. It also allows for obtaining objective information concerning external stimuli such as details of architectonic objects and spaces with their information content, which are merely noticed in the process of perception, as well as those which are additionally learned, understood and memorised. It is essential in determining the causes of the low level of social awareness concerning the value of cultural heritage and people's indifference to the degradation of historic objects in their vicinity. Obtained results allowed for confirming the rule of perceptive competition among details of both historic and contemporary objects and spaces. Focusing one's attention and perceiving those details instead of whole objects or areas of interest, regardless of the length of observation time, is the main reason for the lack of evaluation of the viewed surroundings. Simultaneous occurrence of attractors, i.e. elements attracting attention and demanding to be noticed, disturbs the content conveyed by objects with historic and contemporary learning value. It has also been shown that various forms of external advertising and information boards have a strong impact here.

To conclude the findings established while carrying out the research using the eye-tracking method, it should be admitted that the method is useful in preparing guidelines and concrete activities connected to protecting historic objects and spaces, as well as educational activities addressed to local communities and people sightseeing places representing historic and architectonic values. The above findings refer to Rabka-Zdrój, but can also be more generally applied.

References

[1] Kuśnierz-Krupa D., *Problematyka rewaloryzacji willi w miejscowościach uzdrowiskowych na przykładzie willi Primavera, Jaworzyna oraz Wawel w Rabce Zdrój,* "Czasopismo Inżynierii Lądowej, Środowiska i Architektury – Journal of Civil Engineering, Environment and Architecture", Vol. 62 (2)/2015, 223-231.

[2] *Eye Tracking in User Experience Design*, edit. J. Bergstrom, A. Schall, Elsevier Inc, Waltham 2014.

[3] Garczarek-Bąk U., *Użyteczność badań eye trackingowych w pomiarze utajonych determinant zachowań zakupowych nabywców,* "Ekonometria – Econometrics", Vol. 3 (53)/2016, 54–71.

[4] Szymusiak H., *Neurobiologiczne techniki stosowane w biznesie*, EUP, Poznań 2012.

[5] Cholewa-Wójcik A., Świda J., *A Study and Assessment of Selected Elements of the Visual Aspects of Collectible Chocolate Packaging with the Use of the Eye-tracking Method*, "Indian Journal of Marketing", Vol. 45 (7)/2015, 7–18.

[6] Kabaja B., Lisińska-Kuśnierz M., *The Assessmentof the Food Packaging Labelling Systems with the Use of Eyetracking Method*, [in:] Towaroznawstwo w badaniach i praktyce. Kierunki badań i rozwoju produktów nieżywnościowych, edit. R. Salerno-Kochan, A. Wolak, PTT, Kraków 2017, 33–46.

[7] Lisińska-Kuśnierz M., Jaracz E., *The Effect of the Visual Aspect of Packaging on Consumer Perception of Energy Drinks*, [in:] Food Products Marketing. Concepts and Research, edit. M.Gębarowski, T. Hermaniuk, University of Maribor, Celje 2015, 115–124.

[8] Krupa M., *Rabka-Zdrój. Aspekty urbanistyczno-architektoniczne dziedzictwa kulturowego*, DWE, Wrocław-Kraków 2018.

[9] Richardson D., *Eye-Tracking: Characteristics and Methods*, Stanford University, 2004.

[10] Duchowski A., *Eye Tracking Methodology. Teory and Practice*, Springer, London 2007.

[11] Holmqvist K., Nystrom M., Andersson R., Dewhurst R., Jarodzka H., Weijer J., *Eye Tracking: A Comprehensive Guide to Methods and Measures*, Oxford University Press, New York 2011.

[12] Bojko A., *Eye tracking the user experience. A practical guide for research,* Rosenfeld, New York 2013.

[13] *Current Trends in Eye Tracking Research*, edit. M.Horsley, M.Eliot, B.Knight, R.Reilly, Springer International Publishing, Switzerland 2013.

[14] Wawer R., *Eyetracking w przestrzeniach edukacji medialnej*, Lubelskie Towarzystwo Naukowe, Lublin 2014.

[15] Wawer R., Pakuła M., *Zastosowanie techniki eyetrackingowej do analizy postrzegania historycznej przestrzeni wystawienniczej przez osoby starsze i młodzież – teoretyczne i metodologiczne podstawy badań,* "Zeszyty Naukowe Uniwersytetu Szczecińskiego. Ekonomiczne Problemy Usług", Vol. 88/2012, Gospodarka elektroniczna: wyzwania rozwojowe, Vol. 2, 698–707.

[16] Kabaja B., Krupa M., *Możliwości wykorzystania metody eye tracking do badań nad historyczną przestrzenią architektoniczną w kontekście jej postrzegania przez użytkowników*

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[17] Lebrun Ch., Sussman A., Crolins W., Van der Linde G., *Eye Tracking Architecture: A Pilot Study of Building in Boston*, Institute for Human Centered Design&Ecole de Design Nantes Atlantique, Boston 2016.
[18] Junker D., Nollen Ch., *Mobile eye tracking in landscape architecture. Analysing behaviours an interactions in natural environments by use of innovative visualisations*, [in:] Proceedings of the International Conference "Between Data and Senses. Architecture, Neuroscience and the Digital Worlds", edit. A.Korandinon, UEL, London 2017, 16–18.
[19] *User Manual – Tobii Studio, Version 3.2. Rev A*, Tobii Technology AB, Stockholm 2012.

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