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Evaluation of Advertising Images with Laptop Camera Eye Tracking

Abstract

Object: The goal of this article is to evaluate the quality of the eye tracking method for studying the perception of advertising images using a laptop camera.

Methods: The method of scientific experiment was chosen as the main method of research, with hypotheses, their verification, confirmation or refutation. For processing the results, the calculation of the mean value of the percentage of fixation and t-test were used to determine the statistical significance of differences in the results.

Findings: Options were developed to improve the eye tracking method: recommendations to improve the reliability of the results, and factors influencing the respondent's actions were identified. The described methods for improving the quality of images are of a qualitative nature. The main criteria for obtaining the most reliable result when working with a focus group are determined. The necessity of using artificial intelligence to combine eye-catching areas of drawings with a heat map is revealed. Recommendations for teaching the use of the research method under consideration are given.

Conclusions: An eye tracking tool using a laptop camera was evaluated. Possible reasons for the distortion of the results were identified. The ways of further improvement of the tool, methods of its use and processing of the obtained results were proposed. Due to the limited sample size, the reasoning is qualitative. Possible directions for further work are identified.

Keywords: Eye Tracking, laptop camera, experiment, heat map, attention focusing, focus group, market research, hypothesis.

Introduction

It is recognized that marketing activities are successful in case they are based not on the assumptions of marketers, but on the results of real research. One of the areas in which this statement is particularly relevant is the development of advertising images. The relevance of this area has not diminished, but rather increased in the era of digitization, as advertising images are widely used in digital media.

An important part of studying the perception of advertising images is how they are viewed by the respondent and where their gaze is fixed. To this end, various tools are proposed, including those based on artificial intelligence. However, with such rapid development of tools, there is not always enough careful evaluation of innovations.

New tools also imply new methodologies for their use, which must also be tested in practice. This article is devoted to evaluating the quality of the eye tracking method for studying the perception of advertising images using a laptop camera: the process of data collection, their reliability and usefulness. Measures proposed to improve the procedure for using the tools and directions for further research are discussed. Practical use of the investigated tool for startups and educational purposes is also discussed.

Literature review

The study of eye movements during image viewing has a long history (Płużyczka, 2018), which began in 1897 with direct observation methods. Later, reflections from the cornea of the eye were recorded on photographic film. In 1950, Soviet scientist Alfred Yarbus created a setup that recorded reflections from a mirror attached to the pupil on photographic film. In 1967, the book Eye Movements and Vision was published abroad (Yarbus, 1967). The devices attached to the eye, such as contact lenses (Biancalana, Chessa, 2022), were quite uncomfortable for the subjects. Complex and bulky devices of various types emerged (Young, Sheena, 1975;

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were quite uncomfortable for the subjects. Complex and bulky devices of various types emerged (Young, Sheena, 1975; Fraser, 2020; Mento, 2020), including those that used electrooculography (Alam et al., 2021), which is based on the study of eye muscle dynamics and external retinal layers through changes in bioelectrical potentials during eye movement.

Currently, video monitoring is widely used for eye tracking. Special glasses, stationary devices (Tobii, 2023), and video cameras are used for this purpose. However, they are quite difficult to use, primarily because they require specially organized studies. Many recent developments have focused on the use of video cameras for eye tracking, and the difficulties encountered in this regard are overcome using artificial intelligence (Housholder et al., 2022).

Historically, the first application of eye tracking was the study of the reading process. The next application, since 1947, was observing a pilot's eye movements (Mohan et al., 2019), which is considered the beginning of the use of eye tracking in usability. Yarbus studied the dependence of eye movements on the task that the subject was solving when viewing an image. Subsequently, the scope of eye tracking applications significantly expanded and continues to evolve (Punde et al., 2017; Santoshikka et al., 2021; Eye Tracking Market, 2022). The applications include:

- medicine (diagnostics), psychology: cognitive processes, attentional control, visual memory studies;
- marketing research: product evaluation, packaging, design, purchasing behavior, advertising; optimization of customer behavior in general;
- website usability, especially on mobile devices;
- gaming behavior;
- study of attention in drivers and pilots;
- human-computer interface.

It is evident that marketing is quite important in most areas of its application.

The development of its tools is moving from complex devices that attach the head, helmets and glasses to a camera on a laptop that is invisible to the respondent and does not require the presence of the researcher.

Therefore, the use of cameras that are equipped with the overwhelming majority of modern laptops and even computer monitors appears to be very promising for marketing tasks.

The application of this tool has a number of difficulties (Housholder et al., 2022). In addition to the process of processing the collected data, the conditions for measurements are also important. If the respondent is at home, for example, there is no guarantee that their face is well lit, that the camera is in good condition, etc. Although this is not as critical in this case as for an autonomous car, it can still lead to errors in the decisions made. Therefore, it is important to test the applicability of the tool in practice. However, there are few reports on solving practical problems.

As for the measurement methodology itself, there are some practical guides for educational purposes, such as (Polevaya et al., 2017), although a rather complex iWiewX SDK toolkit is proposed for use, which requires qualifications for installation and operation.

The emergence of online eye tracking services significantly expands the list of potential users. These are easy-to-learn systems that do not require knowledge of computer science, provide the opportunity for surveys without special equipment and premises, and provide data in a convenient form. They allow new and small companies to quickly and without significant costs test advertising materials in the field. In addition, this tool is extremely useful for educational purposes.

In modern conditions, specialists no longer need to rely on lower levels of abstraction than solving their immediate tasks. Marketers should already know only what concerns their work, rather than dealing with software, developing and training neural networks, and configuring functions of universal systems. Therefore, according to the authors, the maturity of a particular method is determined by the availability of ready-made tools, including online ones.

Methods

The following marketing task is considered: it is necessary to propose the most appropriate advertising image for the purpose of attracting maximum attention to the target part of the image.

Stages of solving the problem:

- consider the problem in the context of marketing research;
- select the criterion for achieving the research goal;
- develop a procedure for evaluating advertising images based on this criterion;
- propose a method for comparing image variants and selecting the best one.

The general problem within which the given task is solved is to increase the number of purchases of a certain product. With the advent of digital marketing, the concept of the customer journey has become popular (Belding, 2021; Gingiss, 2021). The stages of this journey include:

- attracting attention to the product or at least to a specific category of products;
- arousing interest;
- the respondent searching for additional information;
- selecting a specific product;
- making a purchase.

There are numerous methods for managing this process. Many of them are related to displaying various images. This can be street advertising, advertising in the media, or images on websites. In all these cases, the aim is to convey a certain idea or image to the viewers.

This article discusses product image without text in a real environment. The following techniques are used for initial attention-grabbing:

- large size;
- bright colors;
- a striking, contrasting element in the image that evokes certain emotions (not necessarily positive);
- in online environments, this can be achieved with pop-up images based on the visitor's browsing history.

The next step involves careful examination of the image, which is the most critical stage that requires accurate fixation. There are several ways to visualize the information obtained through eye-tracking:

- heat maps that use colors to show the areas where the respondent's gaze lingered during different time intervals;
- fog maps that provide a clearer view of the areas where the gaze stopped;
- gaze path maps that display the sequence of gaze movements across the image.

These maps allow researchers to understand the respondents' behavior and make useful conclusions. The fog map is useful for previewing and evaluating the image quality, while the heat map is more suitable for the described task as it provides clear preliminary information. The gaze path map is used for more precise image design, based on empirical rules for controlling gaze movements.

For the heat map, the online service GazeRecorder – Cloud Eye-Tracking Insights Platform was chosen. This platform offers a range of solutions for eye tracking. Compared to traditional gaze tracking, which requires specialized technologies and respondents to be invited to laboratories, GazeRecorder can track eye movements using respondents' home computers. The system uses advanced algorithms for face and eye identification, iris tracking, and 3D motion tracking, allowing for accurate tracking even when people move, lighting changes, or faces are partially obscured (GazeRecorder, 2023).

The online service has a minimalist user interface with sufficient useful functions and adjustable parameters for most users. No special skills are required to create tasks or for respondents to answer from their computers, making this feature significantly expand the scope of the method. The program and online service are free for non-commercial use, making them particularly convenient for educational purposes. To use the service, users need to create an account using a working email address. The aim of the remainder of the article is to describe the basic methodology for testing the applicability of eye-tracking tools and its adaptation for solving a real-world problem. The experiment starts with uploading an image file, with the image shown in the Figure a) used for research purposes, aiming to familiarize or remind participants of a food packaging film in its branded packaging.

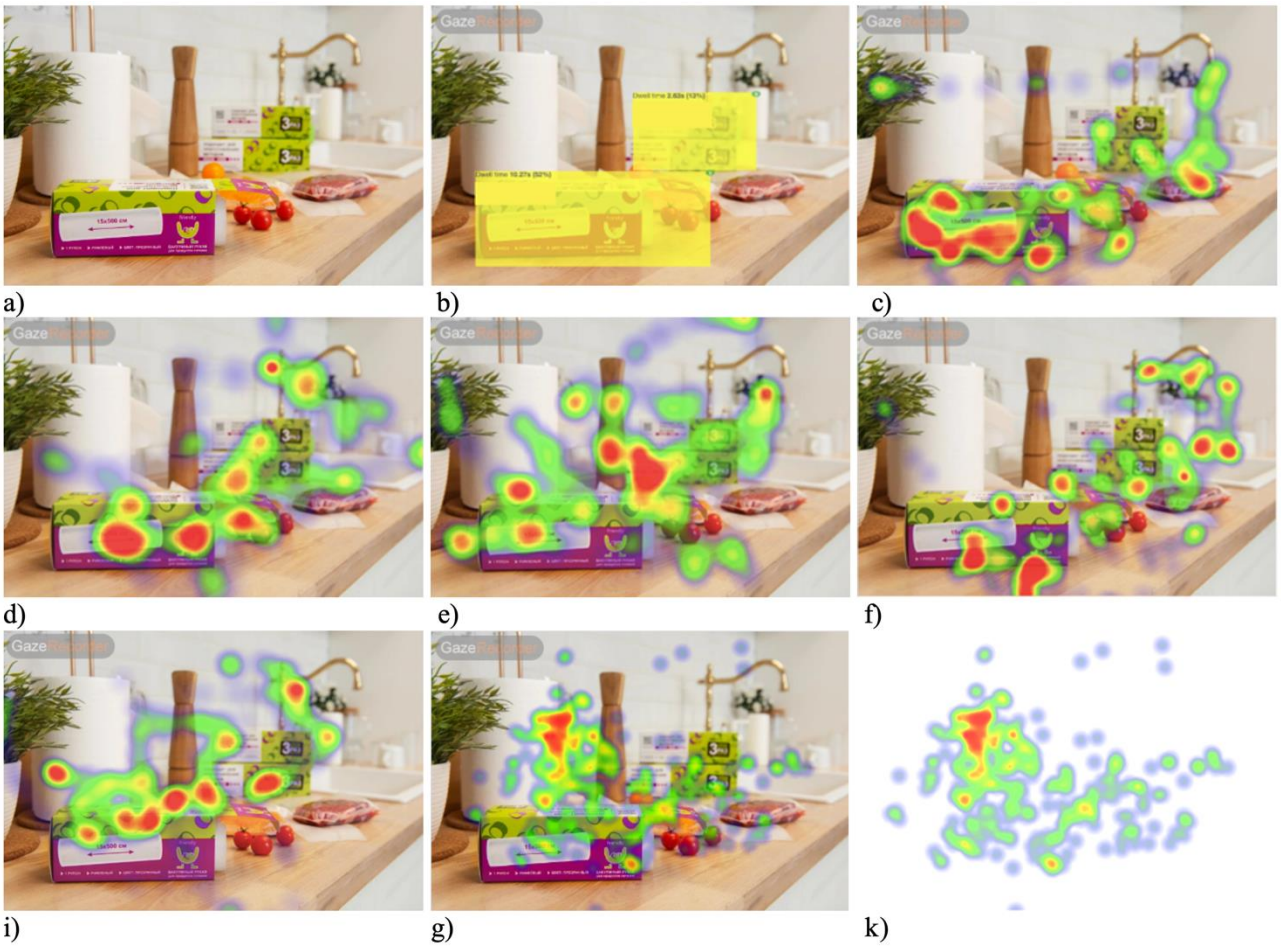

Figure. Results of eye-tracking experiments

Note – created by the authors' team.

The viewing time can be set between 1 and 60 seconds. The demonstration time is a separate issue. A short time will not provide a reliable picture, while a long time will fatigue respondents and make the results unreliable. At the same time, the trend towards short-term attention fixation requires a minimum time provided that a reliable and informative picture is obtained. In preliminary testing, it was found that a clear informative picture with areas of different intensities can be obtained starting from a viewing time within 30 seconds.

The link to the study is sent to the respondents. Upon opening it, they will receive instructions. To begin, they will need to turn on their camera and provide the following conditions:

- your face is visible;
- you have good light in your room;
- there is no strong light behind your back;
- there is no light reflections on your glasses.

It is the respondents' responsibility to ensure these conditions. Next, a fairly lengthy calibration process begins. The respondent must watch the marker on the screen and then turn their head towards it. If the respondent significantly changes their position, they will need to repeat these tasks. Then the respondent will be presented with the tested image, which should be new to them. No instructions are required, they just need to look at it.

The result is a heat map that can be adjusted by changing its intensity (Scale engine) and the size of the point areas (Blure engine). The program allows one to assess the proportion of attention, assessed as the proportion of time the gaze is fixed on the highlighted area. An important area for displaying the image is shown in Figure b).

To evaluate the application of the tool, a limited pilot study was conducted with five respondents who were presented with three images of similar purpose. Of course, the obtained data cannot be used to make decisions, but a number of useful conclusions can be drawn from them.

The following were used to process the results:

- calculation of the average value of the percentage of gaze fixation on the important fragment of the image for advertising purposes;
- t-test to determine the statistical significance of differences in results for different images.

The obtained results were analyzed using the following methodology:

- qualitative analysis was conducted to identify possible deviations of the results from reality;
- hypotheses about possible ways to improve the results were made;
- the feasibility and usefulness of these methods were assessed;
- manual improvement of the results was conducted;
- recommendations for improving the method and possible directions for further research were formulated.

Results

The data from the pilot study involving five individuals are presented in the Figure c)-i).

The simplest processing of these results involved determining the average attention fixation time in the given area (Table 1).

Table 1. Indicators of the percentage of attention focus time.

Image	Percentage of time focused
1	19
	32
	33
	41
	18
	Average: 29
	Variation coefficient: 34%
2	51
	34
	32
	35
	36
	Average: 38
	Variation coefficient: 20%
3 (in the Figure)	59
	31
	37
	52
	49
	Average: 45
	Variation coefficient: 31%
Note – created by the authors team.	

According to these results, image 3 proved to be the most useful. A noticeable difference in the mean values and high coefficient of variation was observed. To test the hypothesis of differences in mean values, a t-test was used (Lehmann, Romano, 2010). The results showed that even for such a small sample, the null hypothesis of equal mean values for options 1 and 3 could be rejected. Thus, it may be possible to eliminate unsuccessful options as results accumulate. This is the main part of the research process.

Next, an analysis of the features of the used methodology was conducted. Firstly, the researchers checked the functionality of the tool themselves. To do this, the researcher deliberately fixed their gaze on the dark vertical object in the image for most of the time (in the middle of element a) of the Figure). The result is visible in element g) of the Figure, where a noticeable shift occurred during gaze registration. The reasons for this could be various, such as imperfections in the calibration method, careless calibration by the

participant, uncontrolled eye movements, especially during prolonged viewing time beyond what is necessary to study the image, and involuntary posture changes.

One part concerns the measurement instrument itself, and the other part concerns the measurement methodology. The visual assessment of the quality of the results of the five respondents' study involved checking whether the gaze really stopped at the noticeable, highlighted elements in the image, rather than in empty areas. The heat maps are arranged in descending order of quality on the Figure. The map in element c) should be considered reliable since the gaze was fixed on the highlighted elements of the image. The right edge of the map in element d) may be slightly shifted upwards. The map in element i) is clearly shifted upwards. Therefore, the estimates in the Table 1 give an underestimated result, and in more complex studies, they may simply distort it.

The following improvements to the method were developed:

- manually align the separately saved heat map with the original image. The heat map can be saved as a separate image (element k for element g) in the Figure);
- another option could be to shift the area that is highlighted as important in the desired direction. Of course, this is a subjective process. In this case, rotating the area is impossible. The improved results obtained using this method are presented in Table 2.

Table 2. Indicators of the percentage of time focusing attention.

Image	Image element	Percentage of focus time before modification	Critical Area Shift	Percentage of focus time after modification
3 (in the Figure)	e)	59	No changes	59
	f)	52	No changes	52
	i)	49	Up	54
	g)	37	To the right	43
	k)	31	To the left	39
		Avegare: 45		Avegare: 49
		Variation coefficient: 31%		Variation coefficient: 16%
Note – created by the authors team.				

It is evident that the results have improved, although not as significantly as expected, and the coefficient of variation has slightly decreased. Perhaps an even simpler method is to expand the important area, but this may result in less reliable results, albeit more stable ones. Finally, a rather problematic recommendation for image design is to make the areas around the important element less bright and without attention-grabbing elements.

Discussions

The following conclusions can be drawn from the conducted research. All the described methods of improving image quality are qualitative and largely subjective. When comparing a series of images and selecting the best one, the question arises of how to compare them for the purpose of selecting the best one. To reliably distinguish similar images, a large number of experiments will be required, and the result will be meaningless since the real effect of such variations will be practically the same. The problem arises of making a decision about the level of similarity of the remaining “good” options. As a first approximation, it is proposed to test the hypothesis of the equality of image quality based on the available number of surveyed respondents.

The bias of the heat map or important area was still subjective. Therefore, the accuracy of the results cannot be quantitatively evaluated. However, the need for further improvement of the method can be considered proven. Obviously, combining attention-grabbing areas of the image with a heat map is a task for artificial intelligence.

Another important issue when conducting research is to improve the respondent's working process. The following factors influence the survey process:

- carelessness during calibration;
- respondent fatigue and loss of attention due to prolonged viewing of the image;
- lack of interest in the image;
- behavior distortion due to knowledge that actions are being recorded.

The focus group conducted with the surveyed respondents showed the following:

- the comfortable time for showing the image is 30 seconds;

- since the task is not complicated and the image is unknown in advance, distortions due to knowledge about the study are small;
- according to the subjective opinion of the respondents, the gaze stops on attention-grabbing fragments;
- if the number of offered similar images is more than three, it starts to become tiring and reduces interest in the experiment.

The following measures are proposed to increase the reliability of the results:

- careful selection of the respondent segment. Representatives should be interested in the product related to the study and have time to answer calmly;
- distributing a link to the study via email with a description of the importance of the research and the possible benefits for them personally;
- tighter control over the calibration process. However, this may cause irritation, and the subject may refuse to continue the study;
- more accurate management of the duration of image presentation. This will require research for different segments. A possible option is to allow the subject to control the duration. When they feel they have studied the image enough, they should be able to indicate this;
- introduction of measures to distract the subject from controlling their actions when viewing the image, so that they do not act “for show”. This could include playing music, possibly at the respondent's request before the start of the study;
- control over lighting conditions during the study. However, this may lead to an increase in the refusal rate from the study;
- screening out unreliable results. This can be achieved by a) removing outliers in measurement results; b) evaluating the coincidence of the heat map and the image. For example, in element f) of the Figure, the heat map almost goes beyond the image boundaries.

The last measure has its drawbacks. The number of respondents must increase. And a high percentage of rejected results almost always leads to bias (Iacobucci, Churchill, 2018).

Finally, some recommendations should be made regarding training in the use of this method:

- obviously, the method should be used in the context of a real marketing situation. It is necessary to describe it in order to make the relevance of using this method clear;
- since the research is likely to be conducted among students themselves, the topic should be close to them;
- in addition to creating and managing the research project itself, students must formulate a cover letter to disseminate the link;
- when processing the results, students must indicate possible errors and their causes.

All the conclusions of the report must be justified.

Conclusions

The goals set out in the article can be considered achieved.

An evaluation of the eye-tracking tool using a laptop camera was conducted.

Possible causes of result distortion were identified. They relate to both the tool itself and the methodology of conducting the study, and directions for their elimination were proposed.

Ways to further improve the tool, its methodology, and the processing of the obtained results have been suggested.

Due to the limited sample size, the reasoning is of a qualitative nature. Quantitative analysis and formal recommendations are a matter for the future. This study identifies possible directions for further work.

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Н.В. Павлов, П.О. Пантюхина, Е.А. Зотова, А.П. Шабан

Ноутбук камерасының көмегімен Eye Tracking әдісі арқылы жарнамалық бейнелерді бағалау

Аңдатпа

Мақсаты: Мақаланың мақсаты — ноутбук камерасының көмегімен жарнамалық бейнелерді қабылдауды зерттеу үшін көз қозғалысын бақылау әдісінің сапасын бағалау.

Әдісі: Зерттеудің негізгі әдісі ретінде гипотезаларды құру, оларды тексеру, растау немесе теріске шығарумен көрініс табатын ғылыми эксперимент әдісі таңдалды. Нәтижелерді өңдеу үшін нәтижелердегі айырмашылықтардың статистикалық маңыздылығын анықтау үшін бекіту пайызының орташа мәнін және t-тестін есептеу қолданылды.

Қорытынды: Көз қозғалысын бақылау әдісін жетілдіру нұсқалары әзірленді, нәтижелердің сенімділігін арттыру бойынша ұсыныстар және респонденттің жұмыс үдерісіне әсер ететін факторлар анықталды. Суреттердің сапасын жақсартудың сипатталған әдістері сапалық сипатқа ие. Фокус-топпен жұмыс істеу кезінде ең сенімді нәтиже алудың негізгі критерийлері анықталады. Сызбалардың көз тартарлық аймақтарын жылу картасымен үйлестіру үшін жасанды интеллектті пайдалану қажеттілігі айқындалды. Қарастырылып отырған зерттеу әдісін қолдануды үйрету бойынша ұсыныстар берілген.

Қорытынды: Ноутбук камерасының көмегімен көз қозғалысын бақылау құралы бағаланды. Нәтижелердің бұрмалануының ықтимал себептері анықталды. Құралды одан әрі жетілдіру жолдары, оны пайдалану әдістемесі және алынған нәтижелерді өңдеу ұсынылды. Таңдаудың шектеулі көлеміне байланысты дәлелдеулер сапалы сипатқа ие. Әрі қарайғы жұмыстың мүмкін бағыттары белгіленді.

Кілт сөздер: Eye Tracking, ноутбуккамерасы, эксперимент, жылукартасы, назараудару, фокус-топ, маркетингтік зерттеу, гипотеза.

Н.В. Павлов, П.О. Пантюхина, Е.А. Зотова, А.П. Шабан

Оценка рекламных изображений методом *Eye Tracking* с помощью камеры ноутбука

Аннотация

Цель: Цель данной статьи — оценка качества метода отслеживания движений глаз для изучения восприятия рекламных изображений с помощью камеры ноутбука.

Методы: В качестве основного метода исследований выбран метод научного эксперимента, с выдвижением гипотез, их проверки, подтверждения или опровержения. Для обработки результатов применялись расчеты среднего значения процента фиксации и *t*-теста для определения статистической значимости различий в результатах.

Результаты: Были разработаны варианты по усовершенствованию метода отслеживания движений глаз, рекомендации по повышения достоверности результатов, обозначены факторы, влияющие на процесс работы респондента. Описанные выше методы повышения качества изображений носят качественный характер. Определены основные критерии получения наиболее достоверного результата при работе с фокус-группой. Выявлена необходимость использования искусственного интеллекта для совмещения привлекающих взгляд областей рисунки с тепловой картой. Приведены рекомендации по обучению использованию рассматриваемого метода исследования.

Выводы: Проведена оценка инструмента отслеживания движений глаз с помощью камеры ноутбука. Выявлены возможные причины искажений результатов. Предложены пути дальнейшего совершенствования инструмента, методики его использования и обработки полученных результатов. Ввиду ограниченного размера выборки рассуждения носят качественный характер. Выявлены возможные направления дальнейшей работы.

Ключевые слова: отслеживание движений глаз, камера ноутбука, эксперимент, тепловая карта, фокусирование внимания, фокус-группа, маркетинговые исследования, гипотеза.