

Usability in E-Commerce Websites: Results of Eye Tracking Evaluations

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Abstract—Usability is one of the most important quality attributes for web-based information systems. Specifically, for e-commerce applications, usability becomes more prominent. In this study, we aimed to explore the features that experienced users seek in e-commerce applications. We used eye tracking method in evaluations. Eye movement data are obtained from the eye-tracking method and analyzed based on task completion time, number of fixations, as well as heat map and gaze plot measures. The results of the analysis show that the eye movements of participants' are too static in certain areas and their areas of interest are scattered in many different places. It has been determined that this causes users to fail to complete their transactions. According to the findings, we outlined the issues to improve the usability of e-commerce websites. Then we propose solutions to identify the issues. In this way, it is expected that e-commerce sites will be developed which will make experienced users more satisfied.

Keywords—E-commerce websites, eye tracking method, usability, website evaluations.

I. INTRODUCTION

USABILITY has gained great importance in software systems with the development of information technology. Usability is defined by the International Standards Organization (ISO) in the ISO 9241-11 standard as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” [1], [2]. Users want to complete tasks quickly, easily, and successfully. Therefore, while software systems are being developed, it is aimed to meet these expectations of users by creating user-oriented design. If the users' expectations are not taken into account and if an easy-to-use and understandable interface is not provided, the system will not be adopted by the users [3].

Eye tracking method is widely used to evaluate the usability of software systems. This method provides data for understanding users' focus points in the software systems. It collects eye movements data when users using a system with eye-tracking device. Collected eye movements are analyzed based on fixation and saccade-based measures [4], [5]. After the analysis process, user's visual behaviors are determined. In this way, the strengths and weaknesses of the design features are revealed.

In this study, it is aimed to reveal which usability features should be provided in e-commerce websites for experienced users. In order to achieve this, usability problems in e-commerce websites are identified by using eye tracking

method. After the usability issues of e-commerce sites were identified, various design recommendations have been made in order to avoid these problems in the future website design.

The rest of the paper is organized as follows. In Section II, we described the previous work related to eye tracking. The methodology of this research is explained in Section III. In Section IV, we presented the results obtained from the evaluation. The discussions of the results are shown in Section V. Finally, general conclusions obtained from this study are presented in Section VI.

II. RELATED WORK

Eye tracking method is applied in usability evaluations in the analysis of eye movements that users make while using a system. Several studies have used eye tracking for usability analysis. Therefore, there are various studies in the literature for evaluating e-commerce sites using eye tracking method. In [6], heuristic evaluation and usability testing were used to evaluate the impact of usability and social and trust elements on four e-commerce websites. For usability testing, eye tracking was used to determine the impact of social presence in one e-commerce website. After evaluating the websites using two methods, they discussed the importance of usability and design elements, such as Gestalt principles, Fitts' Law, heuristics, and social networking. As a result of the discussion, they found that it is important to apply the Gestalt Principle, Fitts' Law and affordance across the e-commerce websites. Additionally, other principles such as trust, offline communication, and social presence need to be added in e-commerce websites.

In [7], eye tracking method was used to examine the eye movements of users as they interacted with the interface of e-commerce websites. In this way, they tried to obtain eye movement data as an indicator of the user's cognitive processes. In addition to the acquired eye movement data, expert inspections and user-based observations were also used in the usability evaluation. As a result of the study, they suggested a new usability evaluation method that combines all other usability evaluation methods.

The effects of user testing and heuristic evaluation methods have been compared to define usability problems of e-commerce websites in the study by [8], for determining the usability problems of e-commerce sites. As a result of the comparison, they determined that user tests are more effective in determining the basic usability problems of e-commerce sites. They found that the heuristic evaluation method was effective in finding problems that are not important.

In [9], a study was made to combine guidelines of web

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design and empirical studies as found in the literature. Thus, they combined eye tracking and state-of-art techniques to examine e-commerce websites. They performed four different sub-experiments for this study. In each study, they compared their combined approach with other approaches in the literature. As a result of the comparison, they determined that combined approach supported the other approaches in the literature. When we look at the results of the study, it was seen that there was a similarity relation between these approaches.

In [10], eye tracking method was used to evaluate user experiences in e-commerce websites. They used eye tracking metrics and other traditional usability metrics in evaluation process. As a result of the study, convenient interface design for e-commerce websites has been revealed.

A Finnish e-commerce website was examined using eye tracking method in [11]. They have tried to improve existing website's usability using eye tracking method. Firstly, they evaluated a Finnish e-commerce website's usability with a group of 17 people, of which, 59% were women and 41% were men. The participants analyzed the eye movement data of users to make mock-ups based on their findings and to suggest improvements in the website design. In the results of the study, they compared their mock-ups with the evaluated website's mock-ups.

In [12], eye tracking method was used to evaluate the cognitive processes of novice and experienced users when shopping online. Users evaluated two popular e-commerce websites using eye tracking method. As a result of the evaluation, it has been determined that using eye tracking provided important advantages in usability studies compared to other methods. In particular, this method provided important information as to website usage and user satisfaction rates.

III. METHODOLOGY

In this study, eye-tracking method is used to find out the features that improve the usability of e-commerce websites. Experiments are conducted with 20 participants and two e-commerce applications are used. After the experimental study was performed, eye movement data were analyzed using metrics such as heat maps, gaze plots, task completion time, and number of fixation. Thus, the features that are important for the usability of e-commerce websites have been obtained.

A. Participants

Usability evaluation of e-commerce websites was conducted with two different groups of participants. The first group consisted of 10 people, of which, four were female and six of them male, with an average age of 26.2 years. The second group consisted of 10 people, of which, seven were male and three of them female, with an average age of 22.4 years. All of the participants are experienced in e-commerce and have used an e-commerce website at least once in the past to make a purchase.

A questionnaire was administered to participants prior to the experimental study being carried out. In this questionnaire, participants are asked how frequently they used an e-

commerce website and how important the usability of an e-commerce website is for them. The frequency of participants' use of e-commerce websites is shown in Fig. 1.

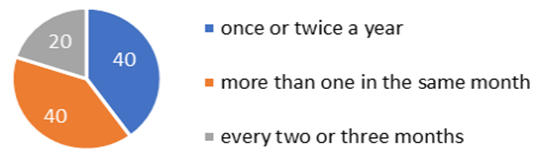


Fig. 1 The frequency of use of the e-commerce website

As shown in Fig. 1, 40% of participants use more than one e-commerce site in the same month, while 40% use these sites once or twice a year. And, 20% of the participants stated that they do shopping using e-commerce sites every two or three months. Based on these results, it is determined that users who have made usability evaluations are familiar with the interface designs of e-commerce websites.

The responses given by participants to the question of how important the usability of an e-commerce website is for them are shown in Fig. 2.

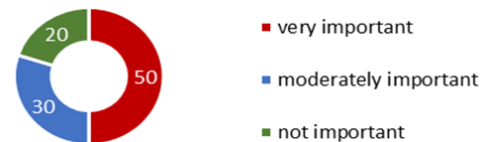


Fig. 2 The importance of e-commerce website's usability

As shown in Fig. 2, 50% of users stated that the usability of e-commerce sites is very important when shopping, while 30% stated that usability in the e-commerce website was moderately important, and 20% indicated that usability is not very important in such websites.

B. Examined E-Commerce Websites

In recent years, the use of e-commerce web sites has become more common with the widespread use of the internet and the growth of logistics networks. With the increasing popularity of the usage, the expectation from such sites has been increasing gradually. In particular, users expect e-commerce sites to be safe and easy to use. In this study, two e-commerce websites were identified for the experimental study. The e-commerce websites are specialized in selling technological products.

Other features of the web sites selected for examination are explained below.

1. Website A

Website A sells a wide range of computers and computer-related products, including monitors, printers and computer accessories. In addition, desktop computers, notebook, and gaming computer models are also being sold through this website; moreover, it includes a large number of computer brands. Therefore, it provides their users the ability of comparing different brands. The homepage of the website A is shown in Fig. 3.



Fig. 3 Homepage e-commerce website A



Fig. 4 Homepage of e-commerce website B

When the overall design of the website is examined, it is seen that the images are used very frequently in pages. It is thought that it is aimed to draw attention of users faster by using pictures. In addition, it is also seen that different color tones and font sizes have been used to direct the attention of users to specific points.

2. Website B

Unlike website A, e-commerce website B offers fewer product varieties. It sells only a variety of computer models such as gaming, notebook, or desktop, and no computer related products. Fig. 4 shows images of the homepage of the website B.

As shown in Fig. 4, there are not many pictures on this website. It has been seen that the products are introduced with more articles instead of pictures. It has also been observed that

there are not many colors used in the design of the site. It has been determined that the main color theme was black, white and blue colors, in combination with different front sizes and styles, and characters to attract the attention of the users. Thus, the attention of users is drawn to certain points.

C. Tasks

During the evaluation process, various tasks were assigned to participants. These tasks are determined by taking into account the activities that users often perform while using e-commerce websites. Three tasks were assigned to each participant group. Table I shows the tasks that participants of group_1 carry out during the usability evaluation of e-commerce websites.

The tasks that participants group_2 perform during the usability evaluation of e-commerce websites are listed in Table II.

TABLE I
TASKS FOR PARTICIPANT GROUP 1

Task	Description
1	Sign up to the e-commerce website for the evaluation.
2	Search for a specified product using the search box on the website and then review the product specifications.
3	Add a specified product to the shopping cart and perform the purchase process until the payment stage.

TABLE II
TASKS FOR PARTICIPANT GROUP 2

Task	Description
1	Sign up to the e-commerce website for the evaluation.
2	Search for a specified product using the search box on the website and then review the product specifications.
3	Find the two specified products in the website and add them to the comparison list and then compare the specifications of these products.

D.Procedure

The experiment took place in an eye-tracking laboratory. Eye movements were recorded using a screen based Tobii X2-60 eye tracking device. Tobii Studio software was used to analyze the eye movement data of the participants. This software enables the eye movement data to be visualized as heat maps, gaze plots and areas of interest.

In the usability evaluation process, participants were informed about the purpose of this study and how to implement the eye tracking evaluation. Before starting the test, all participants signed a consent form agreeing to participate in this experiment and for the use of their information. To begin the eye tracking test, a calibration process was first performed separately for each participant. After the calibration process was completed, participants performed the three tasks indicated on the screen. At the end of the evaluation process, the eye movements of all participants were successfully recorded.

E.Measures

After the usability evaluation process, recorded eye

movements were analyzed based on task completion time, number of fixation, heat map and gaze plot measures. These measures are briefly explained below [13]:

Task completion time: It measures how long the user completes the task assigned to him.

Number of fixation: It measures the number of fixations that the user has made in the interface to perform his task.

Heat map: The color representation of the eye movements that users perform on the system. When the duration of the pauses that users make at one-point increases, this area is shown in red, while the short focus points are shown in yellow or green. Heat maps provide important data in terms of showing users' points of interest. For this reason, it is frequently used in interpreting which points are attracting attention and which points are not.

Gaze plot: It shows the fixation points of the users on the website in sequence. When the complexity of the websites increases, the distance between the fixation points increases. Thus, it is considered that these distances will be shorter when more usable websites are designed.

IV. RESULTS

In the usability evaluation process, participants' eye movement data obtained using the eye-tracking method are analyzed based on task completion time, number of fixation, heat map and gaze plot measures.

A.Task Completion Time

On a user-friendly website, it is necessary for users to complete their operations as soon as possible. When the system provides this feature, it also increases productivity. This is why the completion period of the task is an important measure of the efficiency level of the system being evaluated. The average completion times of tasks in e-commerce website A and website B are shown in Table III.

TABLE III
AVERAGE TASKS COMPLETION TIMES

E-commerce Website	Evaluating Group	Task	Average Task Completion Time (sec)	Total Task Completion Time (sec)
A	Participant Group_1	Task_1	68	205.5
		Task_2	15.6	
		Task_3	121.9	
B	Participant Group_2	Task_1	77.1	184.3
		Task_2	46.8	
		Task_3	60.4	

The average task completion times in website A and website B are compared. In e-commerce website A, it is measured that the participant group_1 completed their all tasks in an average 205.5 seconds. However, participant group_2 completed their all tasks in an average 184.3 seconds in e-commerce website B. These results demonstrate that participant group_1 completed the tasks assigned to them in a shorter time than the second participant group.

B.Number of Fixation

The number of fixations is used to investigate the effectiveness and efficiency of software systems. The number of fixations increases significantly in tasks with too many operations. The sub-operations should be well organized to reduce the number of fixations. The average number of fixations in e-commerce website A and website B are listed in Table IV.

As shown in Table IV, participant group_1 had an average

124.7 fixations for task_1, 93.4 fixations for task_2 and 199.9 fixations for task_3 in website A. When the number of fixations of the other participant group is examined, it was seen that they had an average 128.3 fixations for task_1, 75.9 fixations for task_2 and 71.4 fixations for task_3 in e-commerce website B. According to these results, participants in the website B can complete their tasks with fewer fixations than participants in website A. The average number of fixations for the common and different tasks performed by participant group_1 and participant group_2 is shown in Fig. 5. The minimum number of fixations is recorded for product comparison. Both groups are fixated at similar rates for the sign up to the website and product research procedures. The biggest fixation is recorded in the product purchase process. This process has more fixation than other processes because it requires to enter a lot of information.

TABLE IV
AVERAGE NUMBER OF FIXATIONS IN E-COMMERCE WEBSITES

E-commerce Website	Evaluating Group	Task	Average Number of Fixation
A	Participant Group_1	Task_1	124.7
		Task_2	93.4
		Task_3	199.9
B	Participant Group_2	Task_1	128.3
		Task_2	75.9
		Task_3	71.4

C. Heat Map

Heat maps use color to represent the eye movements of users. When users pause for a long time at one point, this area is shown in red, while the short focus points are shown in yellow or green. In this study, heat maps are used to specify users' points of interest. Fig. 6 shows the eye movements of the participants on the homepages of e-commerce website A and website B. As indicated by e-commerce website A's heat map, most of the participants focused their attention on the

large titles and advertisements related to products. Therefore, fonts and images used together with large fonts on the homepage have resulted in gaining more attention from users. When the heat map obtained for e-commerce website B is analyzed, it has been determined that the participants are made more fixations in the main headings on the left. Additionally, it was also seen that there were too many fixations in the images. Thus, images are very important to attract the attention of users.

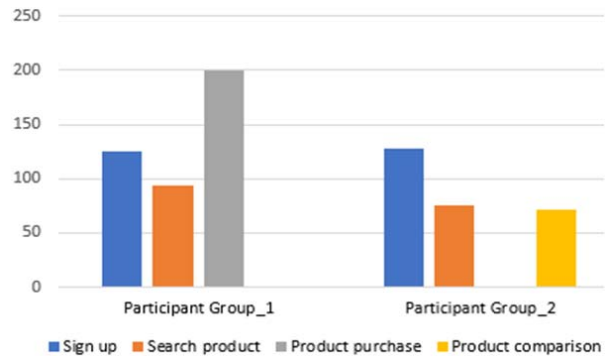


Fig. 5 Average number of fixations for the assessed tasks

D. Gaze Plot

Gaze plots represent the focus points of the users on the websites in sequence. The sequential display of focal points helps to understand in what order users are performing their actions. Fig. 7 shows the gaze plots obtained for the sign-up process. As indicated by the gaze plots of e-commerce website A and website B, it has been determined that there are many pauses for the sign-up process. The increase in the number of fixations is influenced by the activity requiring the filling in of information during the sign-up process. For this reason, while creating more efficient and effective websites, designs should be made so that users enter as little information as possible.



Fig. 6 Heat maps of e-commerce websites' homepages

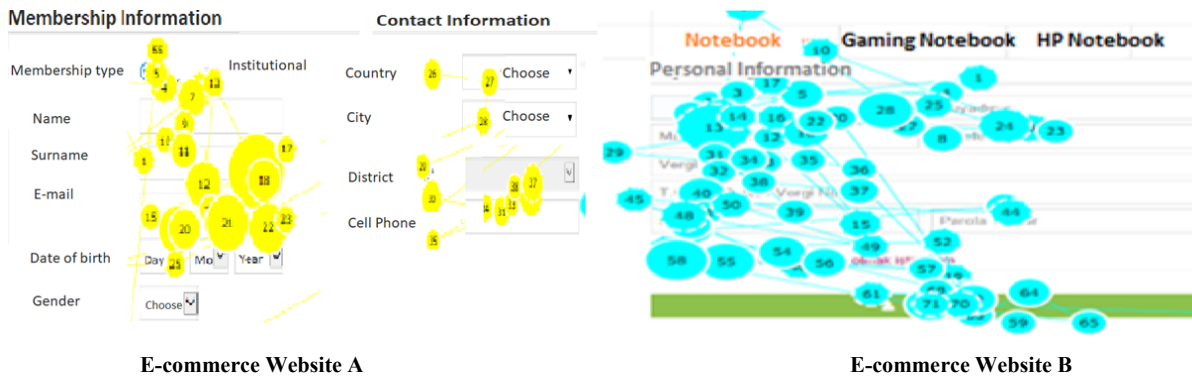


Fig. 7 Gaze plots for sign-up processes

V. DISCUSSION

In this study, the usability of e-commerce websites was evaluated using eye tracking method. As a result of the evaluations, it has been seen that users spend a lot of time performing their tasks. In addition, they focus on different points on the pages related to the tasks. This situation leads to an increase in the number of fixations.

The following usability issues have been identified as causing this situation:

- 1) **The product purchase process has too many subprocesses:** Compared to the time spent on tasks, it was determined that the task of purchasing products was the longest task. It can be seen that the reason for this is that the buying process is made up of 4-5 steps while other tasks can be completed in 1 or 2 steps. For this reason, the duration of task completion has increased.
- 2) **Requesting too much information from users in the sign-up process:** When the number of fixations was examined, it was seen that the number of fixations increased in places where too much information was required to be entered. The sign-up process is one that requires maximum information to be entered. So, this process increased both the number of fixations and the duration of task completion.
- 3) **Product comparison button is not clear enough:** When looking at the gaze plots and heat maps, it was detected that the product comparison button was not easily noticed.
- 4) **Warning posts are lengthy and complex:** The numbers of fixations made it clear that users paused more times in warning posts. However, when looking at the heat maps, it was seen that these places are red because of the long and complex information.
- 5) **Terminologies and expressions are not clearly shown:** It has been determined by observing the gaze plots that the number of pauses increases for the terminologies of products. Thus, it has been revealed that terminologies of products are not shown clearly.
- 6) **Notices and buttons do not attract attention:** When looking at the heat maps, it is seen that notices and buttons are shown in yellow and green colors. So, the heat maps show that the notices and buttons on the websites do not draw the attention of users.

- 7) **Button functions are not clear enough:** When the number of fixations was examined, it was seen that this figure increased where the button function is not clear.
- 8) **Key buttons for important operations not included in the main menu:** When looking at the gaze plots, it has been seen that users are looking for key buttons related to tasks for a long time in the main menu. This search process increases the task completion time.
- 9) **Users are not informed about the status of the system:** When the heat maps were examined, it was seen that different points on the homepage are red. It is thought that users are looking at different points because of the lack of information about the status of the system.

VI. CONCLUSION

Many e-commerce sites have been developed with the widespread use of the internet. While some of these e-commerce sites are frequently used by users, others are less preferred. One of the biggest factors in choosing e-commerce sites for users is their usability.

In this study, the usability of two e-commerce website have been evaluated using eye tracking method. After the usability evaluation process, we analyzed collected data based on task completion time, number of fixation, heat map and gaze plot measures. The results show that the evaluated e-commerce websites have several usability issues, and that these affect the performance of the users in the several processes.

The results of this study show the focus points of users when using e-commerce sites. Moreover, it is also revealed bad design features in e-commerce website A and website B. Considering the results obtained in the study, the following principles should be given importance when designing the interface of e-commerce websites:

- 1) Original and descriptive titles should be used.
- 2) The names and functions of the buttons should be obvious.
- 3) Terminologies and expressions must be consistent.
- 4) Informative feedback should be given to show the website's current status.
- 5) Helpful articles should be written to assist users for solving issues.
- 6) Important information should be located in places where

they can be found easily.

We recommend these several design principles to improve the usability of e-commerce websites. We hope that the results obtained from this work will be useful in designing more user-focused sites.

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