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Comparing Glasses-Based and Remote Eye Tracking for Mobile Banking Usability Assessment

Araştırma Makalesi /Research Article

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ABSTRACT: *Mobile banking applications, one of the digital marketing tools, enable users to perform banking transactions quickly and easily. The way to create usable mobile applications is through detailed user experience tests. In user experience tests, eye tracking technique, which can provide reliable and detailed results, stands out. The purpose of this study is to compare the metrics and data outputs of two eye tracking techniques used to measure user experience: glasses-based (TobiiPro) and remote (Realeye) with a webcam. Eleven participants with mobile banking application experience were asked to perform two different tasks. During the procedure, in addition to the eye tracking technique, the system usability scale (SUS) was used as a method, and user opinions were also utilized as part of the think aloud protocol. As the output of the task-based procedure, findings on the mobile application experience were obtained, while the results of the data collected from different eye tracking techniques were also obtained comparatively. While close values were obtained in the average fixation time, it was found that the fixation amounts differed. Due to the differences in the findings between the techniques, it is recommended that further research should be standardized refresh rates across both eye-tracking techniques and test a larger sample to validate these findings.*

Keywords: *Digital marketing, eye tracking, user experience, mobile banking application*

Mobil Bankacılık Kullanılabilirlik Değerlendirmesinde Gözlük Tabanlı ve Uzaktan Göz Takibinin Karşılaştırılması

ÖZ: *Dijital pazarlama araçlarından biri olan mobil bankacılık uygulamaları, kullanıcıların bankacılık işlemlerini hızlı ve kolay bir şekilde yapmasına olanak sağlamaktadır. Kullanılabilir mobil uygulamalar yapmanın yolu detaylı kullanıcı deneyimi testlerinden geçmektedir. Kullanıcı deneyimi testlerinde güvenilir ve detaylı sonuç alınabilen göz takibi tekniği öne çıkmaktadır. Bu araştırmanın amacı, kullanıcı deneyiminin ölçülmesinde kullanılan, gözlük bazlı (TobiiPro) ve web kamerası ile uzaktan (Realeye) olmak üzere, iki göz takibi tekniğinin metriklerinin ve veri çıktılarının karşılaştırılmasıdır. Mobil bankacılık uygulaması deneyimi olan 11 katılımcıdan iki farklı görevi yerine getirmeleri istenmiştir. Prosedür esnasında yöntem olarak göz takibi tekniğinin yanı sıra, sistem kullanılabilirlik ölçeği (SUS) kullanılmış ve yüksek sesle düşünme protokolü kapsamında kullanıcı görüşlerinden de yararlanılmıştır. Görev temelli prosedür çıktısı olarak, mobil uygulama deneyimine yönelik bulgulara ulaşılırken aynı zamanda farklı göz takibi tekniklerinden toplanan verilerin sonuçları da karşılaştırmalı olarak elde edilmiştir. Ortalama odaklanma süresinde yakın değerler elde edilirken odaklanma miktarlarının farklılık gösterdiği bulgulanmıştır. Teknikler arasında meydana gelen bulgu farklılıklarından dolayı, her iki göz izleme tekniğinde de yenileme hızlarının standartlaştırılması ve daha büyük bir örneklem üzerinde test yapılması önerilmektedir.*

Anahtar Kelimeler: *Dijital pazarlama, göz takibi, kullanıcı deneyimi, mobil bankacılık uygulaması*

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1. Introduction

With the widespread use of the Internet, digital marketing tools such as social media platforms, search engines, websites, mobile applications, etc. have emerged. Digital marketing processes have also played an active role in the banking sector, and in this direction, internet banking and electronic banking applications that focus on the user experience of bank customers have become widespread. These technological service channels, which have diversified as digital marketing tools, have started to be used as the main technological resource that will differentiate banking services from competitors, such as improving and accelerating customer experience (Todua and Gogitidze, 2021; Windasari et al., 2022).

It has been observed that the importance and use of mobile banking has increased in all bank-customer contact points other than bank branches due to the preference for mobile devices. Mobile banking - the execution of financial services through mobile devices - reduces the costs of bank organizations and provides various conveniences (such as sending money quickly, making payments, withdrawing loans, saving time, etc.) to customers (Al Amin et al., 2021; Chandran, 2014; Nagaraju, 2015: 100).

Thanks to the Internet's functionality in obtaining information, customers can learn about the products and services of different banks and compare the quality and ease of use of banking services offered over the Internet. Likewise, bank organizations in a competitive environment can quickly access and respond to customer demands thanks to the Internet and emerging usability technologies (Chauhan et al., 2023).

According to the Banks Association of Turkey Digital Internet and Mobile Banking Report, as of September 2024, 91% of the number of active digital banking customers (114 million people) only perform mobile banking transactions (TBB, 2024). On a global scale, Turkey has one of the highest rates of mobile banking adoption, as evidenced by the Statista Global Consumer Survey (2023). According to the results of the survey conducted in 56 countries between 2022 and 2023, Turkey (83%) and Nigeria (83%) stand out as the countries with the highest mobile banking usage (Statista, 2023).

In addition to improving the customer experience, the widespread use of mobile banking provides banks with significant benefits, particularly in terms of cost. The average transaction cost of mobile banking is approximately 2% of traditional banking. Mobile banking significantly reduces the transaction cost of banks and saves time for customers, creating a win-win situation. In addition, the ability to collect data from customers using mobile banking and the opportunity to develop personalized products and services makes mobile banking service advantageous (Jun and Palacios, 2016: 307-308).

With the increasing popularity of mobile banking services, banks have faced intense competition to expand and retain their loyal customer base. As a natural consequence of this competition, it has become a necessity to develop highly usable mobile banking applications. In this context, usability and user experience research, which examines and tests the process of users performing banking transactions on mobile devices, has gained importance. In the process, user studies have been conducted on mobile applications of various banks, and findings have been evaluated with various data collection and analysis methods such as expert opinions, system usability scale, content analysis, analytic hierarchy process (AHP), heuristic evaluation, etc. (Abubakar et al., 2016; Alhejji et al., 2022; Başar and Sinan, 2020; Hamid et al., 2022; Hussain et al., 2014; Malik et al., 2021). Qu et al. (2017) suggested that eye tracking data can be used as an objective measure to evaluate the user experience of mobile applications. Hyökki (2012) stated that individuals' cognitive biases have an impact on the measurement of user experience and suggested that the effect of these biased attitudes can be reduced with eye tracking and multi-method approaches. Although eye tracking techniques are preferred in user research, which of these techniques to prefer is open to debate. There is no study in the literature comparing the outputs of remote and glasses type eye tracking techniques that collect data simultaneously. This study has a unique value by filling this gap in the literature.

In user research on mobile applications, in addition to the effective and efficient completion of the task given to the users, measuring visual attention increases the validity and reliability of the research findings. The use of traditional methods such as questionnaires and interviews in user tests, where visual attention is important, creates depth, scope and validity problems on the findings because it only considers the consciousness aspect of users. Users' mobile application behaviors cannot be explained only by conscious behaviors, and these behaviors are processes in which the unconscious level is more active (Schiessl et al., 2003: 2). Users' behaviors within the scope of the task they perform while using the mobile application are systematic and fast behaviors controlled by motor skills beyond conscious awareness. For this reason, the use of psychophysiological techniques such as eye tracking, which can also measure the unconscious level in user research, increases the reliability and validity of the findings to be obtained from the research (Wang and Minor, 2008). When the related literature is examined, it is noteworthy that there is a scarcity of research on the web mobile application experience of the eye tracking technique.

The research provides an innovative methodology for examining mobile banking applications at the level of task-based user research. Moreover, there are very few published studies on the performance of eye-tracking tools outside of manufacturers. There are also no open-source systematic benchmarks for evaluating the performance of these tools (Ehinger et al. 2019: 3). Therefore, this research can provide a valuable perspective to compare the results of different eye-tracking measurement tools. In this framework, the research examines Garanti

BBVA mobile application, one of the most widely used banking applications in Turkey, in terms of usability, while also comparing the tools that collect gaze data. Firstly, the usability of Garanti BBVA mobile banking application was examined and it was concluded that the application was usable. Secondly, the question of whether the fixation measurements and gazeplots created by TobiiPro and Realeye differ significantly was sought. Differences were observed in the measurement results and suggestions were made.

2. Conceptual Framework

2.1. User Experience

When the concept of usability was first defined, it was often referred to as ease of use (Shackel, 2009: 340). Later, with the expansion of the factors that determine usability, the definitions on the concept have also changed. The International Organization for Standardization (ISO) defined user experience as “the degree to which a product can be used with effectiveness, efficiency and satisfaction by specific users in a specific context of use to achieve specific objectives” (ISO 9241-11, 1998). As Internet-connected systems have become an ordinary part of daily life, it has become clear that users expect more than the ease of use of the system. In addition to being able to fulfill tasks easily, users' enjoyment of using the system has been included in the scope of usability (Bevan, 2009: 1-4). Usability has been seen as a dynamic field that is gradually expanding its scope.

The usability of marketing tools that are digital content media, such as mobile applications or websites, is viewed through the interfaces where the medium confronts the user and where the main interaction takes place. Usability can be defined as the ease of use and suitability in a system where users perform various tasks through these interfaces. Ease of use here affects the user's performance and satisfaction level in the system. Mobile applications are applications that users interact with through relatively small devices. Visibility and clarity of design elements are critical success factors in mobile applications (Hussain et al., 2014: 136). Apart from the limitation of small screen size in mobile apps, there are several key challenges that designers face: Mobile context, different screen resolutions, limited data processing ability and power of devices, data entry methods, etc. are seen as the main components that cause users to experience difficulties in mobile applications (Harrison et al., 2013: 2). In addition, it has been observed that the mobile application version of the web-based system has difficulties that may cause excessive cognitive load on users due to the transfer of web-based applications one-to-one without adapting them to mobile systems, loading too much content into the application, size, interaction differences, etc. (Hoehle and Venkatesh, 2015: 436).

It is possible for a system or basic content to be adapted from a web interface or designed from scratch for a mobile interface. In both scenarios, the visual, auditory and usability-based experience adapted for the mobile interface enables users to interact with the system without difficulty, easily and enjoyably while using the mobile interface and performing the relevant task scenarios (Gatsou, 2015). At this stage, Norman's (2005) human-centered design approach can be taken as a basis. Although the user's finding a system usable and interacting with it depends on his/her past experiences and ability to use it in most scenarios, it is possible to increase the level of users' interaction with the system they are using for the first time by using metaphors in the context of a clear and easy-to-use interface design and content interaction (Blair-Early and Zender, 2008; Marcus, 1998).

As a result of all these approaches, a well-designed mobile interface will provide an output that will allow the user to fulfill the basic task it targets easily. This output will create a happy and satisfied customer as a reflection of the user experience. A happy and satisfied customer is one of the fundamental principles of marketing, whether digital or traditional. In this context, it is important to perform user tests that will enable the construction of a positive user experience.

3. Methodology

In testing the usability of a system, effectiveness, efficiency and system satisfaction are generally emphasized. While the user's ability to complete a given task is referred to as effectiveness, the time the user spends to complete the given task is referred to as efficiency. It is aimed to measure system satisfaction with the answers given to the questions asked to the user about the system after the task is fulfilled (Harrison et al., 2013: 7).

When it comes to effectiveness, efficiency and satisfaction within the scope of the system, integrating structures such as finance and banking, which include critical timing, security, etc. on both the user and practitioner side, into mobile systems poses various challenges. For this reason, developing a mobile banking application is a very costly investment for financial institutions and one that needs to be created in a very careful manner. Research shows that not only does mobile application development cost millions of dollars, but most of the applications fail or fall short of expectations in terms of usability. Banking applications that contain too much product and service content also suffer from this failure (Hoehle and Venkatesh, 2015: 425-436). Within the scope of this theoretical perspective, the research takes a task-based research approach that will provide a better understanding of banking mobile applications and an eye-tracking-based design that will provide qualitative and quantitative psychophysiological findings.

Eye tracking, one of the psychophysiological data collection techniques, provides the opportunity to generate quantitative and qualitative data to understand the performance of key objects and to measure components such as usability and user experience. In studies where tools such as websites or mobile applications are examined in terms of usability, the eye tracking technique stands out as a technique with high international reliability and validity (Țichindelean et al., 2021: 7).

Using the eye-tracking technique in mobile phone applications with relatively small screens causes difficulties in the research procedure due to the high probability of participants taking their eyes off the screen and calibration problems. The sample size is reduced by excluding participants with missing eye data (Harezlak et al., 2014). Despite this difficulty, the eye tracking technique comes to the fore in examining the usability of applications on mobile devices, which are more frequently preferred in daily life.

Retinal trace data obtained from eye tracking provides evidence of where users focus and look. These data are the basic data that occur without the conscious intervention of the user and establish a reflexive and subconscious relationship with the content that the eye is looking at and focusing on. The metric referred to here as focusing is usually gaze fixations lasting 200-300 milliseconds (Duchowski, 2007). While scanning the retinal trace of the eye with the eye tracking technique, the eye's scan path, pupil size and blink reflex are metrics that can be measured to be tracked at the millisecond level. As a result of these numerous physical measurements, both many numerical metrics and qualitative output are generated (Tobii, 2024).

The focusing sequences resulting from eye tracking that allow us to qualitatively visualize retinal track motion are called scan paths. Often the scan path is also referred to as a gaze plot. The scan path or gaze plot is seen as an effective tool for evaluating the user's basic navigation behaviors in mobile applications (Cellary, 2023; Holmqvist et al., 2011; Tobii, 2024).

Thanks to the rich high-precision technical measurement possibilities provided by eye tracking, it is possible to easily identify elements that prevent the user from easily navigating, distract or confuse them throughout the entire task-performance process (Dos Santos et al., 2015: 34). The findings of gaze plot, which are created on the horizontal or vertical axis that the user is looking at, are key outputs that contain important clues for designing effective interfaces to create usability and user experience. Gaze plots enable very rich usability and experience outputs to be obtained even from a single user test. This enables highly accurate results to be obtained without the need to conduct tests with many users (Nielsen, 2000). Due to this feature, as the main component of the eye tracking findings in the study, the participants' gaze plots that occurred while performing the tasks given to them in the mobile banking application were taken into consideration as reference findings.

The sample size (n>5) recommended by Nielsen (2000) was taken into consideration for usability studies conducted with techniques that can obtain sharp findings without the need to use statistical information. It can be determined by the researcher that qualitative usability studies conducted with the eye-tracking technique have reached saturation. In a usability study where the number of participants is determined above a sample group of 5 people, the answers received generally repeat each other (Nielsen, 2012). For this study, a group of 11 participants (6 males and 5 females) between the ages of 18-49 was determined by convenience sampling method. The data obtained from 11 people show consistency and it has been determined by the researchers that the results of the study have reached saturation. The sample size is not statistically representative. The second data collection method used in the study is the system usability scale that evaluates the usability of the mobile banking application.

SUS is a quick and familiar method of usability research. Each SUS is based on a 7-point or 5-point Likert scale (strongly agree, agree, no opinion, disagree, strongly disagree). It is a questionnaire consisting of 10 questions (5 positive, 5 negative). The result of the SUS questionnaire is a usability score between 0-100. The literature suggests that a score of 68 and above is the threshold for a usable system (Cameron et al. 2019; Pradini et al., 2019). It is stated that 50% of mobile applications fall below this SUS score (Hyzy et al., 2022: 2). In addition to the SUS scale, the participants were administered the Think Aloud Protocol (TAP) during the research. In other words, the participants were asked to express their thoughts about the mobile application out loud while performing the task.

Within the scope of the research, the participants were first asked to examine their account movements on the Garanti BBVA mobile application and then they were asked to find the motor vehicle tax (MVT) payment screen, one of the payment types. In this study, after these two tasks, a 5-point Likert-type SUS questionnaire was applied to the participants to evaluate the mobile banking application. This study seeks to answer 2 research questions.

1. Does the Garanti BBVA mobile banking application meet usability standards?
2. Do the fixation values and gaze patterns generated by TobiiPro and Realeye differ significantly?

Ethics committee approval was obtained for the study on 09.02.2024. Data were collected simultaneously with web cam-based eye tracking software (Realeye.io) and TobiiPro Glasses 2.0 eye tracking tool in the form of glasses. Collecting the data simultaneously with 2 different eye-tracking tools allows the data obtained to be compared in terms of consistency. After collecting the eye-tracking data, the system usability (SUS) scale was administered to the participants. While determining the effectiveness, efficiency and satisfaction level/usability score from the data obtained from the users, comparative evaluations are also made with the eye tracking data.

3.1. Conducting Fieldwork

Participants were taken to a laboratory and seated 60 cm away from the monitor. Only a fixed ceiling light was used in the environment isolated from daylight.

Subjects performed the given tasks by looking at a mobile phone screen (60Hz, 1792 x 828-pixel resolution and 6.1 inches screen size) with average brightness. A prototype was used in the study where both measurement tools collected eye data simultaneously. In other words, while participants were looking at the screen with the Glasses type eye tracker collecting the data, the webcam-based eye tracking tool was also recording.

Participants were asked to perform two different tasks (reviewing account transactions and accessing the Motor Vehicle Tax (MVT) payment screen) using the Garanti BBVA mobile application. While performing the tasks, the participants simultaneously collected gaze data in constant light conditions using the glasses-based "TobiiPro Glasses 2.0" eye-tracking tool and the "Realeye" eye-tracking software that collects eye data remotely via webcam. The characteristics of these two different eye tracking techniques are given in the table below.

Table 1: Characteristics of Glasses-Based and Webcam-Based Remote Techniques

TobiiPro Glasses 2.0	Realeye
Scans retinal trace with 50/100 Hz	Scans retinal track with 30/60 Hz
Can be used in all physical field conditions	Can be used with any webcam
Light variable affects data quality	Light variable is under control
Cosmetic elements such as eye makeup, glasses, etc. can interfere with data acquisition	There are no warnings about cosmetic elements such as glasses or makeup
Provides visual and numerical data output such as heatmap, scan path, gaze plot, areas of interest (AOI), fixation, pupil size and blink data	Provides visual and numerical data output such as heat map, gaze plot, mouse cursor tracking, clicked area tracking, areas of interest (AOI), mood detection with micromimic expression analysis, fixation, attention level

As can be seen in Table 1, although there are differences in the characteristics of the two techniques, they both provide the basic fixation metrics that are often used in research using eye tracking. The numerical metrics of participants' gaze data are composed of fixation values. In the gaze data obtained in this study, the duration of gaze to be considered as fixation was limited in order to provide consistent results in both techniques and this information is given in the table below.

In this study, in order to compare the data outputs of the two techniques, filtering was performed on their software so that the minimum and maximum fixation times were equalized. Table 2 shows the minimum and maximum times required for a point gaze to be considered as fixation.

Table 2: Adjusting Fixation Times

Tobii Pro Lab Analysis Software	Realeye Analysis Software
I-VT stabilization, glance speed threshold 30 %/s	I-VT stabilization, gaze speed threshold 100%/s
Maximum fixation time 70ms	Maximum fixation time 70ms
Minimum fixation time 60ms	Minimum fixation time 60ms

Note: When conducting remote fieldwork with smartphones, the gaze speed threshold value Realeye studies min. 100%/s was preferred, considering the differences in front camera quality and scanning speed depending on the brand and model of the phone. Thus, it is aimed to approach the refresh and capture speed in the glasses model as a saturation value.

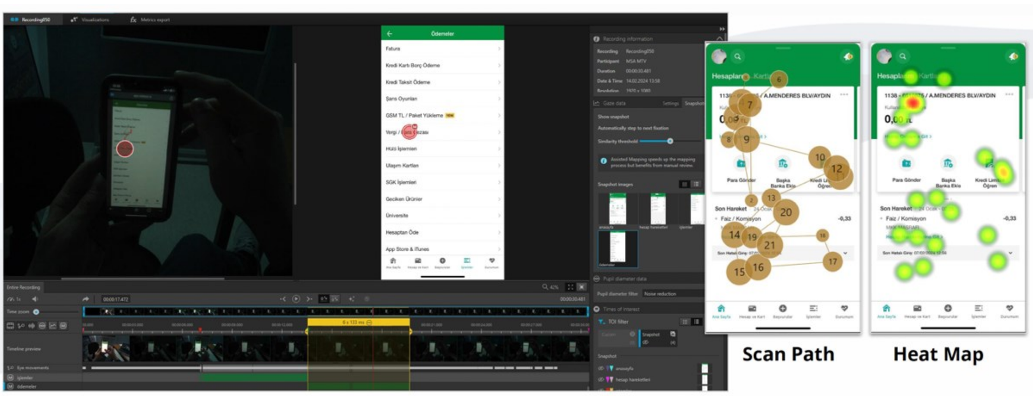
4. Findings

The research both evaluates the participants' mobile banking application experiences with a task-based approach and examines how two different eye-tracking techniques generate findings comparatively. In this direction, it is possible to analyze the findings obtained from the research under two main headings.

4.1. Findings of a Task-Based Usability Assessment

During the task-based usability evaluation, participants simultaneously used the glasses-based eye tracker and the webcam-based eye tracker software while using the prototype of the application presented to them. During the user test, the participants were given two tasks and were expected to fulfill these tasks. In the last stage of the test, the users were asked questions that included the SUS scale and then they were asked questions that performed the TAP. The results obtained in this framework are evaluated Figure 1.

Figure 1: Analysis of Simultaneous Data Results: Tobii Pro Lab Software and RealEye Software



The demographic data of the participants are presented in the table below. Participants were between the ages of 18-49 and had previously used a mobile banking application.

Table 3: Demographic Data

Age	
18-25	%46
26-33	%18
34-41	%27
42-49	%9
Gender	
Woman	%45
Man	%55
Past Experience	
Yes	%73
No	%27

Data were collected with the SUS, which determines the usability of systems such as websites and mobile applications. The responses to the SUS scale applied to the Garanti BBVA mobile application are given in Table 4.

Garanti BBVA mobile application SUS score was calculated as 72.27. This score (above 68) indicates that the mobile application was found usable (Cameron et al. 2019; Pradini et al., 2019). In addition to the SUS, the TAP was used to ask a question about the participants' thoughts on the usability of the Garanti BBVA mobile application they used while performing the research procedure.

At this stage, the answers given to the question of how you find the use of Garanti BBVA mobile banking application are given below:

- "I like it, it doesn't have a complicated design like Yapıkredi bank. Design colors are easy on the eyes..."
- "Habit..."
- "It's easy to use app, I just had a hard time finding the MVT payment..."
- "Overall, I like it, it has its complexities but it's better than some other apps..."
- "It's very useful in terms of convenience and shortcuts, I like it..."
- "It is a bank application I use. I encountered fewer errors compared to other bank applications. Especially after the errors I encountered in Akbank mobile and Denizbank mobile, it is a bank application that I prefer in terms of performing my work without errors. This is also why I preferred Garanti Bank's mobile application when there was an IPO..."
- "You can quickly find the page you want with a little browsing..."
- "I like it, at first you need to spend time in the app to learn how to use it, then it's easy to integrate into the interface..."
- "I like the Garanti BBVA mobile application because I can easily make the menus and transactions I want..."

Participants' user experience with the Garanti BBVA application is generally positive. This situation is also consistent with the results of the SUS scale.

Table 4: SUS Scores of Participants

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS raw score	Final SUS
4	2	4	2	4	2	4	2	4	2	30	75
5	3	3	2	3	2	4	2	4	1	29	72,5
4	2	4	2	4	2	3	2	2	2	27	67,5
2	3	3	2	3	2	2	3	3	3	20	50
4	2	4	2	4	2	4	2	4	2	30	75
4	1	5	1	5	1	5	1	4	1	38	95
3	2	4	2	3	2	3	2	5	2	28	70
5	3	3	1	2	1	4	3	4	1	29	72,5
4	2	4	1	5	1	4	1	5	2	35	87,5
2	3	3	2	3	3	3	3	3	2	21	52,5
3	2	4	1	4	2	4	2	4	1	31	77,5
Average											**72,27**

Note: Q2, Q4, Q6, Q8, Q10 reverse questions.

4.2. Comparative Findings of Eye Tracking Techniques

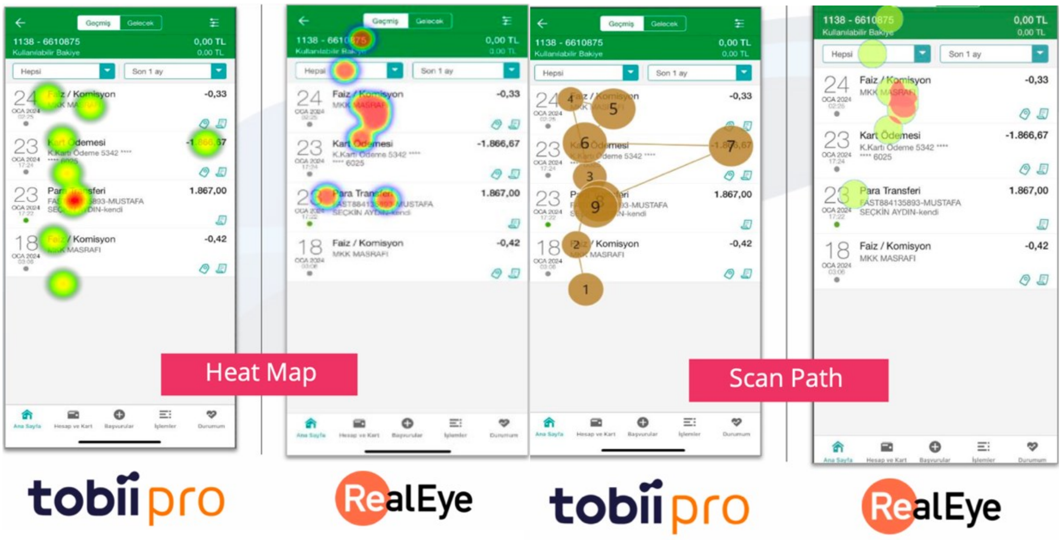
In the study, the technical capacities of the glasses-based TobiiPro eye tracker 2.0 and the webcam-based Realeye eye tracking software, which is based on remote data collection, were examined comparatively by running them simultaneously during the same procedure. The first of the findings of this comparison is shown in Figure 1.

Figure 2 first shows the prototype mobile application interfaces where account activity is analyzed. The green and red circles on the interface (left group) are heat maps representing the locations where participants experience focus. The principle of the heat maps is a color grading where the area of interest is red as the participant's focus increases and blue as the focus decreases. In the area where there is no color variable in the heat map, it is considered that no fixation has occurred.

When we examine the image with this information, it is observed that the participant, while examining the account transactions belonging to someone else on the prototype, mostly creates a cognitive process to understand the source of the transaction rather than the transaction amount. The card payment transaction with a high negative amount was the only item that attracted the participant's attention in terms of amount. At this point, it can be considered that the participant evaluated the card payment action as one of the items that he paid the most attention to in his own account transactions practice.

The numbered and unnumbered circles (right group) in Figure 1 show the scan path, which we refer to as the gaze plot in this study. The gaze plot shows which area the user focuses on first and for how many milliseconds, followed by the movement of the eye trail to which area, and the flow that follows. At the level of each individual user, the gaze plot results tell us, in other words, the user journey and the overall experience of the user as they cognitively move through the task. For this reason, it can be considered as one of the most effective eye tracking metrics.

Figure 2: Comparison of Heat Map and Scan Path (Gaze Plot) of Account Movements



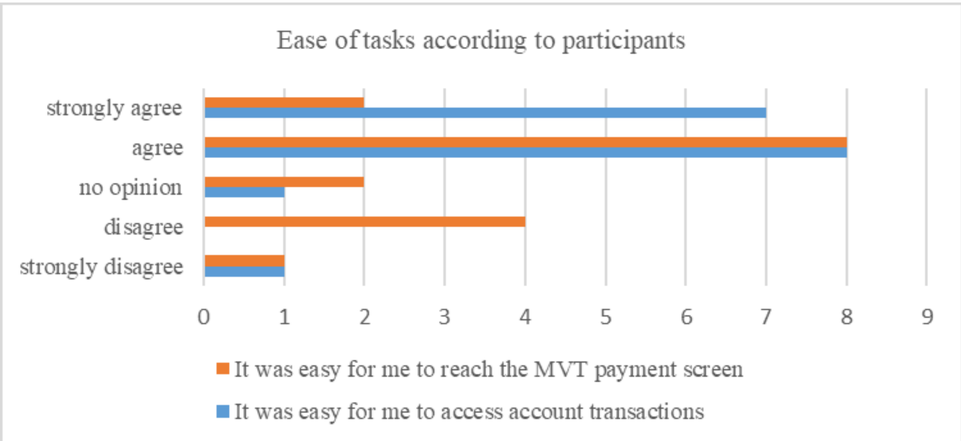
As the fixation increases on the area of interest, the diameter of the relevant ring in the gaze plot increases. When the participant's data is analyzed, it is seen that the most focus and cognitive load occurs on the card payment transaction and the related balance, which is the result that the heat map shows us. This is evidence of the participant's mental activity on the card payment and the related amount. This precise data obtained by eye tracking has the ability to produce results that can be evaluated from many interdisciplinary theoretical and practical approaches.

When the heat map and gaze plot data collected simultaneously by both eye tracking techniques on the same participant were analyzed, it was observed that although there was more fixation in the data collected with the TobiiPro Glasses 2.0 glasses model, both techniques were sufficient to obtain certain insights and created similar patterns as retinal trace patterns. The eye tracking data for task 2 (payments screen and MVT payment) is also shown in Figure 2.

Figure 3: Payments Screen Heat Map and Scan Path Comparison

Figure 2 shows the heat maps and gaze plot maps visualizing the gaze data on the interface for both techniques as in Figure 1. In this task, the differences in the data visualizations obtained with the TobiiPro Glasses 2.0 eyewear model and the Realeye software model, which collects data with a remote webcam, were observed to increase. The glasses model showed fixation on menu components aligned to the left side of the screen, while the webcam technique showed focus data concentrated in the middle and top of the screen. Participants were asked about the ease of the given tasks, and the answers are given in Figure 4.

Figure 4: User Response Analysis of Task-Based Components



As seen in Figure 4, the MVT payment task stood out as the task in which users had difficulty in performing the task and expressed that they could not complete the transaction. Most of the participants could not find the MVT payment area and could not complete the interaction action for the corresponding payment action.

This was noticeably identifiable by the larger diameter of the focus circles in the gaze order map, although the scan areas varied.

The numerical fixation metrics provided by both applied techniques were collected and the findings are presented in Table 5 for comparison.

Table 5: Comparative Metrics on MVT and Account Transactions Interface Screens

METRICS	MVT Payment		Account Transactions	
	Realeye	**TobiPro Glasses 2.0**	**Realeye**	**TobiPro Glasses 2.0**
Duration of Interval	5300	5300	5.000	5.000
Total Duration Fixation (TDF)	--	6626	--	2928
Average Duration of Fixations (ADF)	600	666	600	418
Number of Fixations	8	5	4	7
Duration of First Fixation (DFF)	700	240	600	200

Note: Durations are given in milliseconds.

When the metrics in Table 5 are analyzed, TobiiPro Glasses 2.0 glasses model and Realeye software, which offers remote webcam-based eye tracking, yielded similar results in terms of the amount of focus when examining both the MVT payment screen and the account transactions screens. Average fixation durations were similar for both task scenario screens. In the first fixation duration metric, the time spent (duration of interval) on the MVT payment screen and the time spent on the account transactions screen differed in terms of the results of the techniques but were proportionally consistent. In general, it was found that both techniques gave similar results.

5. Conclusion and Discussion

The Garanti BBVA mobile application study, one of the most widely used mobile banking applications in Turkey, which was analyzed in terms of user experience, was evaluated as an easy-to-use application because of participant opinions. As a matter of fact, the SUS results (SUS score: 72.27), which quantitatively measure the user experience, determined that the system was usable in parallel with the user opinions. In the study, selecting a usable system was considered as a prerequisite for comparing eye tracking techniques and Garanti BBVA mobile application fulfilled this requirement. Selecting a system with a positive user experience is important to ensure that the system does not create cognitive load on the participants and does not create a scan path that will create many saccades instead of fixation on eye movements. Because both eye tracking techniques calculate the data visualization and gaze metrics, which are expressed as gaze plot, based on fixation. Therefore, Garanti BBVA mobile banking application, as a usable system, provided a favorable environment to conduct research on fixation data. Thus, the first research question was answered as a usable mobile banking application.

The research is also based on the comparison of the data outputs of glasses-based and webcam-based remote eye tracking techniques. For this purpose, two eye tracking techniques used in the literature were selected and data were collected simultaneously from the prototype application during the user experience test. One of these techniques is the TobiiPro Glasses 2.0 glasses-type eye-tracking tool, which provides convenience for field research, and the other is the Realeye eye-tracking software, which provides convenience in terms of collecting many participant data in a short time with remote webcam data collection. Although the advantages and disadvantages of both techniques differ, they are similar in that they collect the same type of data.

The other questions of the study are that both eye tracking techniques provide similar and consistent results in terms of heat maps and metrics. Both eye tracking techniques simultaneously collected data from the prototype application while the participants viewed account activity and the payments menu. The collected data is presented as two different data visualizations: a heat map and a gaze plot. In order for both eye tracking techniques to accept the same periods as fixation, settings were made in their software before data collection (minimum 60ms - maximum 70ms). Although both accepted the same durations as fixation, differences were observed in these data visualizations obtained from the fixation values. TobiiPro Glasses 2.0 provided a denser heat map and scan path.

When analyzing eye tracking techniques in terms of metrics, gaze data on the homepage and account gestures interfaces were analyzed. The metrics of average fixation duration, fixation amount and initial fixation duration were analyzed in terms of duration and number. On the MVT payment screen, Realeye achieved higher average fixation duration and number of fixations than TobiiPro Glasses 2.0. On the account transactions screen, TobiiPro Glasses 2.0 achieved a higher number of fixations.

The differences in fixation metrics observed between the Realeye and Tobii Pro Glasses 2.0 can be attributed to various factors. The Tobii Pro Glasses 2.0 provides higher accuracy due to its proximity to the eyes, superior sampling rate, and robustness to environmental factors such as lighting. In contrast, Realeye's webcam-based system is more sensitive to participant movements, lighting conditions, and head positioning. Moreover, the screen refresh rate mismatch between the two systems could also influence the fixation metrics. These differences suggest that Tobii Pro Glasses 2.0 is more effective in capturing shorter fixations and providing a more detailed representation of user attention. However, Realeye's remote approach remains useful for broader, less precise usability assessments.

Although there is no study in the literature directly using the same two eye-tracking measurement tools and types, there are similar studies comparing eye-tracking tools. Ehinger et al. (2019) compared the outputs of Eyelink 1000 remote eye-tracker and Pupil Labs Glasses-based eye trackers completed with 4 participants (11 participants were excluded). He found less fixation and micro saccade in Pupil Labs glasses. Moreover, he found that spatial accuracy decreased with the type of glasses. Burton et al. (2014) compared the outputs of SMI remote eye tracker and Sticky webcam-based eye tracker. The eye tracker technologies were not used simultaneously in this comparison study. It was found that SMI remote eye-tracker captured small images farther from the center of the screen more accurately than the other eye-tracker. The two eye-trackers were similarly accurate in capturing large objects on the screen.

As a result, the data results obtained by Realeye software, which is based on the remote data collection technique with a webcam, and Tobii Glasses 2.0 eye tracking techniques differed from each other. Since the light conditions were constant, it is thought that the light level did not cause this difference. On the other hand, as stated in the study, TobiiPro Glasses 2.0 scans 50/100 Hz retinal traces while Realeye scans 30/60 Hz retinal traces. It is thought that the reason why heat maps and metrics as fixation-based outputs give different results in the two techniques is due to the difference in Hertz levels, also referred to as screen refresh rate. Future studies should standardize refresh rates across both eye-tracking techniques and test a larger sample to validate these findings.

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