Applying eye tracker technology for analyzing user interface design of online transportation applications (case study: grab application)

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Abstract. In the past few years, online transportation has gain popularity in Indonesia. Many passengers prefer to choose online transportation for traveling due to several reasons including accessibility and price. In response to this, several online transportations have been operating in Indonesia, the most popular one is Grab. Despite its popularity, little is known about the usability of its interface design in respect to specific groups of user especially for elderly. In order to provide information on how to better design online transportation application especially for elderly, this paper aims to analyze interface design of Grab application from the elderly point of view. For this purpose, an experiment was conducted by using the eye tracker. This technology has applied for different purposes including design and marketing research purposes. The experiment was conducted by involving 10 elderly participants with ages ranging from 55-69 years. The eye tracker data used in this study is a fixation number, fixation duration, saccade number, and saccade duration. The result of study reveals that gender influence the fixation number, fixation duration, saccade number and saccade duration. Eye condition also influences fixation number and fixation duration but not for saccade number and saccade duration. The highest fixation number occurred in the area of interest (AOI) 2 and the largest fixation duration is also in the area of interest (AOI) 2.

1. Introduction
The development of modern technology has influenced the way transportation business is operated in Indonesia. Nowadays, online transportation has become a choice that is more popular for traveling rather than conventional ones. This because the applications (apps) are easy to install on a smartphone and provide various offers. Grab is one of online transportation that operates in Indonesia. Grab, formerly known as Grab Taxi, is a company that originally established in Singapore that serves as transportation applications provider which are now available in six countries in Southeast Asia, including Malaysia, Singapore, Thailand, Vietnam, Indonesia, and the Philippines. The high population in Indonesia together with the increasing demand for transportation makes Indonesia become the potential market for the online transportation provider. One potential segment of markets for online transportation is elderly.

The population of elderly in Indonesia is increasing year by year. The percentage of elderly growth reaches 8.97% of the total population in Indonesia. Elderly according to the Republic Indonesia Ministry of Health (2006) is an advanced preparatory period that shows the maturity of 55-year-old souls and above. Physically, the process of aging is the gradual disappearance of the tissue's ability to
repair itself or replace and maintain its normal function so that it cannot withstand the infection and repair the damage suffered [1]. Nowadays, the elderly are required to be more independent. Data from Indonesia Statistics revealed that nearly half of Indonesia's elderly (47.92%) still actively working at their age and 61.70% of elderly make the elderly as the head of the household. One of requirements for the elderly to be able to work and to be independence includes ability to use smartphone for acquiring their need such as transportation. Indonesian Internet Service Provider Association (2017) shows that the elderly is one of the active users of internet in Indonesia by percentage 15 - 72% [2].

However, most of design of online applications currently does not consider elderly users’ limitations [1]. The current smartphone application interface design is not meet the needs of the elderly. This is supported by research conducted in South Korea regarding the design of interface design on smartphones for the elderly, which found that there are some difficulties experienced by the elderly users when interacting with interface devices on smartphones. The highest difficulty experienced by older people is the length of time they need to learn and understand the new icons that exist on an interface device [2]. Due to this reason, it is necessary to improve the interface design of applications used by elderly since in the future elder people will depend on such application for living.

Study on user interface design usually uses interview methods or questionnaires. While these methods are easy to apply, however, these approaches have some limitations such as the subjective nature of the result [3]. Different method is needed that could provide information on the behavior and attention of the elderly in using an application. In this case, the eye tracker technology could provide such benefit. Eye tracker is a sensor technology that allows the device to know precisely where the user's eyes focused [4]. Few studies have been conducted for applying this technology, for example, a study that uses eye tracker to investigate consumer behavior in choosing a product by considering the type of product being reviewed [5]. But, there is a lack of publication that analyzes online transportation interface design for the elderly by using an eye tracker. Therefore, in this study, the eye tracker experiment is conducted to focus on the elderly while using the Grab application. Tobii Pro Lab Eye Tracker is used for the experiment. It provides a comprehensive platform for recording and analysis of eye gaze data, which helps in the interpretation of human behavior, consumer responses, and psychology [6].

2. Methodology

Eye-tracking experiments were carried out in the Work System Design and Ergonomic Laboratory of ITS. In this experiment, elderly participants were given the task to order GrabCar services installed on smartphones. The eye tracker is placed in front of the smartphone to track the user's eye movements while working on the task of ordering GrabCar services. Before the experiment began, a calibration process is carried out to measure the level of precision and accuracy of the eyes for all elderly participants. Calibration results must have a minimum value of 0.5 (<= 0.5) so that the resulting data can be used [6]. Because elderly participants have limited vision, this process must be carried out repeatedly to get the right accuracy and precision.

2.1 Participants

Ten elderly participated in the experiment, these include six women and four men with an age range from 55 to 69 years. These participants are elderly who live in the city of Surabaya. They were divided into three groups based on their eye conditions, which are elderly with farsightedness, elderly with a combination of farsightedness and cylindrical eyes and elderly with normal eyes. Participants consisted of 6 elderly (1 men and 5 women) who wore glasses with nearsightedness, 3 elderly (2 men and 1 women) with a combination of farsightedness and cylindrical eyes, and 1 elderly man who didn't wear glasses (normal eyes).

2.2 Eye Tracker

Eye tracker is a sensor technology that allows the device to know precisely where the user's eyes are focused. Eye tracker technology is a technique for measuring physiological responses to visual stimuli that has the advantage that responses can be recorded in real-time [7]. The device determines the presence, attention, focus, sleepiness, awareness to other mental states. The information can be
used to gain insight into consumer behavior or to design revolutionary new user interfaces on various devices. Eye tracker technology has many uses in obtaining product information, such as what information influences consumer decisions, whether visual attention varies based on level of importance, familiarity, or external pressure (time, purpose, etc.) and product design or label on which packaging is the most visually appealing [8]. Researchers can also focus on certain format choices (such as font style or size, color, image, number of products, etc.) or an advertising content (including branding, value-added information, and promotional messages).

The Tobii eye-tracker software comprises three modules and a Project Overview. It consisting of the design module, the record module, and the analysis module. Design module is how to outline the way the stimuli are presented to study participants. This includes what the stimuli look like on the screen, in which order they get displayed, as well as how to proceed to the next stimuli. The record module is where you make recordings in Tobii eye tracker. It enables you to select which Timeline to use for which recording and lets you control the recording process, in general. Then analyze module is necessary when you want to conclude the collected data. The analyze module provides analysis tools that enable you to visualize and export the data you have collected [6].

There are currently four kinds of projects consisting of screen projects which are supposed to be used when stimuli presentation and data collection are done using a screen-based eye tracker. Glasses projects which are supposed to be used when data has been collected using Tobii Pro Glasses 2. Scene Camera projects, when using an external video camera to record events in the real world and VR 360 projects, when analyzing 360-degree images and videos using Tobii Pro VR Integration. In this paper, the experiment used a scene camera project because the eye-tracking process while participants are doing the task will be recorded using an external camera. Eye tracker is also designed to work with other software commonly used for recording and analyzing data. Result data from eye tracker can be enabling data exports in standardized formats, for example for Microsoft Excel, Matlab, and SPSS. Result data from eye tracker enabling data exports in standardized formats, for example for Microsoft Excel, Matlab, and SPSS. In this study, the data used to be processed is fixation number, fixation duration, saccade number, and saccade duration. During the eye-tracking process, the data collected will be very much because the eye tracker records eye movement data every 45 milliseconds. So the data needs to be filtered and tested using the Anova Test.

2.3 Experimental Design
Tasks were given to all participants. This test is done by displaying the Grab interface application with a participation scenario to order GrabCar (car services). The main tasks are to order car to a specific destination. The task does not include the payment process. The tasks carried out in the eye tracker experiment is described in Figure 1. The first step is briefing with the elderly participants. This briefing includes requests that participants keep their seating positions during the test, how the calibration process takes place, and the main task of this research is to ask elderly participants to order GrabCar services in the Grab application. The explanation should be done one by one because the elderly have limitations in receiving new information. Then the calibration process is assessing the level of accuracy and precision of the user's pupils. As for the process, participants were asked to see the three red dots on the mobile screen (dots on the top left, middle and bottom right). The calibration process showed in Figure 2. To calibrate the user's students, they are asked to look at three points on the mobile screen, then if the accuracy and accuracy numbers reach 0.5, it can proceed to the main experimental stage of assessing the design of the Grab application.

2.4 Experimental Variables
2.4.1 Fixation Number
Fixation is a situation where the user's pupils focus on one point of the object [9]. Fixation number is the number of fixations that are formed when the user's eyes are focused on an object. Fixation number is calculated by tracking the number of fixations in the Area of Interest (AOI) area so that you can find out which area of interest is the most fixation.

2.4.2 Fixation Duration
Fixation duration is the time needed when a fixation occurs or when the user's eyes see an object [5].

2.4.3 Saccade Number
Saccade is data when the pupil moves from one object to another [10]. The Saccade number is the amount of saccade formed when participants see the interface tested using an eye tracker.

2.4.4 Saccade Duration
Saccade duration is the time needed when the saccade occurs or eye movement from one object to another object.

![Diagram of Procedure of Experiment](image)

**Figure 1.** Procedure of Experiment

![Image of Calibration Process](image)

**Figure 2.** Calibration Process. Figure (2a) is calibration point on the mobile phone screen and Figure (2b) is the calibration points that appear on the computer. The points used are dots on the top left, middle and bottom right.
2.5 Apparatus and Stimuli
Eye Tracker used in this study is Tobii Pro Lab Full Edition (x64). The Samsung Galaxy Grand Prime SM-G530 smartphone was also installed near to the eye tracker device. The smartphone is placed on a Gorilla Mini Camera Tripod to be easily seen by elderly users. The Grab version 5.51.0 application was installed in the smartphone. HP All-in-One 22-c0035d computer is also installed to see the calibration results. During the experiment, the Logitech C922 webcam recorded a screen display that integrated with Tobii's eye tracker, to record the point of fixation and eye movement. Participants sat at 50 cm in front of the Tobii Eye Tracker. The distance between a smartphone and a Logitech camera is 80 cm. The elevation angle between the eyes of the elderly participant and the smartphone is 40 degrees while the elevation angle between the eyes of the elderly participant and the eye tracker is 45 degrees. Figure 3 shows the experiment layout of this study. It presents the apparatus of the experiment with the relative position to the participant.

![Figure 3. Illustration of experimental layout](image)

3. Data Collection and Analysis
3.1 Data Screening Process
The result of eye tracker testing with 10 respondents produced 18,404 data. This data is taken by exporting data from the eye tracker that records the eye position of the respondent every 45 milliseconds. Since the recorded data is huge then it needs to be filtered. The screening process showed in Figure 4. This eye record data consists of data fixation, saccade, unclassified, and eyes not found. Then unclassified data and eyes not found are removed because it is invalid data so that the data from the eye tracker becomes 7318 data. In this study, the results of the eye tracker data will be filtered according to the Area of Interest (AOI). Furthermore, the data filtration process is carried out in accordance with predetermined variables so that the data to be processed becomes as much as 1984 data.

![Figure 4. Eye tracker data screening process](image)

3.2 Gaze plot
Gaze plots are lines that indicate saccade movement that occurs when the eye moves focus from one object to another [11]. The difference in color in the gaze plot display shows the number of participants who did the testing. While the numbers written on the circle gaze plots indicate the order
in which the user's eye movements occur. In the Figure 5 showed 10 different colors are indicating 10 people tested participants.

![Gaze plot](image)

**Figure 5.** The Gaze plot showed the movement of the user’s eye in the Grab application interface.

### 3.3 Heatmaps

Heat maps are color maps used to illustrate the amount of fixation that occurs when participants use an eye tracker [12]. Heat maps mark certain areas affected by participants' eye focus stimuli with certain color indicators. It is showed in Figure 6, the color indicators are red means the highest number of fixations and the longest duration of fixation and green means a small amount of fixation and short duration of fixation [13].

![Heatmaps](image)

**Figure 6.** Heatmaps
3.4 Area of Interest (AOI)

Area of Interest is an area that is limited to being used as a focus of vision on the interface to be examined in testing [14]. The interface in the Grab application will be divided in three areas of interest that it is shown in Figure 7. The selection of three Area of Interest (AOI) is because it refers to the design of an existing Grab application, where they classify menus on the application interface based on the similarity of functions. The first area is the payment area which consists of the pay menu, refill menu, gift menu, and OVO balance. These menus are very important to be accessed in using the Grab application related to payment matters. The second menu is a core menu that contains services that can be used by Grab users, such as ordering cars, motorbikes, food, delivery, savings packages, credit, tickets, and others. The third area is the menu area consisting of the homepage, user purchase history, payment, inbox, and account profile menu.

![Figure 7. Area of Interest (AOI) in Grab Application](image)

3.4.1 Fixation Number Data

Fixation number or number of fixations that are formed when the user's eyes are focused on an object. The fixation number is calculated by tracking the number of fixations in the Area of Interest (AOI) area so that it can be seen which area of interest has the most formed fixation. In the Table 1 showed the distribution of fixation data that is formed in each Area of Interest that has been determined. Then the biggest fixation number is in the area of interest 2, which is consist of services in the Grab application interface.
### Table 1. Fixation Number in Every AOI

| Participants | Area of Interest 1 | Area of Interest 2 | Area of Interest 3 |
|--------------|--------------------|--------------------|--------------------|
| 1            | 56                 | 60                 | 21                 |
| 2            | 45                 | 67                 | 34                 |
| 3            | 52                 | 74                 | 40                 |
| 4            | 49                 | 68                 | 37                 |
| 5            | 38                 | 51                 | 26                 |
| 6            | 33                 | 46                 | 24                 |
| 7            | 41                 | 63                 | 30                 |
| 8            | 35                 | 58                 | 32                 |
| 9            | 39                 | 61                 | 28                 |
| 10           | 30                 | 68                 | 32                 |
| **Total**    | **418**            | **616**            | **304**            |

#### 3.4.2 Fixation duration Data

Fixation duration is the time required when a fixation occurs. Fixation duration data can also be traced based on the location of the Area of Interest. In Table 2 showed the distribution of fixation duration data that is formed in each Area of Interest that has been determined. Then the biggest fixation duration is in the area of interest 2, which is consist of services in the Grab application interface.

### Table 2. Fixation Duration in Every AOI

| Participants | Area of Interest 1 | Area of Interest 2 | Area of Interest 3 |
|--------------|--------------------|--------------------|--------------------|
| 1            | 353.9107           | 352.0833           | 383.1905           |
| 2            | 324.22             | 471.63             | 268.14             |
| 3            | 593.5              | 344                | 372                |
| 4            | 361.52             | 416.78             | 291.8              |
| 5            | 405.29             | 479.08             | 126.5              |
| 6            | 248.68             | 283.97             | 246.71             |
| 7            | 519.91             | 584.23             | 483                |
| 8            | 456.41             | 523.59             | 423.93             |
| 9            | 515.91             | 1094.25            | 379.04             |
| 10           | 386.6364           | 446.4              | 329.64             |
| **Average**  | **416.60**         | **499.60**         | **330.40**         |

#### 3.4.3 Saccade Number Data

Saccade numbers are many saccades that are formed when participants view the interface tested using an eye tracker. The data on the number of saccades will be described in Table 3 below.

### Table 3. Saccade Number

| Participants | Saccade Number |
|--------------|----------------|
| 1            | 88             |
| 2            | 76             |
| 3            | 82             |
| 4            | 69             |
| 5            | 64             |
| 6            | 50             |
| 7            | 67             |
| 8            | 61             |
| 9            | 46             |
| **Total**    | **646**        |
3.4.4 Saccade duration Data
Saccade duration is the time required when a saccade or eye movement occurs from one object to another. The saccade duration data for 10 participants are described in Table 4 below.

| Participants | Saccade Number |
|--------------|----------------|
| 1            | 88             |
| 2            | 76             |
| 3            | 82             |
| 4            | 69             |
| 5            | 64             |
| 6            | 50             |
| 7            | 67             |
| 8            | 61             |
| 9            | 46             |
| Total        | 646            |

Average 64.6

4. Result
In this section, the results of the eye tracker experiment with One Way Anova test revealed that the fixation number, fixation duration, saccade number, and saccade duration have a significant influence on the gender of the elderly. Also, fixation number and fixation duration have a significant influence on the eye condition of the elderly but saccade number and saccade duration have no significant influence on the eye condition of the elderly. To find out this, the One Way Anova test was carried out.

4.1 Normality Test
The eye tracker results are processed by statistical testing, namely the One Way Anova test by first performing the Shapiro-Wilk normality test and Kolmogorov-Smirnov to ensure that the distribution of fixation duration data is normally distributed. Data can be said to be normally distributed if the significance value (sig) in the Tests of Normality table is greater than 0.05. It is shown in Table 5 the significance value for farsighted is 0.214 and the significance value for farsighted and cylindrical eyes is 0.722, it is mean greater than 0.05. So it can be concluded that the distribution of fixation duration data is normally distributed.

| Fixation_duration | Eye conditions                  | Kolmogorov-Smirnova | Shapiro-Wilk |
|-------------------|---------------------------------|---------------------|--------------|
|                   | Statistic df Sig.               | Statistic df Sig.   |
|                   | Farsighted                      | .237 6 .200        |
|                   | Farsighted and cylindrical eyes | .233 3 .214        |

4.2 Homogeneity Test
Homogeneity tests are also needed to fulfill the assumptions on the One Way Anova test that will be carried out. Data is considered homogeneous if the significance value (sig) in the Test of Homogeneity of Variances table is greater than 0.05. It is shown in Table 6 the significance value is
0.176 and it is mean greater than 0.05. So it can be concluded that the distribution of fixation duration data is homogeneous.

**Table 6. Homogeneity Test**

| Levene Statistic | df1 | df2 | Sig. |
|------------------|-----|-----|------|
| 2.208            | 1   | 8   | .176 |

The aggregate result of the relationship will be described in Table 7.

**Table 7. One Way Anova Result**

| No | Variables | One Way Anova Result | |
|----|-----------|----------------------|---|
|    |           | There is a significant difference | There is no significant difference |
| 1  | Relationship between participants gender with fixation number | ✓ | |
| 2  | Relationship between participants gender with fixation duration | ✓ | |
| 3  | Relationship between participants gender with saccade number | ✓ | |
| 4  | Relationship between participants gender with saccade duration | ✓ | |
| 5  | Relationship between participants eye condition with fixation number | ✓ | |
| 6  | Relationship between participants eye condition and fixation duration | ✓ | |
| 7  | Relationship between participants eye condition and saccade number | ✓ | |
| 8  | Relationship between participants eye condition and saccade duration | ✓ | |

**4.3 Saccade Analysis**

The Saccade number is the amount of saccade formed when participants see the interface tested using an eye tracker [15]. To find out the saccade number can only be known based on the results of the eye tracker in each participant. The average value of saccade number for 10 participants was 64.6 saccade which occurred with an average saccade duration of 50.56 milliseconds. Whereas to see the saccade movement on the Grab interface, it can be seen on the video recording carried out during the test. Figure 8 shows the saccade movement at the beginning process of seeing the Grab interface, it can be seen on the video recording carried out during the test.
1. Saccade movement at the beginning when participant looking at the Grab interface
The movement of the eyes of the elderly when they first see the Grab application interface is to look at the top of the interface that says "Good Morning". In Figure 8 showed the saccade movement in the beginning interface of Grab application. This means that such greeting words are quite interesting to the attention of the elderly. Then the saccade formed in the payment ad area which is also at the top of the interface. This advertisement also distracts the attention of the elderly when they first see this Grab display.

![Figure 8. Saccade movement in beginning interface of Grab application](image)

2. Saccade movement when order GrabCar services
Before starting to order, the focus movement of the elderly eye leads to the ads in the middle area of the lower part of the Grab interface like showed in Figure 9. This indicates that advertisements placed in the area are quite capable of distracting the elderly.

![Figure 9. Saccade movement when order the GrabCar](image)

3. Saccade movement when the elderly enter the location to order the GrabCar Service
After choosing the GrabCar service, the elderly are required to enter the pickup location point and also the destination location point. In Figure 10 showed that the saccade movement is right at the bottom of the place to enter the location. Then the elderly can add the 'Message' option to order GrabCar after entering their location. It also seen the saccade occurring in the pickup location map to the destination location. This section is enough to make the elderly experience confusion in seeing the map. Because several saccades form in the area.
5. Conclusion

This study used four eye-tracking data variables, which are the fixation number, fixation duration, saccade number, and saccade duration. These four variables are associated with the elderly gender factor (men and women) and the eye condition of the elderly using the Anova test. The result is known that the relationship of the fixation number, fixation duration, saccades number, and saccade duration with the elderly gender has a significant influence. While variables of the fixation number and fixation duration, related to the eye condition of parents (nearsightedness, farsightedness near the combination of cylindrical eyes, and normal eyes) is known to have a significant effect. On the other hand, the number of saccade variables and the duration of the saccade is associated with the eye condition of the elderly (nearsightedness, nearsightedness combination of cylindrical eyes, and normal eyes) are known to have no significant effect. Also based on saccade analysis shows that elderly users experience confusion in using the existing Grab application interface. So that the existing Grab application design needs to be improved to meet the limitations of elderly users.

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