Relationship of Reading Speed, Number of Lines and Number of Words on Indonesian Highway's Variable Message Signal (VMM)

Anik Budiati

Civil Engineering Department, Bhayangkara Surabaya University, Indonesia

DOI: 10.29322/IJSRP.13.11.2023.p14352
https://dx.doi.org/10.29322/IJSRP.13.11.2023.p14352

Paper Received Date: 15th October 2023
Paper Acceptance Date: 20th November 2023
Paper Publication Date: 28th November 2023

Abstract- This article discusses the legibility of letter dimensions, number of lines, number of words on the information panel board on the Variable Message Sign (VMS) in relation to readability, the driver's reading speed. This research aims to obtain the readability distance and reading speed of the driver. In some countries, VMS media is used in an effort to reduce traffic incidents. Department of Transportation/DOT (2014) developed Commuter Link in an advanced traffic management system to provide real time information. In Indonesia in particular, there are no guidelines that regulate the maximum number of lines and dimensions of letters on one VMS panel board, so it could be that the driver has not finished reading the entire message conveyed, or the driver does not understand it. message delivered. In this condition, it could be because the sentences or words on the panel are too long, the dimensions of the letters are small so a longer reading time is required or a longer legibility distance is needed to complete reading the message. Several other factors that can influence the driver not finishing reading the message include the driver's reading speed, the number of lines, and the color combination between the panel board and the letters. This research focuses on finding the relationship between the readability of messages delivered on a VMS and the average reading speed, the number of words in the VMS, and the dimensions of the letters. The aim of this research is to obtain a valid distance in the relationship between the driver's average reading speed (Y) on the VMS with the number of lines (X1), number of words (X2) and letter dimensions (X3) and their types. vehicle used (X4). For data analysis, SPSS v23 was used to test the validity and correlation of each variable. The research results show that the average reading speed based on the number of words shows a constant reading speed of 2.21 words/second, while for field reading speed the average is 1.37 words/second. This value is different from previous research. Based on vehicle type (R2 and R4) there is no significant difference, but there is a significant difference based on field reading speed and constant reading speed. The results of the relationship between variables obtained Y1 = 7.255 +0.263X1 + 0.787X2 -4.494X3 +0.008 for field reading speed and for field reading speed Y = 4.269 +0.228 X1+0.376 X2 -1.657X3.

Index Term- *Font dimensions, number of lines,* Variable Message Sign, *reading speed.*

I. INTRODUCTION

Variable message signal (VMS) is a set of electronic messages that provide information on real traffic conditions to drivers. The messages conveyed are real time or actual conditions at that time and need to be conveyed to the public, whereas for normal conditions road safety messages are displayed. Department of Transportation/DOT developed information in VMS in an effort to prevent Traffic Incident Management [1]. Some existing guidelines regarding VMS include the New York State Authority specifically providing guidelines governing electronic signs that provide real time information [2]. Several countries already have guidelines that regulate VMS, including in Europe in EN 12966-1, applicable in Austria in western Guidelines for Variable Message Signs (2015) and several other countries [3][4]. The regulations explain the rules regarding the maximum number of words and the maximum number of lines in one VMS panel at several permitted vehicle speeds.

Setting the maximum number of words and lines is an important issue, considering that the message conveyed on the VMS is important information, so research is needed on the readability of the message conveyed. Another problem that needs to be researched is the driver's reading speed on the highway. It is possible that the driver's reading speed in conditions of constant traffic (standing) is different. This can be caused by several factors, including traffic conditions, road geometry, vehicle speed, weather conditions, and the driver's PIEV time, etc.

In the regulation of the Minister of Transportation of the Republic of Indonesia Number PM 13 of 2014 concerning traffic signs, article 6 paragraph 2, it is stated that electronic traffic signs are used for information on traffic, weather, road repairs and traffic and road transport safety campaigns. In the attachment to this guideline, it is written that the sizes of letters, numbers and symbols follow the permitted vehicle speed. Meanwhile, in this regulation there is no article that regulates restrictions on the number of words, lines and dimensions of letters on one panel board, so it is possible that if the dimensions of the letters are too small, or the number of

messages conveyed consists of several lines on one panel board, then the driver cannot complete message delivered or specific time required to complete the message [5].

II. REVIEW LITERATURE DAN PROBLEMS

A. Recent research.

Several studies have been conducted on message understanding and the number of lines in VMS. Driver's understanding of the messages conveyed on the VMS has been studied by Peeta.S, Ramos J.L and Pasuphaty (2006) in Italy and Guattari.C (2012) in Italy and Zhao. W et al (2019) in China, concluded that drivers better understand messages consisting of two lines [6][7][8]. Taylor, B (2016) in Australia examined drivers' understanding of the messages conveyed on the VMS using a simulation method showing that more than 75% of drivers understood the messages and complied with the messages conveyed. Arbahzadeh. N, et al (2019), examined the effect of traffic conditions on driver reaction time and found that drivers required additional reaction time 2 and 3 seconds [9][10].

Research on message understanding on the number of messages delivered has been studied by Song, T.J; Kim, T; Od, J and Yeon, J. and the number of messages delivered. Armstrong (1994) and Tachyung (2014) examined the driver's reading speed model and found that reading speed on the VMS was influenced by the number of words, but in this study the dimensions of the letter characters on the VMS were not mentioned [11] [12].

Research on drivers' reading speed of conventional signs was carried out by Budiati,2014 [13] found that the average driver's reading speed for conventional signs was 2.5 syllables per second. Proffitt, Wade and Lynn (2011) in Highway Sign Visibility chapter 7, wrote that the normal average reading speed for adults is around 250 words per minute or 4.2 words per second, while Smiley et al found that 94% of drivers needed 2 .5 seconds for 3 (three) target names and reduced by 87.5% if the mark displayed is 4 (four) or 5 (five). Dudek (2001), recommends using a driver's reading time of 1 (one) second per short word or 2 (two) seconds per unit of information. Mcness and Messer (1982), the equation for determining reading time on VMS is $t = (N/3)+1$ for 1 or 2 words and $t = 0.31 N + 1.94$ for a number of words, where t is the time in seconds and N is the number of words. This research does not explain the research method using a field scale or laboratory scale.

B. Guidelines.

European Standard/EN (2007) states that the minimum matrix size for one character is 5 (five) x 7 (seven) pixels. This size can be enlarged and adjusted as needed to obtain the desired readability distance. Department of Transportation, recommends that if the message conveyed consists of one line, then the size that can be used is as follows: 1). 6 pixels for width and 9 pixels for height, 2). 7 pixels for width and 9 pixels for height, 3). 16 pixels for width and 22 pixels for height, if the message conveyed is more than 1 line [1]. New York State Thruway Authority, 2011 also provides recommendations for the maximum number of messages in one panel for various vehicle speeds for a maximum readability distance of 300 M. As an example, if the speed is 60 km/hour, the maximum number of messages is 2 messages. In Highway Sign Visibility, chapter 7 (2011), it also provides an approach to the relationship between vehicle speed, the number of words and the height of the letters. It is stated that for higher vehicle speeds, the recommended dimensions of the letters are also larger to obtain a constant reading speed. For a vehicle speed of 40 mph with a number of messages conveying 1-3 words and a letter height of 4-5 inches, the reading speed is 3-4.5 seconds. EN (2007) also provides an approach to the relationship between vehicle speed and letter height and reading speed. For a speed of 60 km/h and letter height of 100 mm, the reading speed is 3.5 seconds.

In conditions on the roads in Indonesia, the use of VMS as a medium for messages that need to be conveyed to drivers has also been widely used. The number of words, number of lines, dimensions of letters in one panel board also vary. In this condition, it is possible that the sentences or words in the panel are too long so that a longer reading time is required so that a longer readability distance is required or it could be said that the driver takes a long time to complete the message conveyed. It is important to carry out this research with the initial assumption that the driver's reading speed will be influenced by the dimensions of the letters, the number of words and the number of lines. The aim of the research is to find out the relationship between the driver's average reading speed on the VMS. As variables the driver's reading speed (Y) and the number of lines (X1), the number of words (X2) and the dimensions of the letters (X3).

III. RESEARCH PURPOSE

This research is to obtain an approach to modeling the relationship between the driver's reading speed in actual conditions in the field during driving activities and the number of lines conveyed, the number of words, and the dimensions of the letters on the VMS. The object of installation is a VMS which is installed on the road and which is installed at the road shoulder position. This is to get a comparison of the reading distance to the VMS installation position. The types of vehicles used consist of 2 wheels (R2) and 4 wheels (passenger cars). To get the average value of additional driver reading time in the field caused by the PIEV factor, this research also needs to compare the driver's reading speed in constant/standing conditions and in driving conditions. The selected vehicle speed is in the range of 30 km/hour to 40 km/hour. To achieve the objectives, this research focused on the driver's reading speed in several variations in the number of lines, the number of words on one panel board and the vehicle used, while geometric conditions, weather conditions were ignored and eye health and education level were ignored.

IV. RESEARCH METHOD DAN MATERIALS

A. Method

This research is experimental in nature with research locations in the city of Surabaya, the selected roads are Dukuh Menanggal Street and Ahmad Yani Street, Surabaya City, East Java Province, Indonesia. (Figures 1 and 2). The number of respondents consisted of 35 students. The VMS used for data collection is the inventory of the East Java Provincial Transportation Service and Jasa Marga with VMS specifications in black without light with luminous yellow letters. In the VMS installed on the road shoulder, there are 3 variations of characters tested consisting of variations in letter dimensions, number of lines and number of words on the panel board, while the VMS installed on the road consists of 1 variation (Table 1). use SPSS v.23.

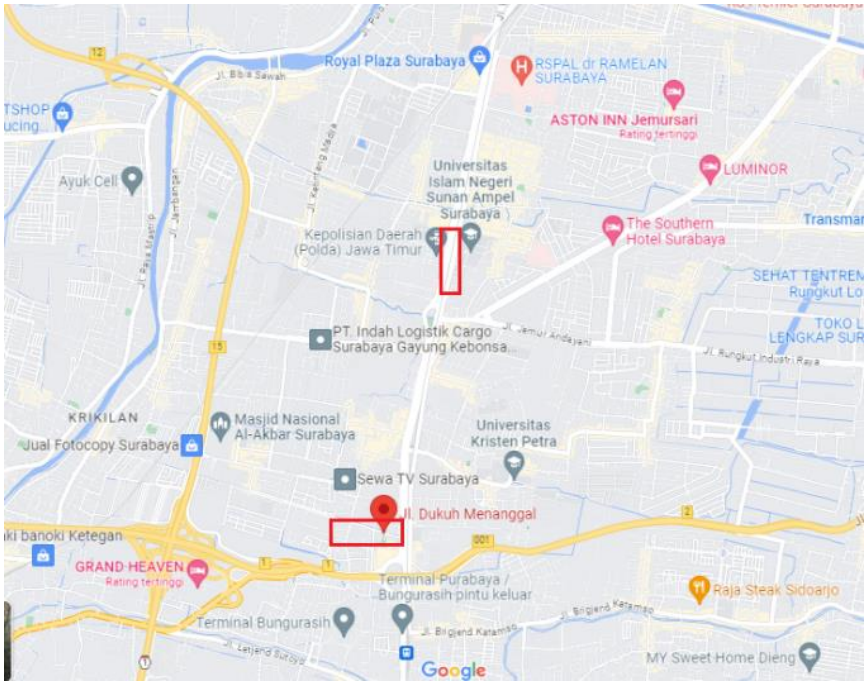

Figure 1: Research location

Table 1: VMS variations tested

VMS characters	Letter dimensions h x t x l	Number of rows	Number of words
	10 x 7 x 2	5	11
	10 x 7 x 2	4	9
	12 x 8 x 2	2	6

Description: h = letter height
t = letter width
l = letter thickness

C. Research instrument. +

In Fig. 2, it is displayed the the data collection scenario in the field for this research stability.

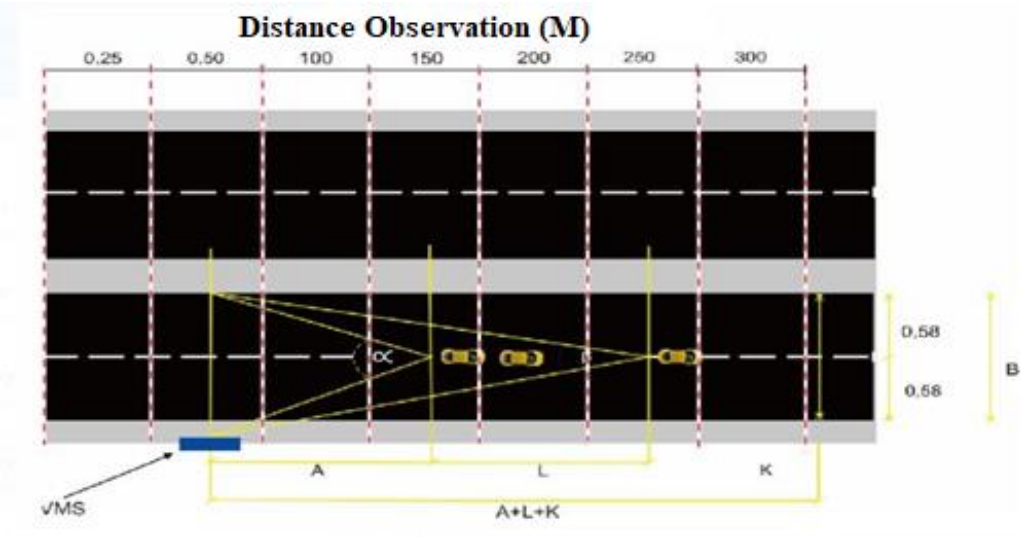

Figure 2: data collection strategy in the field.

Description:
K : The distance from when the driver sees the VMS to when he starts reading
L: The driver's distance from start to finish reading
A: Distance the driver finishes reading
B: Road width. The survey implementation steps are as follows:

1. Level of preparation

Data collection was carried out during the day and in bright conditions and smooth traffic. As a tool for measuring reading speed and clear reading distance or the distance the driver starts reading, a stopwatch is used and to identify the respondent's reading distance, signs are used that are attached to the road pavement in combination with traffic cones. Initial marking starts at a distance of 100 meters from the next VMS panel for marking with a difference of 25 m. This marking is up to a distance of 500 meters from the point where the VWS is installed.

2. Data collection scenario

Before starting data collection, respondents were given a briefing about the purpose of the survey and data collection as well as vehicle speed. The scenario for collecting data in the field is as follows:

a. Constant read speed data

Standing reading time is the driver's reading time when he is still or not driving. This reading time is obtained by asking the driver to read the message on the VMS, while the driving reading time is the reading time needed by the driver to finish reading the message while the vehicle is driving. The time required to complete reading is recorded by the surveyor, while the driver's reading speed is obtained by dividing the number of words installed on the VMS by the time to complete reading the message.

b. Read Distance Data

The driver accompanied by surveyor 1 (behind the respondent) was asked to sound the horn when he clearly saw the sentences arranged in the VMS (in position K) and to sound the horn again when starting to read (position L) and after finishing reading (position A), while the other surveyors took notes the distance between respondents starting to read and finishing reading sentences on the VMS. The task of surveyor 1 is to record the driver's reading speed, so that reading driving speed data is obtained.

Data collection on driving reading time and reading distance is carried out simultaneously. Some of the data recorded in the research is distance from starting to read a message, distance from finishing reading, reading distance, constant reading time, constant reading speed, reading time while driving, reading speed while driving and additional time. The distance referred to on the side is the distance between the driver and the VMS board, while the reading distance is the difference between the distance between starting reading and finishing reading.

V. DISCUSSION

The test results on the reliability of the CMS installed on the road shoulder can be seen in Table 2.

Tabel 2: the results of the feasibility test

		View distance	Start reading distance (a)	End reading distance (b)	Reading distance (b-a)	Constant Time Reading (X1)	Constant Speed reading (Y1)	Real time reading (X2)	Added time T = X2-X1	Real Speed reading (Y2)
View Distance	Correlation Coefficient	.474**	1.000	.362**	.584**	.189**	.159*	.235**	-.098	.244**
	Sig. (2-tailed)	.000	.	.000	.000	.007	.023	.001	.163	.000
	N	204	204	204	204	204	204	204	204	204
Start reading distance (a)	Correlation Coefficient	.171*	.362**	1.000	-.466**	-.177*	-.119	-.154*	.208**	-.266**
	Sig. (2-tailed)	.014	.000	.	.000	.012	.090	.028	.003	.000
	N	204	204	204	204	204	204	204	204	204
End reading distance (b)	Correlation Coefficient	.375**	.584**	-.466**	1.000	.321**	.244**	.360**	-.344**	.447**
	Sig. (2-tailed)	.000	.000	.000	.	.000	.000	.000	.000	.000
	N	204	204	204	204	204	204	204	204	204
Constant Reading Time (X1)	Correlation Coefficient	.038	.189**	-.177*	.321**	1.000	-.234**	.390**	-.401**	.593**
	Sig. (2-tailed)	.590	.007	.012	.000	.	.001	.000	.000	.000
	N	204	204	204	204	204	204	204	204	204
Constant Speed reading (Y1)	Correlation Coefficient	-.164*	.159*	-.119	.244**	-.234**	1.000	.570**	.474**	.401**
	Sig. (2-tailed)	.019	.023	.090	.000	.001	.	.000	.000	.000
	N	204	204	204	204	204	204	204	204	204
Real time reading (X2)	Correlation Coefficient	-.126	.235**	-.154*	.360**	.390**	.570**	1.000	.300**	.335**
	Sig. (2-tailed)	.073	.001	.028	.000	.000	.000	.	.000	.000
	N	204	204	204	204	204	204	204	204	204
Added Time T = X2-X1	Correlation Coefficient	-.441**	-.098	.208**	-.344**	-.401**	.474**	.300**	1.000	-.279**
	Sig. (2-tailed)	.000	.163	.003	.000	.000	.000	.000	.	.000
	N	204	204	204	204	204	204	204	204	204
Real Speed Reading (Y2)	Correlation Coefficient	-.080	.244**	-.266**	.447**	.593**	.401**	.335**	-.279**	1.000
	Sig. (2-tailed)	.253	.000	.000	.000	.000	.000	.000	.000	.
	N	204	204	204	204	204	204	204	204	204

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

In Table 2, it can be seen that there is a correlation between several variables, for example there is a correlation between field reading time and reading distance of 0.360 > r table = 0.159 and with a Sig value <0.05. In the field reading subdistrict variable with additional time - 0.279, meaning that there is no correlation between subdistricts. read the field with additional reading time required, but the results were significant <0.05. In studies 1 and 2, the following are the results of data processing on the relationship between reading speed and the number of words and the type of vehicle used..

a. Research 1.

In the experiment with constant reading speed and field reading speed as in Table 3 and Table 4. There is a significant difference between field reading speed and constant reading speed. Based on the number of words, the average constant/standing reading speed was 2.21 words per second, while for driving/field reading speed the average was 1.37 words per second. Reading speed is directly proportional to the number of words, the more words conveyed, the lower the reading speed or the longer it will take to finish reading the message. Based on vehicle type (R2 and R4), there are no significant differences. From these differences, it can be concluded that additional driving reading time is needed to complete reading messages on the VMS. This value is different from previous research, namely the reading time on VMS is 6 words per second for a maximum of 3 lines (HARDIE, 2007) and 4.2 words per second Proffitt, Wade and Lynn (2011). Based on the type of vehicle used, the R4 type has a lower reading speed or takes longer to complete reading the message.

Table 3: The average value of reading speed against the number of words

Number of words	Real Speed Reading (Y2)	Konstan speed reading (Y1)

	Mean	1.1981	1.7219
6.00	N	68	68
	Std. Deviation	0.10818	0.22327
	Mean	1.3352	2.5936
9.00	N	66	66
	Std. Deviation	0.10792	0.32968
	Mean	1.5774	2.3134
11.00	N	70	70
	Std. Deviation	0.10250	0.28717
	Mean	1.3726	2.2069
Total	N	204	204
	Std. Deviation	0.19049	0.45893

Table 4: The average value of reading speed for the type of vehicle used

Categori		Real Speed Reading (Y1)	Constant speed reading (Y2)
1.00/R2	Mean	1.3665	2.1995
	N	103	103
	Std. Deviation	0.20103	0.46392
2.00/R4	Mean	1.3788	2.2145
	N	101	101
	Std. Deviation	0.17991	0.45597
Total	Mean	1.3726	2.2069
	N	204	204
	Std. Deviation	0.19049	0.45893

Trial 2.

In modeling the relationship between reading time, regression analysis was used with reading time as the dependent variable (Y) and number of words (X1), number of lines (X2), reading speed (X3) as independent variables to obtain data as in Table 5 and 6.

Table 5. Results of field reading speed regression test

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	7.255	.054		134.271	.000	7.148	7.361
	words (X1)	.263	.023	.565	11.393	.000	.217	.308
	lines (X2)	.787	.036	1.027	21.804	.000	.715	.858
	Real Speed reading (X3)	-4.494	.034	-.867	-131.223	.000	-4.562	-4.427
	R	.008	.006	.004	1.333	.184	-.004	.020

a. Dependent Variable: field reading time

Table 6. Regression test results for standing reading speed

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
2	(Constant)	4.269	.209		20.438	.000	3.857	4.682
	Words (X1)	.228	.068	.598	3.374	.001	.095	.361
	Lines (X2)	.376	.116	.598	3.253	.001	.148	.604
	Real Speed reading (X3)	-1.657	.030	-.944	-55.436	.000	-1.716	-1.598

Where the Dependent Variable is constant speed reading

With reading time as the dependent variable for driving reading time, the model is obtained:

$$Y1 = 7.255 + 0.263X1 + 0.787X2 - 4.494X3 + 0.008$$

Meanwhile, reading time with the dependent variable for standing/stopping reading speed is obtained by the model:

$$Y = 4.269 + 0.228X1 + 0.376X2 - 1.657X3$$

V. VII. CONCLUSION

In this research, it is concluded that the driver's average reading speed was 1.38 words/second, while the speed in standing conditions was 2.21 words/second. The driver's reading time is influenced by the number of words in one VMS panel, the number of lines, the driver's reading speed. The driver's reading time in standing conditions is influenced by the number of words on one panel board, the number of lines and the reading speed. The results of the relationship between variables obtained Y1 = 7.255 +0.263X1 + 0.787X2 -4.494X3 +0.008 for field reading speed and for field reading speed Y = 4.269 +0.228 X1+0.376 X2 -1.657X3.

Acknowlodgement

Appreciation to the Civil Engineering Laboratory of Bhayangkara Surabaya University for independent research with number TUG/019A/FTK/02/2023.

REFERENCES

[1] NY Department of Transportation (2014), Variable Message Sign - Guidelines - Office of Traffic Safety and Mobility, December 2014.

[2] NYSTA, 2011, New York State Transportation Authority.

[3] British Standar International (2007), BS EN 12966-1: Road Vertical Signs - Variable Message Traffic Signs Part 1: Product Standard.

[4] European Commision (2015), Variable Message Signs Harmonisation Principles of VMS Messages Design, December 2012, Report number: ew-dg-2012_vms-dg01_principlesofvmsdesign_02-00-00

[5] Minister of Transportation of the Republic of Indonesia ,"Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 13 Tahun 2014 Tentang Rambu Lalu Lintas", 2014

[6] Peeta.S, Ramos J.L and Pasuphaty (2006)

[7] Guattari.C (2012), The Effectiveness of Variable Message Signs Information: A Driving Simulation Study, Procedia - Social and Behavioral Sciences, Volume 53, 3 October 2012, Pages 692-702

[8] Zhao. W et al (2019), Analizing Drivers Preferences and Choices for The Conten and Fotmat of Variable Message Sign.

[9] Taylor, B (2016), Reading the situation: The relationship between dyslexia and situational awareness for road sign information, Transportation Research Part F: Traffic Psychology and Behaviour, Volume 36, January 2016, Pages 6-13

[10] Arbahzadeh. N, et al (2019), A Hybrid Approach Indentifying Factors Affecting Driver Reaction Time Using Naturalistic Driving Data.

[11] Upchurch, J., Armstrong, J.D., Hadi Baaj, M. & Thomas, G.B. (1992). Evaluation of variable message signs: Target value, legibility, and viewing comfort. Transportation Research Record. Vol 1376. No 35–44.

[12] Tachyung (2014)

[13] Budiati (2014); "Reading Speed To Be Used For Highway Signs And Traffic Marking In Indonesia", Academic Research International (volume 5 number 2), 33-40

AUTHORS

First Author – Anik Budiati, Lecturer, Bhayangkara Surabaya University, anikbudiati2013@ubhara.ac.id.

Correspondence Author – Anik Budiati, anikbudiati2013@ubhara.ac.id.