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TRAFFIC SIGNS COMPREHENSION AMONG MOTORCYCLISTS: THE EFFECT OF SIGN TYPE AND SIGN FAMILIARITY

Dewi Maulina[1]*; Elsa Andini[2]; Diza Tanri[3]; Noviopatra Kamsanih[4]; Shabrina Mazaya[5]; Tamara Zhafirah[6]

[1-6]Faculty of Psychology, Universitas Indonesia
Jl. Margonda Raya, Pondok Cina, Depok, Jawa Barat 16424, Indonesia
[1]dewi.maulina@ui.ac.id; [2]elsa.ayuki@ui.ac.id; [3]diza.distya@ui.ac.id; [4]noviopatra.tri@ui.ac.id;
[5]shabrina.jeihan@ui.ac.id; [6]tamara.hanan@ui.ac.id

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ABSTRACT

The research aimed to examine the effect of sign types and sign familiarity on traffic sign comprehension. A mixed factorial design experiment involved manipulating two sign types (symbols vs symbols and text) and two sign familiarity (familiar vs unfamiliar) of a traffic sign, with sign familiarity as a within-subject factor. Previous studies had found a relationship between the lack of traffic sign comprehension and accident likelihood. However, there was still a lack of research examining the sign characteristics that influence sign comprehension among motorcyclists. Participants were 86 young riders aged 18 to 25 who had a minimum of three years of riding experience in Jakarta, Bogor, Depok, Tangerang, and Bekasi (Jabodetabek) areas. Participants were given warning signs; then, sign comprehension was measured using sign comprehension time and sign comprehension level. The results show that there is a significant effect of sign familiarity and interaction between sign types and sign familiarity on sign comprehension time. On the other hand, sign types, sign familiarity, and interaction between sign types and sign familiarity have a significant effect on sign comprehension level. The implication of the research is that sign familiarity and sign type must be taken into consideration in designing effective traffic signs, especially warning signs, to facilitate riders in understanding traffic signs more quickly and accurately.

Keywords: *sign comprehension, sign types, sign familiarity, traffic signs, young riders*

INTRODUCTION

The number of traffic accidents in Indonesia keeps growing every year. According to the Land Transportation Statistics office, the road accidents that occurred from 2015 to 2019 have increased by an average of 4,87% annually (Central Bureau of Statistics, 2019). The increased number of traffic accidents was in line with the increase of motorcycles operating on the road (Central Bureau of Statistics, 2019). The majority of fatal accidents are among riders of motorized two-wheelers or motorcyclists out of all road users (Jusuf, Nurprasetio, & Prihutama, 2017). The factors contributing to traffic accidents among motorcyclists have been the centre of many studies. Many of them focus on the role of human factors, such as risk perception (Goh, Leong, & Cheah, 2020; Zheng et al., 2019), risky riding behaviour (Hassanzadeh et al., 2020; Maulina et al., 2018, Stanojević et al., 2020), and attitudes toward traffic rules (Romero et al., 2019; Zheng, Ma, & Cheng, 2019). However, how riders perceive the road environment and the features available on the road is also essential since it may lead the riders to make an inappropriate decision which can cause crashes or other accidents (Das, Mousavi, & Shirinzad, 2021). One important thing that all the riders need to pay attention to on the road is traffic signs. According to Constitution Number 22 of 2009 in Indonesia, traffic signs are part of street equipment in the form of symbols, letters, numbers, sentences, or

*Corresponding Author

combinations of any of these elements. Traffic signs provided information about the condition of the road. According to the Ministerial Regulation no. 13 of 2014 (The Ministry of Transportation, 2014), four types of traffic signs in Indonesia can be differentiated based on their functions, used as a warning, prohibition, instruction, and direction.

The function of traffic signs for the riders makes them have an important role in the road. However, there are still many riders in Indonesia, especially Jakarta, Bogor, Depok, Tangerang, and Bekasi (Jabodetabek), who violate the traffic sign. According to a report given by Greater Jakarta Metropolitan Regional Police (Polda Metro Jaya), there were up to 177 thousand cases of traffic violations in the period from 2019 to 2020, with disobeying the traffic signs being one of the most common violations (Admin Polri, 2021). The high number of traffic sign violations may be related to the low level of sign comprehension among riders. The traffic problems regarding motorcyclists in Indonesia and many other countries in Southeast Asia are caused by the limited knowledge and awareness of road safety and illiteracy in comprehending traffic signs (Kitamura, Hayashi, & Yagi, 2018). Most of the road users explain that they misinterpret or have little knowledge of the traffic signs (Nugroho, 2017). Previous research conducted on young motorcyclists shows that most riders still need to improve their knowledge and understanding regarding the type and meaning of traffic signs on the road (Soimun et al., 2020). The level of comprehension of Indonesian riders is still very limited, and this problem may be related to the lack of socialization from the police and other institutions (Maulana, 2017).

The lack of traffic sign comprehension among riders is also found in other countries, such as Thailand (Choocarukul & Sriroongvikrai, 2017), Jordan (Taamneh & Alkheder, 2018), Pakistan (Rehman & Ali, 2018), and the Philippines (Bañares et al., 2018). Since sign comprehension is the most critical factor of an effective traffic system, lack of understanding and misinterpreting the traffic signs will lead to disadvantages, such as accidents or even death (Zhang & Chan, 2013). A low level of sign comprehension may lead to an error and misunderstanding, which increases the risk of accidents to the riders (Ward, Wogalter, Mercer, 2004). The data of 2019 showed that violation of traffic lights and signs was one of the major causes of traffic accidents in Indonesia (Parwata, 2019). According to the Traffic Corps of the Indonesian National Police (Korlantas Polri), there were 36.358 cases of motorcycling accidents during the first semester of 2019 and 35.980 cases in the later semester (Lokadata, 2019). Specifically, 25.987 cases of motorcycle violations are caused by riders violating traffic signs in the same year (Marhaenjati, 2020). Therefore, motorcyclists need to understand traffic signs to ensure their safety. In the context of traffic psychology, the knowledge and understanding of traffic signs are called sign comprehension.

There are two elements of sign comprehension: sign comprehension time and sign comprehension level (Shinar & Vogelzang, 2013). Sign comprehension time refers to the time needed for the sign reader to give a response towards the sign. On the other hand, the sign comprehension level refers to the accuracy and correctness of the sign reader in responding (Shinar & Vogelzang, 2013). The importance of the riders' ability to quickly and accurately comprehend traffic signs while operating the motorcycle on the road contributes to the urgency in many studies of sign comprehension among motorcyclists.

Previous research has found that personal characteristics from the riders, such as gender, riding experience, education level, culture, and historical background, are some internal factors that influence sign comprehension (Jamson & Mrozek, 2017; Taamneh, 2018; Zhang & Chan, 2013). According to Al-Madani (2000), sign comprehension continues to increase as the rider experience increases. Male road users have also reported better in sign comprehension than female road users (Al-Madani, 2000). Moreover, previous studies have found that road users with higher educational backgrounds, such as university level, are better in sign comprehension (Al-Madani, 2000; Ng & Chan, 2012; Taamneh, 2018).

Another research has found that sign comprehension is also influenced by sign type. There are three types of signs: symbol-only, text-only, and a combination of symbol+text (Shinar & Vogelzang, 2013; Wontorczyk & Gaca, 2021). Several studies have examined the effect of sign type on sign comprehension (Babić et al., 2020; Ben-Bassat et al., 2021). However, inconsistencies in the results are still found. For example, some studies have shown that symbol-only signs are more quickly understood than text-only signs (Wontorczyk & Gaca, 2021). Symbol-only traffic signs are also believed to be widely beneficial as text-only signs only accommodate the comprehension of local people (Choocarukul & Sriroongvikrai, 2017). Interestingly, Koyuncu and Amado (2007) have shown a contrasting result. In their research, the signs using the combination of symbols+texts are more quickly and accurately understood than signs that are symbol-only or text-only. Another research has also found that signs which contain both symbol+text are easier and faster to be understood than symbol-only or text-only signs (Shinar dan Vogelzang, 2013). Based on these results, it can be concluded that which sign type leads to a higher sign comprehension is still unclear.

Furthermore, how the sign type can influence sign comprehension is also related to the characteristics of the signs. McDougall, Curry, and Bruijn (1999) have found that there are five important sign characteristics that would make the sign easier to comprehend; concreteness, complexity, meaningfulness, semantic distance, and familiarity. Concreteness refers to how concrete the picture represents the actual objects, materials, and people. If the sign is not drawn similar to the actual object, it is considered as an abstract (Ahmadi et al., 2021). Complexity refers to the details and elements that the sign provided. Meaningfulness

refers to how the symbol relays the message intended for road users. Semantic distance refers to the closeness of the symbol displayed in the sign with the actual message (Ishartomo, Suhardi, & Rohani, 2020). Lastly, familiarity refers to how frequent the drivers approach the sign while riding on the street. Familiarity also means the degree of the sign is recognizable by the riders (Ben-Bassat & Shinar, 2015; McDougall, Curry, & Bruijn, 1999).

Familiarity is considered as the most important characteristic that determines sign comprehension among riders; the more familiar the sign, the easier it is to comprehend (Taamneh & Alkheder, 2018). Familiarity with traffic signs is correlated positively to sign comprehension (Akple, Sogbe, & Atombo, 2020; Ben-Bassat et al., 2021; Umar & Bashir, 2019). Since the rider has previous real-world experience (McDougall, Curry, & Bruijn, 1999), familiarity is also related to riding experience (Ben-Bassat & Shinar, 2015). Riders with more riding experience will be more familiar with traffic signs; therefore, they have better sign comprehension than less experienced riders (Al-Madani, 2000; Taamneh, 2018).

Several studies have examined the effect of sign familiarity on sign comprehension. However, inconsistencies in the results are still found. For example, the research conducted in Saudi Arabia shows that the familiarity of the language displayed in the sign correlated with the sign comprehension among road users (Alhajyaseen, Ratrout, & Muley, 2018). The results show that the signs presented in a text of Arabic language are easier for the Arabic road users to comprehend than the signs displayed in English text. Another research conducted in the Philippines also shows that familiarity with traffic signs is positively correlated with road users' sign comprehension; the more familiar the sign to road users, the easier it is for them to comprehend (Bañares et al., 2018). However, Liu et al. (2019) have found different results. In their findings, the more familiar the sign to the road user, the easier it is for them to guess. Although, guessing ability does not correlate with sign comprehension.

Based on the previous research, it can be concluded that the characteristics of traffic signs will determine sign comprehension among motorcyclists. Specifically, the effect of sign type on sign comprehension may depend on the sign familiarity. Previous studies have found the effect of sign familiarity on sign comprehension, especially its interaction with the sign types. For example, Shinar and Vogelzang (2013) have found that symbol-only signs will only be quickly understood if the symbol is considered familiar by the riders. Otherwise, if the sign is an unfamiliar symbol, giving text (symbol+text) to it will improve sign comprehension. The previous research by Shinar and Volgezang (2013) was conducted in Israel and used the signs operating on Israeli roads. In their research, most participants are college students who may not represent Israel's road users. Since many road users in Israel are immigrants, they may not be literate in their native language. As a result, it may influence their sign comprehension. In Indonesia, most road users are local people who use Indonesian as their first language. Therefore, further research in Indonesia is still needed as it may generate different results.

The research aims to examine the effect of sign types and sign familiarity on sign comprehension. Several modifications are made in the current research to add theoretical contributions from the previous research. First, Shinar and Vogelzang (2013) have found the significant effect of sign types and sign familiarity on sign comprehension, but they examine each variable separately. In that research, familiarity only becomes an additional character in the sign, not as an independent variable. In the current research, the researchers combine the sign type and sign familiarity to examine their effects on sign comprehension among riders. Secondly, in the research, young motorcyclists are recruited as participants since the number of traffic accidents among motorcyclists is the highest every year in Indonesia and mostly involves young riders (Jemadu & Krisnamusi, 2017). Thirdly, the current research has focused mainly on the comprehension of warning signs. This focus is based on previous research, which states that it is harder for road users to comprehend warning signs than other traffic signs (Schulz et al., 2020). Lastly, in the research, sign comprehension is measured in both sign comprehension level and sign comprehension time, while previous researches only focus on one element of sign comprehension that will lead to a different result (Kaplan, Bortei-Doku, & Prato, 2018; Taamneh & Alkheder, 2018).

Regarding the presence and absence of additional explanatory texts on traffic signs, the researchers have assumed that signs with additional explanatory texts would be understood more quickly and more accurately by riders than symbol-only signs. This assumption is based on the research results by Koyuncu and Amado (2007) and Shinar and Vogelzang (2013). The researchers have also predicted that riders would understand more quickly and accurately comprehend familiar signs than unfamiliar ones. This aligns with previous studies by Zhang and Chan (2013) and Ben-Bassat et al. (2021). Familiar signs are mostly the common ones that road users interact with and usually have simpler graphics, as is easily understood (Fernandez et al., 2020). Thus, the researchers have formulated the hypotheses: (H1) the sign comprehension in symbol+text signs is higher than symbol-only signs; (H2) the sign comprehension in familiar signs is higher than unfamiliar signs; (H3) there is a significant interaction between the sign type and sign familiarity on sign comprehension.

The results of the research could provide information about the relationship between the type of signs and familiarity to the understanding of traffic signs. It could become a means in applying or improving the shortcomings of the traffic sign system itself, especially among motorcyclists. Therefore, increasing the effectiveness of traffic signs will reduce the likelihood of traffic accidents among motorcyclists.

METHODS

The inclusion criteria for participants of the research are having riding experience for three to five years and having a motorcycle riding license. Participants are motorcyclists aged 18-25 years old (M = 19,74; SD = 0,78), undergraduate students from any major and university in Jakarta, Bogor, Depok, Tangerang, and Bekasi. Initially, there are 95 participants in the research, but only 86 participants can be used in the analysis. Most participants are males (69,77%), and 54,8% of participants use automatic motorcycle transmission. A total of 61,3% of participants has been given a ticket in the last three months. Most participants have experienced an accident in the last three months, ranging from 1 to 5 accident cases (M = 2,00; SD = 1,97). Participants are recruited in this research using snowball sampling and convenience sampling techniques. They are given rewards after finishing the experiment.

A sensitivity power analysis (ANOVA; Repeated measures, within-between interaction) is performed using G*Power (Faul et al., 2007), with an alpha of 0,05, a power of 0,80, the current sample size (N = 86), two groups and two measurements. This power analysis shows that the minimum detectable effect size of interest would be f = 0,153 (or $\eta 2p$= 0,023). Hence, the current sample size (N = 86) can reasonably detect an effect of that size (or larger).

The research uses a 2 (sign types) x 2 (sign familiarity) mixed factorial design, with sign familiarity as the within-subject factor. Two factors are examined in this experiment, namely, sign type (symbol-only vs symbol+text) and sign familiarity (familiar vs unfamiliar). The dependent variable is sign comprehension, measured by the sign comprehension time (reaction time) and sign comprehension level (accuracy). Extraneous variables are controlled by matching and constancy techniques. Gender is controlled by matching, while vehicle type, age, and level of education are controlled using the constancy technique.

Some instruments used in the research are websites and computers, sign comprehension measurement, and warning signs. For the website, the experiment uses an internet website developed by researchers as a measuring instrument in the research. The website is made using javascript and administered online through a paid web hosting domain. This website is designed to record participants' answers related to their reaction time and comprehension level of traffic signs. The website is displayed using a standardized monitor for each participant. The website display can be seen in Figure 1.

Sign comprehension is measured by sign comprehension time and sign comprehension level. Sign comprehension time (reaction time) is measured from the latency. The span time between the first appearance of a traffic sign and the moment when participants pressed the enter button indicates that they understand the sign. Sign reaction time is recorded in seconds units by the website. On the other hand, sign comprehension level is measured based on participants' answer to the short question ("what does the sign mean?"), given after participants press the enter button. Then, the researchers use the scoring system based on Metz and Kruger (2014). There are four alternative scores for each question, from +2, +1, 0, and -1; +2 score for every right and complete answer, +1 score for right but incomplete answers, 0 score for wrong answers, and -1 for reversed meaning (e.g., it should be 'turn right', but they answer 'turn left'). The scoring keys are based on Constitution Number 22 of 2009 in Indonesia about Traffic Systems and Transportation. In the sign comprehension level, there are two scorers for each answer to ensure scoring accuracy.

This experiment uses warning signs based on the survey done by Ramadhannisa et al. (2016). The survey is conducted on 254 college student motorcyclists in several cities in Indonesia. The survey uses 30 warning signs and asks participants to rate the familiarity of each sign. The higher score means the higher unfamiliarity of each sign. Based on the

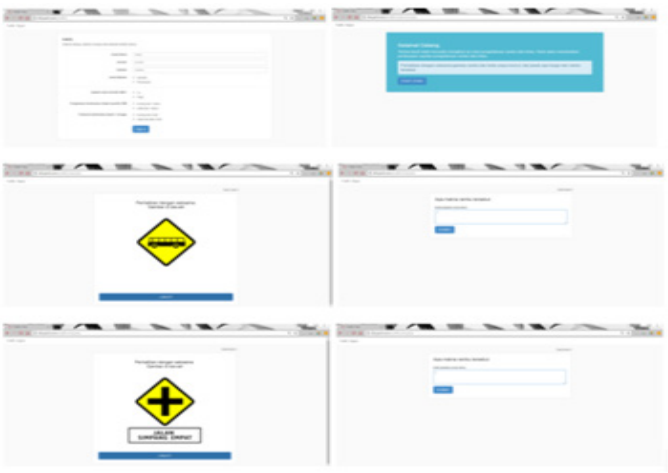

Figure 1 Website Display

survey, the researchers categorize the signs as familiar or unfamiliar (Figure 2), with the highest mean as the unfamiliar signs and the lowest mean as the familiar signs. This experiment uses a total of 20 warning signs, consisting of ten familiar signs and ten unfamiliar signs. The familiar signs are downhill warning sign, right turn warning sign, left turn warning sign, traffic signs ahead warning sign, four intersection traffic sign, slippery road sign, pedestrian warning sign, caution warning sign, bicycle crossing warning sign, and public transportation warning sign. Meanwhile, the unfamiliar signs are staggered side road intersection right sign, lane ends-merge left sign, severe side wind ahead sign, crosswalk ahead sign, deep ravine ahead warning sign, tsunami hazard sign, poisonous vehicle hazard sign, divided highway warning sign, sharp left bend ahead warning sign, and lane ends-merge right sign.

The procedure of the experiment consists of the preparation phase and experiment phase. At the preparation phase, the researchers choose traffic signs that will be used in the research based on the survey by Ramadhannisa et al. (2016). Then, the researchers develop the stimuli for this experiment. At the experiment phase, the researchers conduct the research in the computer laboratory of the Faculty of Psychology and PPSP Indonesia University. Each participant is randomly divided into two groups, symbol-only signs and symbol+text signs. Participants are given two levels of sign familiarity in each group, which consists of familiar and unfamiliar signs. The sequences of stimuli are counterbalanced in each group.

Before starting the experiment, participants are asked to fill out the attendance list and informed consent. Then, the experimenter explains the steps that must be done during the experiment to the participants. The experimenter also gives the practice trial and demo to the participants. Each participant is tested individually using the standardized computer in the computer laboratory and website. The experiment is conducted in the following procedure. First, participants are instructed to do some practice trials on the website to ensure they understood how the experiment would be executed. Secondly, on the next page, participants are asked to choose one group that the experimenter already selected. Then, the experiment is started. Participants are given the stimulus in a picture of signs. They have to press the 'enter' button if they understand the information presented in the picture. The website records the time span between the appearance of the stimulus and the participant's response from pressing the button. After that, participants are asked to write the meaning of the sign that was presented previously to measure their comprehension level. Then, participants continue to follow the following signs with the same procedure until they finish 20 signs. The website display is shown in Figure 1. After completing all the tasks on the website, participants are asked to fill in the questionnaire regarding the type of motorcycle transmission used in their motorcycle, the experience of getting a traffic ticket along with the reason (if said yes), and the frequency of violating the traffic signs in the last three months.

Figure 2 Examples of Road Signs in the Experiment (A: Familiar Sign with Text; B: Familiar Sign without Text; C: Unfamiliar Sign with Text; D: Unfamiliar Sign without Text)

RESULTS AND DISCUSSIONS

A mixed ANOVA 2x2 is used to analyze the effect of sign type and sign familiarity on sign comprehension. Table 1 shows the mean and standard deviation of sign comprehension time in each group.

Table 1 Mean and Standard Deviation of Sign Comprehension Time (*N*=86)

Sign Type	Sign Familiarity			
		Familiar	Unfamiliar	Total
	n	**M (*SD*)**	**M (*SD*)**	**M (*SD*)**
Symbol-only	44	3,21 (1,42)	7,12 (4,21)	5,17 (2,40)
Symbol + text	42	3,83 (1,47)	5,97 (2,56)	4,89 (1,52)
Total		3,51 (1,46)	6,55 (3,53)	

Higher scores mean higher reaction time (in seconds)

In sign comprehension time, mixed ANOVA analysis shows a no significant effect of sign type ($F(1,84) = 0,377$, $p = 0,541$, $\eta 2p = 0,004$); a statistically significant effect of sign familiarity ($F(1,84) = 63,32$, $p < 0,001$, $\eta 2p = 0,43$); and a statistically significant interaction between sign type and sign familiarity ($F(1,84) = 5,42$, $p = 0,022$, $\eta 2p = 0,061$). Based on the significant results, the size of the effect of sign familiarity is large and the interaction effect is medium (Cohen, 1969). Familiar signs ($M = 3,51$, $SD = 1,47$) have a faster reaction time than unfamiliar signs (M

= 6,56, *SD* = 3,53). For familiar signs, symbol-only signs (*M* = 3,21, *SD* = 1,41) have faster reaction time than symbol+text signs (*M* = 3,83, *SD* = 1.47). For unfamiliar signs, symbol+text signs (*M* = 5,97, *SD* = 2,56) have faster reaction time than symbol-only signs (*M* = 7,12, *SD* = 4,21). Figure 3 shows the sign comprehension time graph where the error bars stand for the standard error.

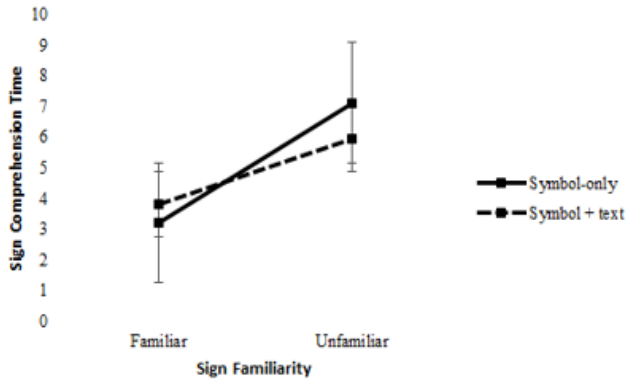

Figure 3 Sign Comprehension Time Graph

Table 2 shows the mean and standard deviation of sign comprehension level in each group.

Table 2 Mean and Standard Deviation of Sign Comprehension Level (N=86)

Sign Type		Sign Familiarity		
		Familiar	Unfamiliar	Total
	n	**M (*SD*)**	**M (*SD*)**	**M (*SD*)**
Symbol-only	44	11,55 (2,79)	7,14 (3,73)	18,68 (5,43)
Symbol+text	42	16,31 (3,21)	15,02 (3,65)	31,33 (6,01)
Total		13,87 (3,83)	10,99 (5,40)	

Higher scores mean higher accuracy (range score: 0-20)

For sign comprehension level, the result shows a statistically significant effect on sign type ($F(1,84) = 105,25$, $p < 0,001$, $\eta 2p = 0,556$); a statistically significant effect of sign familiarity ($F(1,84) = 55,058$, $p < 0,001$, $\eta 2p = 0,396$); and a statistically significant interaction between sign type and sign familiarity ($F(1,84) = 16,56$, $p < 0,001$, $\eta 2p = 0,165$). The size of the effect of sign type, sign familiarity, and the interaction effect is large (Cohen, 1969). Symbol+text signs (*M* = 31,33, *SD* = 6,01) have a higher level of comprehension than symbol-only signs (*M* = 18,68, *SD* = 5,43). Furthermore, familiar signs (*M* = 13,87, *SD* = 3,83) have a higher level of comprehension than unfamiliar signs (*M* = 10,99, *SD* = 5,40). For familiar and unfamiliar signs, symbol+text signs (*Mfamiliar* = 16,31, *SD* = 3,21; *Munfamiliar* = 15,02, *SD* = 3,65) have a higher level of comprehension than symbol-only signs (*Mfamiliar* = 11,55, *SD* = 2,79; *Munfamiliar* = 7,14, *SD* = 3,73). However, the mean difference is higher in unfamiliar sign than familiar sign (*Mdifffamiliar* = 4,76; *Mdiffunfamiliar* = 7,88). From all the results, the researchers have found that all the effects in the current experiment are higher than the prior sensitivity power analysis (minimum $\eta 2p$= 0,023). This result shows that the current experiment (*N*= 86) has good power. Figure 4 shows the sign comprehension level graph where error bars stand for standard error.

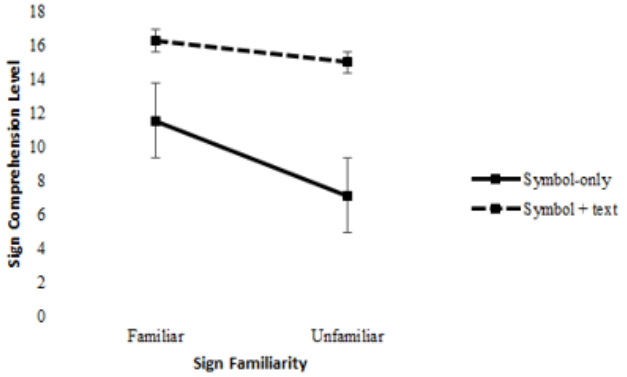

Figure 4 Sign Comprehension Level Graph

The current research examines the effect of sign type and sign familiarity on sign comprehension among young riders. Based on the previous research conducted by Shinar and Vogelzang (2013), the present experiment attempts to modify their findings by comparing sign comprehension between familiar and unfamiliar signs. The research hypothesizes that the sign comprehension time and sign comprehension level would be higher in symbol+text signs than in symbol-only signs. It also hypothesizes that the sign comprehension time and sign comprehension level would be higher in the familiar signs than in the unfamiliar signs.

The result shows that sign type significantly affects sign comprehension level. Symbol+text signs have a higher accuracy level of comprehension than symbol-only signs. This result aligns with the research conducted in Israel by Shinar and Vogelzang (2013). Adding text to the symbol-only sign would increase the accuracy and correctness in comprehending the sign among motorcyclists. The presence of the text may also add a more significant meaning or value to the symbol-only sign, making it easier for the riders to comprehend and add an educational value (Shinar & Vogelzang, 2013). The result of the research is also in line with the concept of understanding information in a more general context apart from driving, such as understanding a text. In understanding information, pictures (symbols) help in providing context for what is written in the text. Comprehending a written text

would be much better if it is combined with pictures, one of which can be in the form of a symbol. Pictures reinforce the meaning of a text and enhance memory, and text with pictures is also easier to read and comprehend than picture only (Hou, Yang, & Sun, 2017; Zhao & Mahrt, 2018).

The research also finds sign familiarity significantly affected sign comprehension, both in sign comprehension time and level. At sign comprehension time, riders who identified the sign as familiar show a faster reaction than the unfamiliar sign. At the sign comprehension level, familiar signs are more accurately comprehended than unfamiliar signs. These results are in line with the study conducted in the Philippines (Bañares et al., 2018), Hong Kong (Zhang & Chan, 2013), and England (McDougal, Curry, Bruijn 1999). Familiarity is the most prominent characteristic in determining sign comprehension among riders. The more often a person sees a sign, the sign will be judged as familiar; therefore, they can easily access its meaning without long thinking (McDougal, Curry, Bruijn, 1999). Riders will be easier to understand the meaning of the sign if the riders frequently see the sign than to the sign they are unfamiliar with. On the other hand, signs with icons that the riders are not familiar with will bring confusion, thus leading to misunderstanding in comprehending the sign (Hou & Yang, 2020; Zhang & Chan, 2013).

Sign comprehension is driven not only by how the sign is produced but also by how it is being comprehended by the user (Watkins & Thompson, 2017). According to the theory of cognitive psychology, familiar information is recognized more accurately and confidently (Van den Broek et al., 2018). Information is easier to comprehend if it is familiar, as people already have sufficient background knowledge that makes the new information easier to understand (Heriyawati, Saukah, & Widiati, 2018). In addition, the familiarity of information heavily influences the process of controlling and accommodating mental load. Familiarity also facilitates the working memory process, which in turn affects the process of comprehending information. For unfamiliar information, individuals need to form a certain process in the working memory to understand the information. If the information presented is familiar, the process will be easier (Ntim, 2017).

Another result in the research is a significant effect of the interaction between sign type and sign familiarity on sign comprehension time. For familiar signs, symbol-only signs have a faster reaction time than symbol+text signs. On the other hand, symbol+text signs have a faster reaction time for unfamiliar signs than symbol-only signs. In line with the findings of Shinar and Vogelzang (2013), this result may have originated from the fact that for familiar signs, symbol-only signs are easier to comprehend even from a great distance. The reason is that traffic signs with symbols only provide road users with some information they need without any other distraction, such as a form of text. Symbols or pictorial stimuli also require less mental processing than words or text, and as a result, they are faster to comprehend (Koyuncu & Amado, 2007). On the other hand, symbol+text signs are a much better option for unfamiliar signs because the text will add an explanation for the unfamiliar signs. So, the riders will have an opportunity to learn the association between the symbol and the meaning (Shinar & Vogelzang, 2013).

Another interaction effect is also found in sign comprehension level. Both familiar and unfamiliar signs, symbol+text signs, have a higher level of comprehension than symbol-only signs. However, the mean difference is higher in unfamiliar signs than familiar signs. For text-only signs, familiarity becomes irrelevant, but adding text to a symbol (symbol+text signs) would help the riders associate the symbol and the meaning from the text displayed (Shinar & Vogelzang, 2013).

It is crucial to note some limitations of the current experiment. First, the participants of the research are college students. The specific characteristics in college students might not represent all young motorcyclists in Jabodetabek. Most college students are expected to be literate and may have a higher awareness of traffic safety than the rest of the population. As a result, the external validity of these findings is still limited. Secondly, this research is conducted on motorcyclists that might have different characteristics from other road users, such as car drivers. The different sizes and forms between motorcycles and cars may affect how riders/drivers see the traffic signs from their vehicles. Thus, future research on other road users is still important to understand sign comprehension among road users in Indonesia. Another limitation is that this research only uses warning signs, so further studies that use the different kinds of signs, such as prohibition, instruction, and direction, are still needed to examine the consistency of the result. Lastly, in the research, the experiment is conducted using a website-based road simulator which may be different from the real-road situation where riders see the traffic signs directly from their vehicle while riding. Therefore, another field experiment in daily road situations is still needed to have higher external validity.

CONCLUSIONS

From the research, it can be concluded that (1) there is no significant effect of sign type on sign comprehension time; (2) there is a significant effect of sign familiarity on sign comprehension time; (3) there is a significant effect of interaction between sign type and sign familiarity on sign comprehension time; (4) there is a significant effect of sign type on sign comprehension level; (5) there is a significant effect of sign familiarity on sign comprehension level; (6) there is a significant effect of interaction between sign type and sign familiarity on sign comprehension level.

Based on these results, there are some practical implications of the research. First, the research is

expected to be a new reference for the authorities in designing effective traffic signs for the riders, especially warning signs based on sign type and sign familiarity. From the research result, the police should consider the sign type and sign familiarity to increase the sign comprehension time and sign comprehension level among motorcyclists. Using additional text in the symbols will help the riders understand the sign more quickly and accurately. Another implication of the research is related to the familiarity of the sign. The higher familiarity of the sign will also lead to higher sign comprehension for the riders. If the riders frequently see the signs, it will be easier to understand them. Therefore, the police should consider re-educating the riders related to the meaning of traffic signs. Socialization and sign comprehension training will be an alternative solution to increase sign comprehension among riders and is expected to reduce traffic violations. Also, it can decrease the number of traffic accidents among motorcyclists.

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