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Prohibitory traffic signs violation by well-educated young drivers based on situation scenarios

Bambang Suhardi^{1,*}, Farid Ishartomo² and Jafri Mohd Rohani²

Abstract: Traffic violations in Indonesia were mostly committed by young drivers. Surprisingly, university students ranked third as traffic violators despite they are expected to have better understanding of traffic signs instead of others. This study was conducted to investigate the influence factors that might encourage university students as well-educated young drivers to commit traffic violations through several situation scenarios. Five prohibitory traffic signs (no u-turn, no parking, stop sign, maximum speed limit, no stopping) were subjectively evaluated by 212 university students (18–23 years old, having valid car and or motorcycle driving license) whether they will violate these signs in 7 situation scenarios as indicators based on human-related factors (no police officers, in a hurry, imitate mistakes, sleep deprivation and fatigue) and environmental-related factors (quiet roads, night driving, driving in heavy rain). From the results, the influence varied for each sign. Both factors influenced no u-turn, no parking and no stopping signs. Human-related factors influenced maximum speed limit sign while environmental-related factors influenced stop sign. This study has provided a useful initial insight to understand young driver's behavior to violate these prohibitory traffic signs. For further studies, it can be applied to other signs with different respondent profiles. Apart from that, the relationship between indicators can also be investigated.

Keywords: Traffic signs; sign violation; young drivers

Subjects: Industrial Engineering & Manufacturing

1. Introduction

Based on Land Transportation Statistics 2019 released by the Central Bureau of Statistics of the Republic of Indonesia (2019), there were 116,411 traffic accidents with 25,671 people deaths, 12,475 seriously injured and 137,342 minor injuries. The number of accidents in Indonesia since 2015–2019 has been annually increased by 4.87%. However, the large number of accidents in Indonesia is also related to the large number of private motorized vehicles and the drivers based on driving license ownership. In 2019, there were 15,592,419 passenger cars and 112,771,136 motorcycles in Indonesia, as well as 4,139,101 drivers who have passenger cars driving license and 9,304,877 drivers who have motorcycles driving license. The number of passenger cars and motorcycles in Indonesia since 2015–2019 has been annually increased by 6.10% and 6.20% respectively.

Drivers are one of the important factors on road safety performance (Arowolo et al., 2014). The Indonesian National Police (2013) stated that drivers who were not orderly traffic rules are a major factor of road accidents in Indonesia, whereas traffic rules are designed to regulate the traffic behavior of road users. Traffic signs are one of the traffic regulation instruments. Comprehension

of traffic signs may consider human characteristics of the drivers, ergonomic principles, cognitive features and the cultural issues (Ishartomo et al., 2020). Familiarity with signs can help drivers understand their meaning (Abduljabbar et al., 2020), but familiarity is not always linear with comprehensibility. Drivers who are familiar with certain signs do not always understand their meaning (Akple et al., 2020).

Based on current regulation in Indonesia by Ministry of Transportation (2014) Article 1 and Article 3, traffic signs are defined as part of road equipment in the form of symbols, letters, numbers, sentences, and or combination that functions as warnings, prohibitions, orders, or instructions for road users. Traffic signs based on their type consist of: (a) warning signs; (b) prohibitory signs; (c) command signs; and (d) information signs. Compared to other type of signs, it was previously known that drivers were able to react more quickly in understanding prohibitory traffic signs (Castro et al., 2012). Article 11 of the regulation (Ministry of Transportation of the Republic of Indonesia, 2014) also explained that prohibitory traffic signs are used to state actions that are prohibited from being carried out by road users. It consist of: (a) prohibition to continues, (b) entry prohibition, (c) parking restrictions and stopping, (d) prohibition of certain traffic movements, (e) prohibition against sounding signals, (f) prohibition with words, and (g) the end of the prohibition signs.

Traffic violations in Indonesia were mostly committed by young drivers in the age of 16–21 years old (Indonesia National Police, 2013). In that age range, mostly young drivers were high schools students and university students. The data from Indonesia National Police (2013) also showed that high schools students and university students ranked first and third as traffic violators. This may come as a bit of a surprise since young drivers studying at the universities are expected to have better understanding of traffic signs (Ghadban et al., 2018). Young drivers with undergraduate background defined as well-educated young drivers because they are considered to have better knowledge of traffic signs than others. In the end, well-educated young drivers as part of a smart society are expected to be an important part of the creation of a smart city (Habeeb & Welj, 2020).

The violation of traffic signs by drivers is an interesting subject to be learned and investigated. It was known by several researchers that traffic signs can influence driver's decision-making behaviors (Vilchez, 2019) and performances (Sandu, 2013) or even a tool for behavioral changes (Meis et al., 2017). Moreover, combination and adjustment of road signs, context and laws can make the drivers avoid ambiguous situations and doubtful decision-making, and then automatically subject the drivers to compliance with applicable laws (Bazire & Tijus, 2009). Violations of traffic signs occurs because of the human errors in understanding the meaning of signs, indifference to signs and the weakness supervision and enforcement of traffic laws (Winarso, 2016). A combination of poor traffic rules knowledge, a tendency to speed, an inability to control emotions and focus on driving can lead to someone violating traffic rules (Lady et al., 2020). Meanwhile, Agustin (2019) identified 3 causes of traffic rule violations, namely: driver's knowledge, intensity of raid operations and intensity of law enforcement.

In the previous study based on subjective interview to local Indonesian drivers about the behavior of road users (Winarso, 2016), it can be concluded that the violation and ignorance of the traffic signs, road markings, and traffic signal devices were stimulated by internal, external and other factors. The internal factor described as the needs to get to the destination as soon as possible. Meanwhile, the external factors described as stimulation of the situation, e.g., the probability to get trapped in a traffic jam and the poor law enforcement by police officers. The other factors described as pressure from environment, such as faded or blurred traffic signs. Poor law enforcement could be due to a lack of traffic police personnel on duty. This kind of situation sometimes provides an opportunity for drivers to break traffic rules. In addition, the lack of police officers can cause violations to be carried out without fines, so that other drivers felt that it was not a wrong attitude and followed by other drivers (Purnamasari, 2019; Purnamasari & Anusanto, 2017). The vehicle-following behavior had been analyzed recently (Fulu et al., 2020). In fact, people actually want the implementation of fines and

sanctions against traffic violators to be applied equally based on their mistakes (Agustin, 2019; Purnamasari, 2019; Purnamasari & Anusanto, 2017).

An investigation of road users' situation awareness in different road environments such as wet, slippery, debris, quiet and busy roads found that it can influence driver's awareness (Salmon et al., 2014). In addition, Imran et al. (2021) observed that traffic flow characterization and driver reaction were related. Another opinion stated that a tired or fatigue driver has its potential to ignore traffic rules (Ho et al., 2015; Ho & Widaningrum, 2016). Sleep related driving fatigue experiment has been previously investigated (Sanjaya et al., 2018). In sleep-deprived condition, the young driver's visual attention was decreased compared to drivers who have 8-hours normal sleep and can affect their driving performance (Wijayanto et al., 2018). Meanwhile, insufficient lighting at night can increase the risk of traffic violations and accidents (Setyaningsih et al., 2018). Driving in heavy rain is also quite dangerous due to reduced visibility of the drivers. The worsening weather conditions, such as heavy rain, etc., have significant effect on increasing drivers' perceived risk due to limited visibility (Chen et al., 2019). This is in line with research related to situation awareness in different road environments (Salmon et al., 2014). However, signs related to environmental condition are needed to warn road users (Ben-Bassat, 2019).

From several previous studies, the causal factors (Winarso, 2016) can be simplified into 2 factors: human-related factors and environmental-related factors. It also related to Iqbal et al. (2020) who identified human errors and environmental factors as the contributing factors in road traffic accidents. Several situation scenarios that may affect driver's intention to violate traffic signs can also be added as shown in Table 1. Human-related factors can be specified into four aspects, that is, "No Police Officers" (Purnamasari, 2019; Purnamasari & Anusanto, 2017; Winarso, 2016), "In A Hurry" (Purnamasari, 2019; Purnamasari & Anusanto, 2017; Winarso, 2016), "Imitate Mistakes" (Purnamasari, 2019; Purnamasari & Anusanto, 2017; Winarso, 2016) and "Sleep Deprivation & Fatigue" (Ho et al., 2015; Ho & Widaningrum, 2016; Sanjaya et al., 2018; Wijayanto et al., 2018) while environmental-related factors can be specified into 3 aspects, that is, "Quiet Roads" (Salmon et al., 2014), "Night Driving" (Setyaningsih et al., 2018) and "Driving in Heavy Rain" (Chen et al., 2019; Salmon et al., 2014). This study analyzed the influence factors of traffic signs violation based on several situation scenarios by well-educated young drivers in Indonesia. This is important for stakeholders so that in the future preventive measures can be taken to reduce the number of traffic violations and traffic accidents among adolescents.

Table 1. Traffic signs violation based on situation scenarios

Factors	Situation scenarios	References
Human-related factors	No police officers	Winarso (2016); Purnamasari and Anusanto (2017); Purnamasari (2019)
	In a hurry	Winarso (2016); Purnamasari and Anusanto (2017); Purnamasari (2019)
	Imitate mistakes	Winarso (2016); Purnamasari and Anusanto (2017); Purnamasari (2019)
	Sleep deprivation & fatigue	Ho et al. (2015); Ho and Widaningrum (2016); Sanjaya et al. (2018); Wijayanto et al. (2018)
Environmental-related factors	Quiet roads	Salmon et al. (2014)
	Night driving	Setyaningsih et al. (2018)
	Driving in heavy rain	Salmon et al. (2014); Chen et al. (2019)

2. Methods

2.1. Research design

This study focused on five prohibitory traffic signs in Indonesia as sample signs, that is, “No U-Turn”, “No Parking”, “Stop Sign”, “Maximum Speed Limit” and “No Stopping”, as it shown in Figure 1. These five signs were selected based on a study conducted by Purnamasari (2019). All of them have comprehensibility level above 83%, so it is expected that all drivers will not experience difficulties in understanding the meaning of these signs. The signs were coded as Sign 1 to Sign 5 respectively.

The research design is shown in Figure 2 below. Human-related factors and environmental-related factors were considered in sign violation. The human-related factors are no police officers, in a hurry, imitate mistakes and sleep deprivation & fatigue. The environmental-related factors are quiet roads, night driving and driving in heavy rain. Data variables are shown in Table 2. Sign Violation (YVIO) as dependent variable consists of two dimensions as independent variables that is, human-related factors (X3HUM) and Environmental-related factors (X4ENV). Human-related factors (X3HUM) consist of four items as indicator variables: No Police Officers (VPO), In a Hurry (VIH), Imitate Mistakes (VIM), and Sleep Deprivation and Fatigue (VSF). Environmental-related factors (X4ENV) consist of three items as indicator variables: Quiet Roads (VQT), Night Driving (VND), and Driving in Heavy Rain (VHR).

2.2. Data collection

The questionnaire survey method was used for data collection. It was developed using Google Forms and distributed online from 22 September to 21 October 2020 via Twitter as social media platform to undergraduate students of Universitas Sebelas Maret (UNS) in Surakarta, Indonesia with the age between 18 and 23 years old and owned a personal driving license to drive passenger cars and/or motorcycles. Newly undergraduate students in Indonesia generally started from 18 years old and graduated at the age of 23 years old (Ministry of Research, Technology and Higher Education of the Republic of Indonesia, 2018). Other than that, the requirement for an individual driving license applicant to drive cars or motorcycles is at least 17 years old based on Article 81 Law number 22 Year 2009 (Government of the Republic of Indonesia, 2009). The

Figure 1. Five prohibitory traffic signs as sample signs.



Figure 2. Research design.

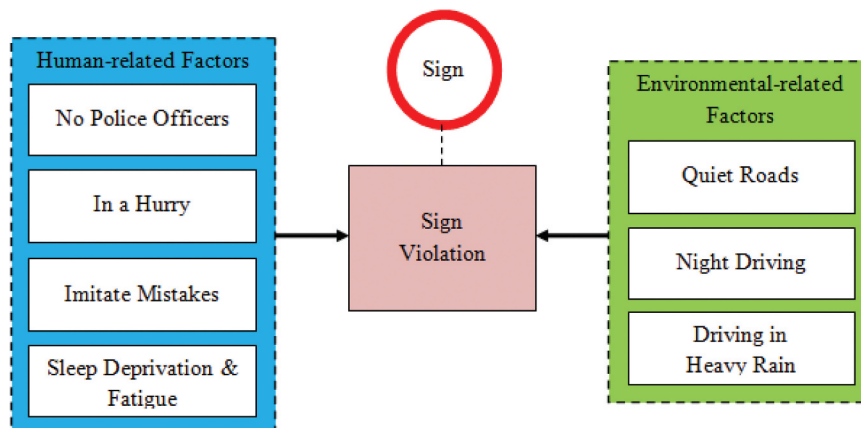


Table 2. Data variables

Dependent variable (latent)	Independent variables (manifest)	Indicators (items)
Sign violation (YVIO)	Human-related factors (X3HUM)	No police officers (VPO)
		In a hurry (VIH)
		Imitate mistakes (VIM)
		Sleep deprivation & fatigue (VSF)
	Environmental-related factors (X4ENV)	Quiet roads (VQT)
		Night driving (VND)
		Driving in heavy rain (VHR)

questionnaire was divided into two parts. In Part I, respondents were asked about their personal characteristics, that is, age, gender, educational background and type of driving license. In Part II, respondents were asked to conduct a subjective evaluation of these signs through seven statements as it shown in Table 3 by choosing one of the five available answer options, that is, Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree. There was no question about the meaning of the signs so that all respondents were considered to know the meaning of the signs being tested.

As many as 212 undergraduate students were willing to participate in this survey. All respondents were considered to have no color blindness problem. Personal characteristics of the respondents are shown in Table 4. The respondents were mostly 21 years old (52 students; 24.53%). Female students were more participated (162 students; 76.42%) than male students (50 students; 23.58%). The respondents consisted of 149 bachelor students (70.28%) and 63 diploma students (29.72%). Most of the respondents had motorcycle driving license (159 students; 75.00%) and the rest had both type of car and motorcycle driving license (53 students; 25.00%). The frequency distribution of human-related factors and environmental-related factors from respondents' answers are shown in Tables 5 and Tables 6 respectively.

2.3. Data analysis

Partial Least Squares-Structural Equation Modeling (PLS-SEM) method was chosen to analyze the data since PLS-SEM can be used to develop an exploratory model (Garson, 2016). SmartPLS 3.2.8 Professional trial version software was used as a tool to do PLS analysis. The PLS analysis theoretical framework was shown in Figure 3. Variable YVIO (Sign Violation) as latent variable

Table 3. Questionnaire statements

No	Indicators	Statements
1	No police officers	I will violate this sign if there are no police officers in charge.
2	In a hurry	I will violate this sign if I am in a hurry.
3	Imitate mistakes	I will violate this sign if others also violate it.
4	Sleep deprivation & fatigue	I will violate this sign if I feel sleep deprived and fatigue.
5	Quiet roads	I will violate this sign if I drive in quiet roads.
6	Night driving	I will violate this sign if I drive at night and it is dark.
7	Driving in heavy rain	I will violate this sign if I drive in heavy rain.

Table 4. Frequency distribution of driver’s personal characteristics (n = 212)

Characteristics	Categories	Frequencies	Percentages (%)
Age	18 years	19	8.96
	19 years	45	21.23
	20 years	41	19.34
	21 years	52	24.53
	22 years	40	18.87
	23 years	15	7.07
Gender	Male	50	23.58
	Female	162	76.42
Educational background	Diploma	63	29.72
	Bachelor	149	70.28
Driving license	Passenger car only	0	0.00
	Motorcycle only	159	75.00
	Passenger car & motorcycle	53	25.00

consisted of two dimensions, that is, X3HUM (Human-related factors), and X4ENV (Environmental-related factors). Dimension X3HUM consisted of four indicators as manifest variables: VPO (No Police Officers), VIH (In a Hurry), VIM (Imitate Mistakes), and VSF (Sleep Deprivation and Fatigue). Dimension X4ENV consisted of three indicators as manifest variables: VQT (Quiet Roads), VND (Night Driving), and VHR (Driving in Heavy Rain).

Two stages of evaluation have been done for each signal, that is, measurement model (outer model) and structural model (inner model). Since it was a formative relation, evaluation were done by checking convergent validity (outer loadings >0.7), co-linearity statistics (VIF < 5), outer weights (T statistics > 1.96; p value < 0.05) and path coefficients (p value < 0.05). After running the PLS algorithm in SmartPLS software, the outer loadings and VIF have to be checked. If the outer loadings are less than 0.7 and the VIF are more than 5, then the indicators have to be deleted and repeated the model running (Garson, 2016). If the outer loadings and VIF of each sign is all valid, the model can be calculated using Bootstrapping with the significance level of 0.05 ($\alpha = 5\%$) to check the outer weights and path coefficients.






3. Results and discussion

The results of this study explained for each sign in detail, that is, Sign 1 (No U-Turn), Sign 2 (No Parking), Sign 3 (Stop Sign), Sign 4 (Maximum Speed Limit), and Sign 5 (No Stopping).

3.1. Sign 1 (No U-Turn)

The final path diagram of Sign 1 is shown in Figure 4 while the outer weights and path coefficients are shown in Table 7. From the outer weights in Table 7, No Police Officers (VPO), Imitate Mistakes (VIM), Sleep Deprivation & Fatigue (VSF) were good indicators (T statistics > 1.96; p value < 0.05) for human-related factors (X3HUM) and also good direct indicators for sign violation (YVIO), while In a Hurry (VIH) was not a good indicator (T statistics 0.076 < 1.96; p value 0.939 > 0.05) for human-related factors (X3HUM) and also not a good direct indicator (T statistics 0.075 < 1.96; p value 0.940 > 0.05) for sign violation (YVIO). Quiet Roads (VQT), Night Driving (VND) and Driving in Heavy Rain (VHR) were good indicators (T statistics > 1.96; p value < 0.05) for environmental-related factors (X4ENV) and also good direct indicators for sign violation (YVIO). From the path coefficients in Table 7, both of human-related factors (X3HUM) and environmental-related factors (X4ENV) had positive influence and significant (p value < 0.05) to sign violation (YVIO).

Table 5. Frequency distribution of human-related factors (n = 212)

Indicators	Answers	Sign 1	Sign 2	Sign 3	Sign 4	Sign 5
						
No police officers	Strongly Disagree	80	79	58	37	66
	Disagree	66	53	62	35	54
	Neutral	37	55	43	59	58
	Agree	20	18	16	55	19
	Strongly Agree	9	7	6	26	15
Total		212	212	212	212	212
In a hurry	Strongly Disagree	77	72	79	33	57
	Disagree	48	72	67	30	61
	Neutral	43	40	41	53	59
	Agree	30	23	17	59	22
	Strongly Agree	14	5	8	37	13
Total		212	212	212	212	212
Imitate mistakes	Strongly Disagree	86	81	88	42	71
	Disagree	56	50	60	43	62
	Neutral	32	43	50	64	49
	Agree	24	35	11	35	21
	Strongly Agree	14	3	3	28	9
Total		212	212	212	212	212
Sleep deprivation & fatigue	Strongly Disagree	100	86	91	50	73
	Disagree	63	71	65	46	70
	Neutral	31	35	41	58	46
	Agree	14	15	12	33	18
	Strongly Agree	4	5	3	25	5
Total		212	212	212	212	212

Both of human-related factors (no police officers, imitate mistakes, sleep deprivation & fatigue) and environmental-related factors (quiet roads, night driving, driving in heavy rain) had positive influence and significant to “No U-turn” sign violation. It means that students have intention to violate it if there are no police officers, if other drivers also violate it, if they feel sleepy and tired, if the road is quiet, if they drive at night and also if they drive in a heavy rain. It is a serious problem that stakeholders must give attention to this matter since 6 out of 7 situation scenarios were had positive influence. There is only in a hurry situation that did not give positive influence. However, this does not guarantee that drivers in a hurry will not violate this sign. Purnamasari and Anusanto (2017) and Purnamasari (2019) argued that in a hurry situation was the second major factor after no police officers situation that might encourage drivers to violate signs. Even though they want to get to the destination quickly, students might also need other situations to strengthen their intention to violate this sign.

Table 6. Frequency distribution of environmental-related factors (n = 212)






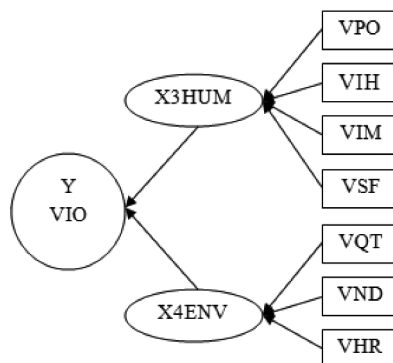
Indicators	Answers	Sign 1	Sign 2	Sign 3	Sign 4	Sign 5
						
Quiet roads	Strongly Disagree	78	79	79	34	67
	Disagree	56	67	61	39	58
	Neutral	36	35	47	55	56
	Agree	25	23	18	43	19
	Strongly Agree	17	8	7	41	12
Total		212	212	212	212	212
Night driving	Strongly Disagree	81	78	83	36	70
	Disagree	61	64	68	45	64
	Neutral	27	38	43	58	45
	Agree	25	21	10	39	18
	Strongly Agree	17	11	8	34	15
Total		212	212	212	212	212
Driving in heavy rain	Strongly Disagree	93	84	87	49	70
	Disagree	73	59	68	54	66
	Neutral	26	39	42	63	45
	Agree	13	23	11	25	19
	Strongly Agree	7	7	4	21	12
Total		212	212	212	212	212

Figure 3. PLS analysis theoretical framework.



3.2. Sign 2 (No parking)

The final path diagram of Sign 2 is shown in Figure 5 while the outer weights and path coefficients are shown in Table 8. From the outer weights in Table 8, In a Hurry (VIH), Imitate Mistakes (VIM) and Sleep Deprivation & Fatigue (VSF) were good indicators (T statistics > 1.96; p value < 0.05) for human-related factors (X3HUM) and also good direct indicators for sign violation (YVIO), while No Police Officers (VPO) was not a good indicator (T statistics 1.911 < 1.96; p value 0.057 > 0.05) for human-related factors (X3HUM) and also not a good direct indicator (T statistics 1.936 < 1.96; p value 0.054 > 0.05) for sign violation (YVIO). Quiet Roads (VQT), Night Driving (VND) and Driving in

Figure 4. Final path diagram of Sign 1 (No U-Turn).

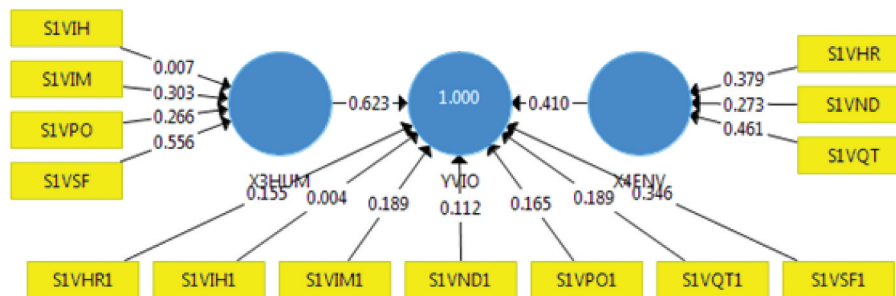


Table 7. Outer weights and path coefficients of Sign 1 (No U-Turn)

Outer weights and path coefficients	Influence	T-statistics	P-value
Outer weights	S1VHR → X4ENV	1.660	0.098
	S1VHR1 → YVIO	1.176	0.241
	S1VIH → X3HUM	2.323	0.021
	S1VIH1 → YVIO	1.270	0.206
	S1VIM → X3HUM	3.160	0.002
	S1VIM1 → YVIO	3.159	0.002
	S1VND → X4ENV	1.390	0.166
	S1VND1 → YVIO	1.389	0.166
	S1VPO → X3HUM	4.378	0.000
	S1VPO1 → YVIO	4.557	0.000
	S1VQT → X4ENV	0.076	0.939
	S1VQT1 → YVIO	0.075	0.940
	S1VSF → X3HUM	3.283	0.001
	S1VSF1 → YVIO	3.310	0.001
Path coefficients	X3HUM → YVIO	27.921	0.000
	X4ENV → YVIO	17.339	0.000

Heavy Rain (VHR) were good indicators (T statistics > 1.96; p value < 0.05) for environmental-related factors (X3HUM) and also good direct indicators for sign violation (YVIO). From the path coefficients in Table 8, both of human-related factors (X3HUM) and environmental-related factors (X4ENV) had positive influence and significant (p value < 0.05) to sign violation (YVIO).

Both of human-related factors (in a hurry, imitate mistakes, sleep deprivation and fatigue) and environmental-related factors (quiet roads, night driving, driving in heavy rain) had positive influence and significant to “No Parking” sign violation. It means that students will violate “No Parking” sign if they are in a hurry, if they know that other drivers did it, if they are tired and sleep deprived, if the road is quiet, if they drive their vehicles at night and also if they drive in a heavy rain. The absence of police officers did not influence the students to violate it. This sign is closely related to the availability of parking spaces that are not only on the roadside but also in certain places, e.g., mall, office, universities, etc., where the police officers are rarely seen.

3.3. Sign 3 (Stop sign)

The final path diagram of Sign 3 is shown in Figure 6 while the outer weights and path coefficients are shown in Table 9. From the outer weights in Table 9, No Police Officers (VPO), Imitate Mistakes (VIM) and Sleep Deprivation & Fatigue (VSF) were good indicators (T statistics > 1.96; p value <

0.05) for Human-related factors (X3HUM) but In a Hurry (VIH) was not a good indicator (T statistics $1.906 < 1.96$; p value $0.058 > 0.05$) for Human-related factors (X3HUM). All of No Police Officers (VPO), In a Hurry (VIH) and Sleep Deprivation & Fatigue (VSF) were not good direct indicators (T statistics < 1.96 ; p value > 0.05) for sign violation (YVIO). Quiet Roads (VQT), Night Driving (VND) and Driving in Heavy Rain (VHR) were good indicators (T statistics > 1.96 ; p value < 0.05) for environmental-related factors (X4ENV) and also good direct indicators for sign violation (YVIO). From the path coefficients in Table 9, environmental-related factors (X4ENV) had positive influence and significant to sign violation (YVIO) while human-related factors (X3HUM) did not have positive influence and significant (T statistics $0.284 < 1.96$; p value $0.777 > 0.05$) to sign violation (YVIO).

Compared to other factor, only environmental-related factors (quiet roads, night driving, driving in heavy rain) that had positive influence and significant to “Stop” sign violation. It means that

Figure 5. Final path diagram of Sign 2 (No parking).

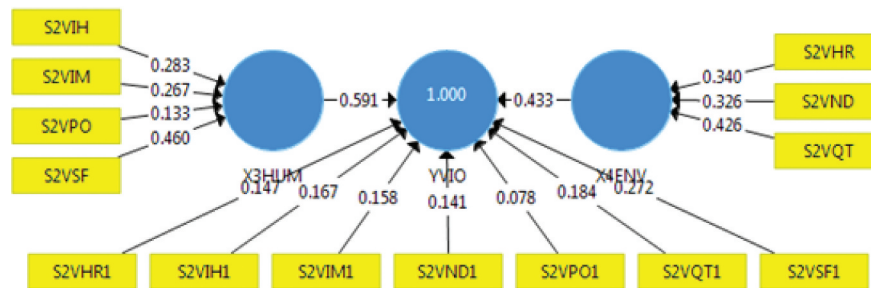


Table 8. Outer weights and path coefficients of Sign 2 (No parking)

Outer weights and path coefficients	Influence	T-statistics	P-value
Outer weights	S2VHR → X4ENV	4.755	0.000
	S2VHR1 → YVIO	4.834	0.000
	S2VIH → X3HUM	3.039	0.003
	S2VIH1 → YVIO	3.005	0.003
	S2VIM → X3HUM	4.149	0.000
	S2VIM1 → YVIO	4.113	0.000
	S2VND → X4ENV	4.210	0.000
	S2VND1 → YVIO	4.424	0.000
	S2VPO → X3HUM	1.911	0.057
	S2VPO1 → YVIO	1.936	0.054
	S2VQT → X4ENV	5.262	0.000
	S2VQT1 → YVIO	4.866	0.000
	S2VSF → X3HUM	6.115	0.000
	S2VSF1 → YVIO	5.358	0.000
Path coefficients	X3HUM → YVIO	35.800	0.000
	X4ENV → YVIO	24.480	0.000

students will violate this sign if the road is quiet, if they drive their vehicles at night and also if they drive in a heavy rain. This is related to the previous studies that short full text printed on the sign makes it easy for drivers to understand the meaning of the sign and improve its familiarity and comprehensibility (Akple et al., 2020; Ben-Bassat, 2019). Since it has very clear meaning, drivers might only look for environmental-related situations instead of human-related situations to violate this sign.

3.4. Sign 4 (Maximum speed limit)

The final path diagram of Sign 4 is shown in Figure 7 while the outer weights and path coefficients are shown in Table 10. From the outer weights in Table 10, No Police Officers (VPO) and In a Hurry (VIH) were good indicators (T statistics > 1.96; p value < 0.05) for human-related factors (X3HUM) and also good indicators for sign violation (YVIO), while Imitate Mistakes (VIM) and Sleep Deprivation & Fatigue (VSF) were not good indicators for human-related factors (X3HUM). Quiet Roads (VQT) and Night Driving (VND) were good indicators (T statistics > 1.96; p value < 0.05) for environmental-related factors (X4ENV) while Driving in Heavy Rain (VHR) was not a good indicator (T statistics 1.557 < 1.96; p value 0.121 > 0.05) for environmental-related factors (X4ENV). From the path coefficients in Table 10, human-related factors (X3HUM) had positive influence and significant

Figure 6. Final path diagram of Sign 3 (Stop sign).

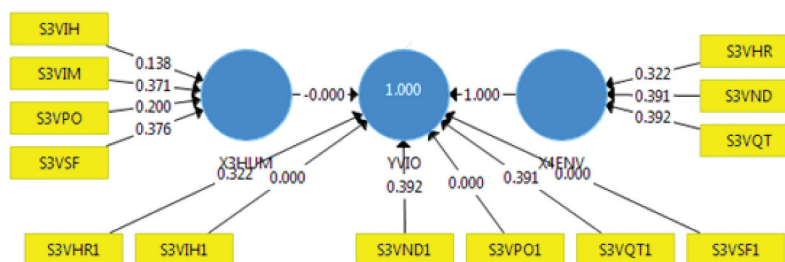


Table 9. Outer weights and path coefficients of Sign 3 (Stop sign)

Outer weights and path coefficients	Influence	T-statistics	P-value
Outer weights	S3VHR → X4ENV	3.443	0.001
	S3VHR1 → YVIO	3.433	0.001
	S3VIH → X3HUM	1.906	0.058
	S3VIH1 → YVIO	0.340	0.734
	S3VIM → X3HUM	4.559	0.000
	S3VND → X4ENV	4.461	0.000
	S3VND1 → YVIO	4.460	0.000
	S3VPO → X3HUM	2.403	0.017
	S3VPO1 → YVIO	0.320	0.749
	S3VQT → X4ENV	5.693	0.000
	S3VQT1 → YVIO	5.672	0.000
	S3VSF → X3HUM	4.822	0.000
	S3VSF1 → YVIO	0.274	0.785
	Path coefficients	X3HUM → YVIO	0.284
X4ENV → YVIO		29,060.450	0.000

(p value < 0.05) to sign violation (YVIO) while environmental-related factors (X4ENV) did not have positive influence and significant to sign violation (YVIO).

There are only human-related factors (no police officers, in a hurry) that had positive influence and significant to “Maximum Speed Limit” sign violation. This means that students will violate this sign if there are no police officers and if they want to get to the destination as soon as possible for several reasons. It is related to previous study by Lady et al. (2020) who stated that speeding behavior can make drivers ignoring traffic rules. Winarso (2016), Purnamasari and Anusanto (2017), Agustin (2019), and Purnamasari (2019) also concluded that weak supervision and lack of law enforcement became loopholes exploited by traffic rule violators.

3.5. Sign 5 (No stopping)

The final path diagram of Sign 5 is shown in Figure 8. After the outer loadings and VIF of Sign 5 were all valid, the model can be calculated using Bootstrapping mode to check the outer weights and path coefficients as shown in Table 11. From the outer weights in Table 11, In a Hurry (VIH), Imitate Mistakes (VIM) and Sleep Deprivation & Fatigue (VSF) were good indicators (T statistics > 1.96; p value < 0.05) for human-related factors (X3HUM) and also good indicators for sign violation (YVIO), while No Police Officers (VPO) were not a good indicator (T statistics 1.326 < 1.96; 0.186 > 0.05) for human-related factors (X3HUM) and also not a good indicator (T statistics 1.338 < 1.96; 0.182 > 0.05) for sign violation (YVIO). Quiet Roads (VQT), Night Driving (VND) and Driving in Heavy Rain (VHR) were good indicators (T statistics > 1.96; p value < 0.05) for environmental-related factors (X4ENV) and also good direct indicators for sign violation (YVIO). From the path coefficients in Table 11, both of human-related factors (X3HUM) and environmental-related factors (X4ENV) had positive influence and significant (p value < 0.05) to sign violation (YVIO).

Figure 7. Final path diagram of Sign 4 (Maximum Speed limit).

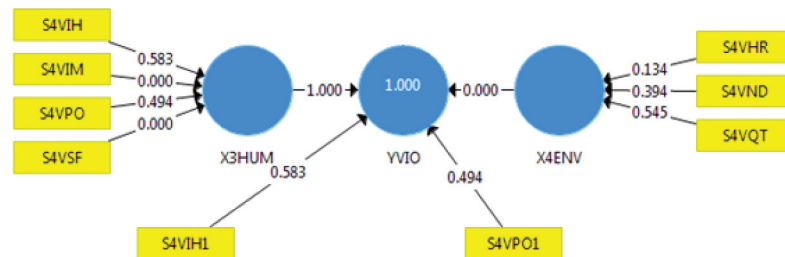


Table 10. Outer weights and path coefficients of Sign 4 (Maximum Speed Limit)

Outer weights and path coefficients	Influence	T-statistics	P-value
Outer weights	S4VHR → X4ENV	1.557	0.121
	S4VIH → X3HUM	17.456	0.000
	S4VIH1 → YVIO	17.451	0.000
	S4VIM → X3HUM	-	-
	S4VND → X4ENV	2.965	0.003
	S4VPO → X3HUM	17.673	0.000
	S4VPO1 → YVIO	17.665	0.000
	S4VQT → X4ENV	5.322	0.000
	S4VSF → X3HUM	-	-
Path coefficients	X3HUM → YVIO	30,060.120	0.000
	X4ENV → YVIO	0.001	0.999

Both of human-related factors (in a hurry, imitate mistakes, sleep deprivation and fatigue) and environmental-related factors (quiet roads, night driving, driving in heavy rain) had positive influence and significant to “No Stopping” sign violation. This means that students will violate this sign if they are in a hurry, if other drivers violate it, if they feel sleep deprived and tired, if the road is quiet, if they drive at night and also if they drive in a heavy rain. The fact that this sign has similar design with the Sign 2 (No Parking) which used single letter is quite interesting since both gave similar results, as it shown in Table 12. According to Purnamasari (2019), both also had high percentages of comprehensibility level above 90%. The absence of police officers is not a sufficient reason to violate this sign that might be because drivers felt that the enforcement of violation is lenient in Indonesia so community actually wants law enforcement against violations of traffic rules in a fair and transparent manner (Purnamasari & Anusanto, 2017). However, having the police officers on duty might discourage young drivers from violating this sign, even though other situations are very favorable for doing so.

4. Conclusion

This study showed that the human-related factors and environmental-related factors influenced well-educated young drivers’ intention to violate these five prohibitory traffic signs. Nevertheless, the influence indicators varied for each sign, as it shown in Table 12. For signs that contained a full

Figure 8. Final path diagram of Sign 5 (No stopping).

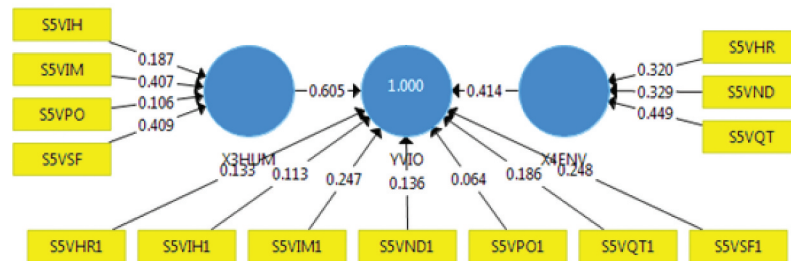







Table 11. Outer weights and path coefficients of Sign 5 (No stopping)

Outer weights and path coefficients	Influence	T-statistics	P-value
Outer weights	S5VHR → X4ENV	4.526	0.000
	S5VHR1 → YVIO	4.648	0.000
	S5VIH → X3HUM	2.147	0.033
	S5VIH1 → YVIO	2.104	0.037
	S5VIM → X3HUM	5.405	0.000
	S5VIM1 → YVIO	4.713	0.000
	S5VND → X4ENV	3.364	0.001
	S5VND1 → YVIO	3.491	0.001
	S5VPO → X3HUM	1.326	0.186
	S5VPO1 → YVIO	1.338	0.182
	S5VQT → X4ENV	6.064	0.000
	S5VQT1 → YVIO	5.122	0.000
	S5VSF → X3HUM	6.629	0.000
	S5VSF1 → YVIO	6.088	0.000
Path coefficients	X3HUM → YVIO	25.652	0.000
	X4ENV → YVIO	15.998	0.000

Table 12. Influence analysis of sign violation

Dimensions	Indicators	Sign 1	Sign 2	Sign 3	Sign 4	Sign 5
						
Human-related factors	No police officers	Π			Π	
	In a hurry		Π		Π	Π
	Imitate mistakes	Π	Π			Π
	Sleep deprivation & fatigue	Π	Π			Π
Environmental-related factors	Quiet roads	Π	Π	Π		Π
	Night driving	Π	Π	Π		Π
	Driving in heavy rain	Π	Π	Π		Π

symbol, for example, “No U-Turn”, and a single letter, for example, “No Parking” and “No Stopping”, both factors influenced driver’s intention to violate it. Meanwhile, for a sign that contained a full text, for example, “Stop Sign”, environmental-related factors are more influenced the driver’s intention to violate it. In the other hand, human-related factors are more influenced young drivers to violate a sign that contained numbers and letters, for example, “Maximum Speed Limit”.

This study was limited to five prohibitory traffic signs with seven situation scenarios only. It should be applied to other signs in further studies. The relationship between situation scenarios is also interesting to analyze. Each situation might influence each other. Since this study only focused on young drivers who study at the university, it is necessary to compare with respondents from different groups. In addition, the coverage of respondents can be expanded to obtain results that can reflect the actual conditions. However, this study has provided a useful initial insight to understand young driver’s behaviors to violate these prohibitory traffic signs. In the future, improvements can be made which are deemed necessary in order to reduce signs violation and traffic accidents.

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