Analyzing the Impact of Human Characteristics on the Comprehensibility of Road Traffic Signs

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Abstract

Traffic safety is one of major challenges facing most communities worldwide. To improve traffic safety, regulating traffic movement through markings, signs, channelization, and others is essential. Traffic signs are used either to regulate road user movements by highlighting priorities or to inform road users about traffic regulations and traffic conditions. In general, traffic signs are essential element in road operation. Thus, understanding these signs by road users is of prime importance for efficient and safe traffic operations. This study investigates the comprehensiveness of traffic signs by drivers and the impact of driver characteristics gender, nationality, age, language, and educational level. Clarifying the correlation between the understanding of traffic signs and driver characteristics will yield to recommendations and help in identifying proper countermeasures to enhance the communities' knowledge of traffic signs and consequently improve traffic safety level. The study used an electronic survey as a research instrument for data collection. The results have shown significant impact of some of human characteristics on their ability to recognize the metal-plate and electronic traffic signals.

Keywords: Traffic safety, traffic sign, driver gender, driver characteristics, survey

1.Introduction

Road safety is one of major challenges facing most of transportation and traffic departments worldwide. Driving has become an essential part of our daily life routine. People are often different in nature and have different personalities and skills, all which can influence the way that they drive and behave (Nazha et al., 2017 and Abdella et al., 2017). To improve traffic safety, regulating traffic movement through markings, signs, channelization, and others is essential. In general, road users are at high risk and vulnerable to many crashes. Drivers and pedestrians are all susceptible to fatal, sever, and slight injuries because of traffic crashes. Communities and organizations all around the world are investing to improve traffic safety by reducing number of crashes as well as their severities. Different techniques and tools are being implemented by traffic engineers. Traffic signs are one of the most important tools used to regulate traffic operations to provide smooth and safer operation. They are being used widely over the entire world to deliver vital information on right

of way, movement restrictions, and others. They are considered as one of the important road safety tools (Fleyeh & Dougherty, 2005). There are international traffic codes that provide a complete set of traffic signs to be used in different countries, which harmonize the design and appearance to help drivers to recognize the functions of these signs. The Convention on Road Signs signed by European countries in Vienna in 8 November (1968) can be considered as the first international step to introduced in detail, a global harmonization and standardization of the norms of road signage. However, still until now many countries are using different traffic signs for example by including letters or words from local language. Traffic signs are usually composed of symbols, texture, or combination of both. Symbolic traffic signs convey messages through symbols and drawings that represent the situation. On the other, textual-traffic signs use words and sentences in a certain language to convey the message. Road operators expect drivers to understand these signs since they are being taught at driving schools and understanding them are a main requirement to obtain the driving license. However, drivers do not always encounter all traffic signs on the road and thus they may forget and even misunderstand the meaning of some signs. This is more evident in countries where traffic laws are not being enforced strictly or traffic sign guidelines are not being implemented properly.

Thus, it is important to investigate the intelligibility of these signs by the road users. This issue has been studied by several researchers. Shinar, Dewar, Summala, & Zakowska (2003) explored the comprehensibility of several traffic signs used in different countries. One thousand participants from four countries participated in the study distributed as 250 from each of the following: Canada, Finland, Israel, and Poland. They concluded that young drivers have higher understanding of traffic signs than older drivers do. On the other hand, Erke, Sagberg, & Hagman (2007) studied the effect of two variable message signs on site routes of Norway. The study used observation method to investigate the drivers' comprehensibility of the two variable message signs. The number of observed drivers was 41 divided into 19 male and 22 female undergraduate students. The study concluded that 20% of the drivers correctly understood the signs and responded very well to them.

Ng & Chan (2008) have investigated the relationship between certain driver characteristics and the intelligibility of traffic signs in Hong Kong. A survey was prepared and consisted of two parts: the first part focused on demographics; while the second part asked to rate the familiarity of different traffic signs on a scale of 0-100. The survey was completed by 109 drivers. The study concluded that age does not have impact on the comprehensibility of traffic signs while education does. On the other hand, it showed that new drivers are more familiar with signs compared to old drivers. Likewise, Chan & Ng (2010) conducted another study by focusing on the comprehensibility of industrial traffic signs in China. They used a questionnaire that is composed from multiple-choice questions of demographics and traffic signs. The survey was completed by 60 drivers. The questionnaire results showed that the comprehensibility of all signs had a mean above 66.12 percent, which means 39 driver out of 60 on average understand the studied traffic signs.

Moreover, Kirmizioglu & Tuydes-Yaman (2012) investigated the comprehensibility of traffic sign by drivers in urban areas in Turkey. The study used a questionnaire that consisted of two parts: the first part asked questions related to demographics such as gender, age, educational level, and driving experience while the second part asked questions to evaluate a selected set of 39 traffic signs. Moreover, there were two versions of the questionnaire; each version used the same demographical questions with few different traffic signs. The comprehensibility was evaluated based on the percentage of correct answers obtained. The survey was completed by

1478 drivers from the public. It was concluded that less than 70% of the participants could answer all signs correctly. In which, on average 12 out of 39 signs were only answered correctly by one participant.

In another interesting study, Shinar & Vogelzang (2013) examined the comprehensibility of symbolic traffic signs and textual traffic signs using a questionnaire that was filled by a group of people of 48 undergraduate students. They were asked to rate 30 traffic signs: 10 symbolic traffic signs, 10 textual traffic signs and 10 signs that combine symbols and text. The rating scale used is from 0 to 10. The study concluded that adding text to unfamiliar traffic signs increase their comprehensibility by road users. In other words, some symbolic traffic signs might not be understood by drivers unless they are comprehended with textual words describing the situation.
Ben-Bassat & Shinar (2015) investigated the comprehensibility of traffic signs based on human characteristics and the context of the traffic signs. The study selected two samples of drivers: 50 young drivers and 50 old drivers. The study used a questionnaire that was prepared electronically. The first part of the questionnaire contains questions related to demographics such as gender, age and driving experience while the second part contain questions about the understanding of 28 traffic signs in which the participant had to state the meaning of each sign verbally. The study drew the following main conclusions: signs with white background are understood better, and young drivers understood signs quicker than older drivers did.

This paper aims at investigating the relationship between the comprehensibility of traffic signs by road users in the State of Qatar and the demographic characteristics of drivers including gender, nationality, age, language capability, and educational level.

2.Methodology

This study uses a questionnaire survey that was developed electronically. It consists of three sections. The first section contains multiple choice questions related to driver characteristics such as gender, age, nationality, language, educational level, and driving experience. The participants were asked to select only one of the answers.

The second section contains questions about the drivers' crash history in the last three years. The purpose was to investigate the correlation between crash history including number of crashes and their severity and the understanding of traffic signs. The third section contains seven multiple-choice questions of seven different traffic signs. Five of these signs were static traffic signs while the other two were variable message signs that use text to deliver messages to drivers as shown in Figure 1. The selected signs are among the most commonly used traffic signs in Qatar. Thus, we selected these signs to investigate the understanding of drivers to these signs, which are encountered daily while driving. It is important to mention that English and Arabic languages are used in some static traffic or variable message signs.

The survey was developed electronically using Survey Monkey and distributed to the community of Qatar University, the largest and the main university inside Qatar that has more than 20,000 students and more than 1000 faculty. According to the national statistics, young drivers are the most committed to traffic violation and the most involved in crashes in the State of Qatar (Traffic Department – Ministry of Interior, 2013). This explains why Qatar University is targeted in this survey since it is the largest community of young drivers in the country. The questionnaire was sent by official email to the community of the university after receiving the ethical approval form the university review board.

Figure 1: Examples of static and variable message sign

3.Results and Discussion

3.1 Descriptive Statistics

After one month from sending the request of participation, 402 responses were received. The summary of the demographics characteristics of the drivers who responded to the survey is shown in Table 1. More than 68% of the respondents were between 18 and 30 years old while 51.9% were female. Majority of the respondents are Arabs in which 25% were Qatari or from other GCC countries. 71.4% of the respondents had a driving experience less than 5 years, which is reasonable considering the young community in the university.

The traffic crash history of the respondents in the last three years is summarized in Table 2 in terms of gender and age group. The average number of crashes per respondent in the last 3 years is 2, which is a high value. It is interesting to see that the standard deviation of crash history for those aged between 18 and 22 is significantly higher (95% confidence level) than all other age groups. Moreover, female drivers reported significantly lower crash number than male respondents. This is also reflected in the standard deviation of reported crash numbers where female drivers had lower standard deviation.

Furthermore, the survey also collected data about the severity of the crash in terms of injuries and the severity of the car damage. The severity of the injury was divided into three categories: no injury, slight injury, and severe injury (No severe injury is reported). Meanwhile, the severity of the car damage was divided into three categories: low, moderate and high.

The statistics of the responses are summarized in Table 3. Around 94% of the reported crashes did not yield to injuries while 72.7% of the reported crashes resulted in low car damage. This paper concentrates on the outcomes of the last section of the survey, which is related to the understanding of traffic signs, and the correlation with the demographic characteristics of drivers

Table 1: Descriptive statistics

Variable	% of participants
Gender	
Male	48.1
Female	51.9
Age	
18-22	43.9
23-30	24.9
31-45	20.9
46-65	9.9
Other	0.4
Nationality	
Qatari & GCC	25.3
Arab	47.3
European/American	9.7
Asian	12.9
Other	4.8
Language	
English	18.7
Arabic	14.1
English & Arabic	67.2
Educational Level	
Undergraduate School	63.4
Graduate School	36.5
Driving Experience	
Less than 2 years	38.0
Between 2-5 years	33.4
More than 6 years	28.6

Table 2: Summary of participants involved in crash in the last three years

	Variable	≥1 crash	Mean crashes	Std. dev.
Gender	Male	37.1%	2.39	3.15
	Female	31.5%	1.81	0.99
Age (years)	18 - 22	31.4%	2.25	3.22
	23 - 30	49.2%	2.00	1.41
	31 - 45	28.8%	2.03	1.99
	46 - 65	21.2%	2.09	1.51

Table 3: Summary of participants' injury and car damage

Description	Variable	Percentage
Human Injury	No injury	94.0%
	Slight injury	6.0%
Car Damage	Low	72.7%
	Moderate	20.4%
	High	6.9%

3.2 Correlation between Responses of Traffic Signs Questions and Driver Characteristics

Respondents were asked about the meaning of seven traffic signs (Figure 1) and asked to select one answer among four choices. Two non-parametric tests called "Wilcoxon test" and "Kruskal-Wallis test" (Hoffman, J., 2015) were used to investigate the correlation between the correct answers of traffic sign question and driver characteristics including gender, nationality, age, language and educational level. The Wilcoxon test is used when the independent variable has two categories that is gender only. Meanwhile, the Kruskal-Wallis test is used when the independent variable has more than two categories. A significance level of 5% is used, thus any p-value lower than 5% shows significant correlation between the comprehensibility of the traffic sign and the selected variable. Before proceeding with the analysis, the responses on the traffic sign questions were converted to binary variable where "1" is assigned for correct responses and "0" for incorrect ones. XLSTAT software was used to perform the analysis.

Figure 2 shows the percentages of correct answers per traffic sign for all participants while Table 4 summarizes the responses for male and female participants separately. Figure 2 shows that Sign 7 had the highest percentage of correct answers. Meanwhile sign 5 and sign 6 had the lowest percentage of correct answers where 30.4% and 35.4% of the participants responded with incorrect choices respectively. These high percentages raise an alarming issue that need to be further investigated. In average, around 20% of the participants fail to answer correctly on at least one of the traffic sign questions. It is important to mention that in Qatar when renewing driving license, drivers are not requested to take any follow-up or refresh courses or lectures. Thus, their knowledge of traffic signs may deteriorate with time (Ng & Chan, 2008). Considering that respondents are mostly fresh drivers (71%) with less than 5 years driving experience, then it is expected that drivers with lower educational levels (outside the university) and/or longer driving experience will have lower comprehensibility of traffic signs than the those involved in our survey.

Table 4: Mean, Standard Deviation and P-value of the correct choice selection of male and female for each traffic sign and the results of the Wilcoxon test

	Male		Female		P-value
Traffic Sign	**Mean**	**Std.**	**Mean**	**Std.**	
Sign 1	0.874	0.333	0.832	0.375	0.270
Sign 2	0.853	0.355	0.811	0.393	0.278
Sign 3	0.921	0.270	0.821	0.384	**0.006**
Sign 4	0.868	0.339	0.800	0.401	0.070
Sign 5	0.789	0.409	0.600	0.491	**< 0.0001**
Sign 6	0.716	0.452	0.600	0.491	**0.018**
Sign 7	0.953	0.213	0.932	0.253	0.404

Table 4 shows that the percentages of correct choices for female drivers are significantly lower (95% confidence level) than those of male drivers for all traffic signs. This looks contradicting with the average reported number of crashes in the last years in which female drivers have significantly lower number of crashes compared to make drivers. Our hypothesis is that poor understanding of traffic signs yields to higher probability of crashes and lower safety level. This somehow contradicts with the reported data of female drivers, which can be attributed to the fact that females drive significantly fewer miles than men do as reported by the 2005 US federal

household transportation survey and Butler (2006). This is commonly observed in GCC counties where most families have chauffeurs (male) to perform daily driving needs. Driving less leads to less exposure to crashes, which can be the reason why female drivers reported significantly lower number of crashes.

Furthermore, Table 4 shows the results of the Wilcoxon test (p-values) to check the correlation between gender and the correct responses on traffic sign questions. Male drivers showed significantly higher correct responses compared to female drivers for three signs only (Sign 3, 5 and 6). In general, the correct responses on signs 5 and 6 were the lowest among all signs for both male and female respondents.

On the other hand, the Kruskal-Wallis test was used to investigate the relationships between the comprehensibility of the traffic signs and nationality, age, language capability and the educational level. The results of the correlation between the traffic signs and nationality are shown in table 5. The different nationalities only affected the comprehensibility of two traffic signs, which are sign 5 and sign 6. European, American, and Asian understood sign 5 better than GCC and other Arabs. This is maybe due to that culture awareness of traffic signs is higher in non-Arab countries. Meanwhile, sign 6 was understood better by GCC and other Arabs than European, American, and Asian. This is mainly due that sign 6 is written in Arabic which is non-readable for these nationalities. Moreover, the results of the correlation between the traffic signs and age are represented in Table 6. It is clear that sign 4 has different comprehensibility by different age groups. It is shown that participants between 31-45 years old understand this sign better. This is can be due that the maturity of people at this age increase than the younger age groups. While, for the elder age group it can be due those getting old impacts the human memory thus affecting the understanding of the signs.

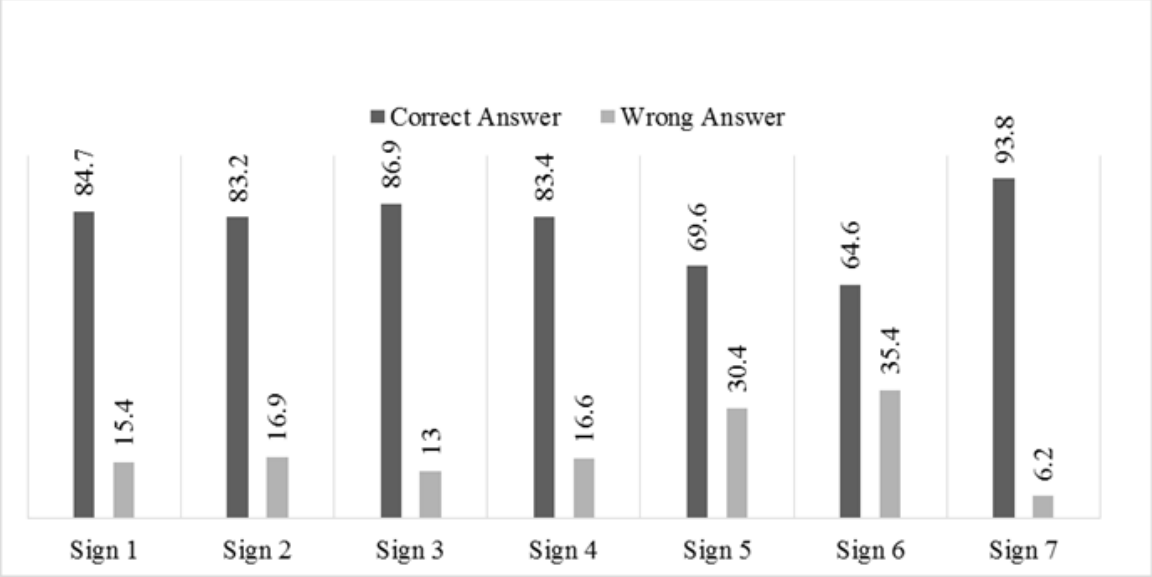

Figure 2: Traffic Signs Scores

Furthermore, the results of the correlation between the traffic signs and language capability are summarized in table 5. Meanwhile, the results of the correlation between the traffic signs and educational level are summarized in Table 6. It can be concluded that the impact of language capability was only statistically significant for signs 5 and 6 (Table 5). As expected, since Sign 6

is completely in Arabic, drivers who understand English language only performed poorly with 49% correct response rate.

Regarding the impact of educational level of participants, the data did not show any significant impact. This is expected since all the participants are from Qatar University; therefore, we do not have variations in the educational level. All participants either are enrolled in or have Bachelor or Graduate degree. To be able to investigate the impact of educational level, data need to be collected outside the university.

Table 5: Mean, Standard Deviation, and P-value of Nationality responses in terms of each traffic sign

	Qatari & GCC		**Arab**		**European/American**		**Asian**		**P-value**
Traffic Sign	**Mean**	**Std.**	**Mean**	**Std.**	**Mean**	**Std.**	**Mean**	**Std.**	
Sign 1	0.856	0.352	0.795	0.406	0.889	0.319	0.836	0.373	0.502
Sign 2	0.847	0.361	0.818	0.388	0.806	0.401	0.800	0.404	0.807
Sign 3	0.876	0.330	0.818	0.388	0.889	0.319	0.909	0.290	0.395
Sign 4	0.817	0.388	0.852	0.357	0.972	0.167	0.764	0.429	0.058
Sign 5	0.703	0.458	0.500	0.503	0.861	0.351	0.818	0.389	**< 0.0001**
Sign 6	0.723	0.449	0.602	0.492	0.528	0.506	0.509	0.505	**0.006**
Sign 7	0.946	0.227	0.920	0.272	1.000	0.000	0.891	0.315	0.169

Table 6: Mean, Standard Deviation, and P-value of Age responses in terms of each traffic sign

	18-22		**23-30**		**31-45**		**46-65**		**P-value**
Traffic Sign	**Mean**	**Std.**	**Mean**	**Std.**	**Mean**	**Std.**	**Mean**	**Std.**	
Sign 1	0.885	0.320	0.833	0.374	0.797	0.404	0.854	0.358	0.304
Sign 2	0.868	0.340	0.824	0.383	0.810	0.395	0.756	0.435	0.306
Sign 3	0.868	0.340	0.870	0.337	0.886	0.320	0.854	0.358	0.963
Sign 4	0.868	0.340	0.722	0.450	0.911	0.286	0.854	0.358	**0.002**
Sign 5	0.690	0.464	0.648	0.480	0.696	0.463	0.878	0.331	0.054
Sign 6	0.684	0.466	0.593	0.494	0.633	0.485	0.683	0.471	0.435
Sign 7	0.908	0.290	0.972	0.165	0.962	0.192	0.927	0.264	0.127

4.Conclusion

This study mainly investigated the comprehensibility of a selected sample of traffic signs by drivers in the State of Qatar. The study shows that the average comprehensibility of all traffic signs is 80.9%. Moreover, the correlation between different human characteristics and the comprehensibility of traffic signs was studied. In this study, we could not identify different performance between static and variable message signs. In average 20% of the drivers fail to respond correctly to at least one of signs. This ratio is quite high and alarming especially with such simple, basic, and common traffic signs. Furthermore, it is important to remember that more than 70% of the drivers are fresh drivers with less than 5 years driving experience with good

educational level and thus it was expected to have higher comprehensibility of traffic signs compared to drivers with lower educational levels and longer driving experience.

The comparison between male and female drivers showed that male drivers have higher comprehensibility in most traffic signs than female drivers. However, on the other hand, the data also shows that female drivers reported lower average crash record in the past three years compared to male drivers. This is reasonable if we know that only 12.7% of all active driving license holder in Qatar are female (Traffic Department, Ministry of Interior, 2016). This also is combined with the fact that female drive significantly less than male drivers (lower mileage) which means that their risk exposure is lower. On the other hand, the study shows that language capability of drivers significantly affect the comprehensibility of variable message signs with language text.

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