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A Field Study of the Impact of Human Characteristics on the Use of Signs

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ABSTRACT

Traffic signs are one of the essentials of roads around the world. While drivers are using them appropriately and take carefully concentrate on them, it's reduces significant road accidents, which it's would depend on human characters. Therefore, in this research, a statistical population of 768 drivers in various categories had been investigated. All kinds of traffic signs such as informative, disciplinary, & route guidance signs were discussed in their corresponding categories. Questions about understanding, recognition and familiarity with signs were asked from 768 participants. The current problems with traffic signs were identified according to answered questions. This procedure was helpful for understanding and getting more familiar with different groups of traffic signs, so the most understandable type of traffic signs was identified. We evaluated drivers' ability to recognize traffic signs by means of a special questionnaire, so different types of traffic signs were investigated according to their understandability. In order to perform our analysis, various groups of drivers were classified based on their age, education level, driving experience, gender. The collected answers were analyzed by statistical methods in SPSS software. According to the acquired results, it was proved that there is a direct relationship between education level and the ability to recognize traffic signs. On the other hand, there is an inverse relationship between driving experience and recognition of various traffic signs. The estimated Pearson correlation coefficient for respondents' right-wrong answers with respect to education level is 0.56. It means that the higher the education level, the higher the percentage of right answers.

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1. Introduction

The transportation system is one of the most complex systems in the global scale which depends on four critical factors such as human, road, vehicles & environment. Any interference in those factors lead to traffic accident and waste of time. Therefore, traffic signs are considered as one of the most important tools for traffic control which have a significant role for controlling traffic flow via transferring message to the drivers. Every traffic sign has its own message and the messages transferred to drivers are classified into three main groups: 1- disciplinary signs, 2- warning signs (alarms), 3- notification (informative) signs. The notification signs have a significant role in guidance of vehicles and generation of a safe environment in various pathways. Traffic signs and specially guidance signs are always considered as an important tool for information exchange with the drivers, they require a good level of visibility and readability in order to be more effective [1,2] One important feature of traffic signs is their “readability” which makes it possible to distinguish between characters, words, numbers, graphics. Readability is directly related to driver’s visual accuracy [3,4]. Since graphics (figures) are a better way to transfer messages in comparison to characters, therefore the authorities try to use graphics in traffic signs as much as possible, while in case where use of characters is inevitable, it is necessary to use the lowest numbers of characters [5,6]. Another aspect which has an influence on better readability, faster and easier transfer on messages to the drivers is “color & dimensions of signs”. Using larger signs in any color scale leads to higher readability. The installing location of traffic also has its own important role on its visibility. In other words, visibility is the level of detectability of a sign from peripheral environment, which can be discovered by human eye. Therefore, both physical and observer’s conditions are considered in the definition of visibility [7]. Undetectable signs increase drivers’ response time, and endanger their safety. On the other hand, different drivers have their own interpretation of these signs, they think they are making the right reaction, while actually they are deceived. It is shown that in rare cases, drivers are certain about signs meanings, while they are diverted from the real meaning [8]. The transportation system is consisted of four factors (human, road, vehicle, environment) which is quite a complex system. The conflict and contrast between these factors lead to accidents and delay in vehicles transportation. Therefore, traffic signs play an important role for controlling traffic flow by sending messages to the drivers [9].

Signs have a very important role for transfer of operational information to road users. If traffic signs are used correctly and in the right locations, the transfer of message to drivers is done in a better and more understandable way and their effectiveness get increases [11,12].

Making mistakes in detection of traffic signs might have undesirable outcomes and consequences. For example, misunderstanding in detection of warning signs might lead to not receiving the right warning message. Investigations proved that drivers usually study traffic signs during initial process of receiving driving license, so by passing of time, much of the corresponding meanings are removed from their memories. Such phenomenon is especially true for low usage (less important) signs.

Shinar et al performed a study in 2013, in order to explore the understanding basis of traffic signs. Investigations showed that drivers with 1-year history of license acquisition, tourists who receives their license from foreign countries, drivers older than 65 years old, unlawful drivers, offenders, and students with at least two years of driving license experience has the highest to lowest understanding in the same order [13,14]. The shape of the traffic signs is also very important. In study, researchers looked at factors affecting users' performance in guessing German traffic signs. this study involved 201 chines student who have driving license, guessed the meaning of the 45 signs and voted for the features of these signs. Results and analyses showed that education and using same singes can have significant help in guessing this signs. Therefore, the researchers suggested that similarity of signs throughout the world to prevent accidents due to being unreadable. Ou & Liu (2012)[15] In another study, a group of adults with a reading disorder and a group of normal individuals were selected to conduct a driving simulation experiment. Participants were asked study the word presented in each of the traffic signs observed along a route and use them as much as possible to maintain driving performance. Word frequency and word length were studied. The results showed that subjects with reading disorder showed lower performance in reading symptoms also The word frequency and word length were also more effective for them and there has been a noticeable difference in vehicle speed while trying to read the traffic signs but while driving in similar cases without traffic signs, this does not happen.

Therefore, the results obtained indicate that the specific needs of people with reading disabilities on the road should be considered in programs designed to increase traffic safety and fluency.

investigated the impacts of “driver” and its designated characteristics on reliability of traffic signs. They used a survey for collection of personal information and rating of understandability features. The results were applied to 109 driving license in the issuing procedure. In such circumstance, an accurate prediction was provided in the license issuance and checking the education level phases., factors such as age group, history of driving (number of years), driving hours, driving at the end of night, experience of driving in non-local environments had no meaningful impact on understandability of signs. Familiarity with signs has direct impact on level of understanding in drivers. Meanwhile uniqueness, simplicity and meaningfulness of signs have no direct relationship with their understanding. The results of this research provide some useful guidelines for design of traffic signs in the future. In this research, some specific driver groups were identified which didn't have a correct understanding about traffic signs, this information are targeted toward organizations in their future efforts for improving the transportation training resources, and performing further analysis [15]. Several Chinese researchers examine and evaluate the effectiveness of traffic signs using simulation experiments developed and demonstrated using a traffic sign assessment method using examples of traffic signs designs in the suburbs of Beijing. Questionnaires show that drivers are more likely to feel that the current traffic signs on the outskirts of Beijing are not sufficient and need to be corrected.

Simulation experiments were then performed and based on these experiments, an ergonomic evaluation model was obtained. Finally, the results of the experimental experiments and the

results of the analysis showed that TGSEM is suitable. This suggests that the proposed approach provides a general framework that can evaluate the performance of traffic signals and their effectiveness at intersections, including laboratory design, data analysis, implementation of simulation models and data. Each of previous studies proved that the understandability of traffic signs in different countries and for different signs is unequal. The results of visionary understanding studies reflect a serious problem, but the roots (causes) of problem or its solution are not provided. The results of this study show that a better understanding of signs doesn't improve the identification of causes or solution, but increase the processing time. From this perspective, many researches focused on "readability of signs", but unfortunately in terms of conclusions, there is no reliable evaluation about readability of guidance signs for different groups of drivers. The lack of such a valid evaluation is even more pronounced for Iran's traffic signs which are not built according to standards. One of Chinese researchers discussed the "fundamental factors" influencing the psychological understanding. Some of these notable factors are: physical properties of signs, viewing angle, quality and conditions of signs information content, mental and psychological characteristics of driver, physiological and physical properties of driver. According to the findings of this study, it can be argued that 25 % of accidents are caused because of imbalance between human & road environment. In addition, it was concluded that 90 % of driving information are acquired through visual understanding [10]. Therefore, 770 questionnaires were used to determine the effective factors in traffic accidents at intersections. The results showed that factors such as age, education, sex, driving experience and income play an important role in paying no attention to symptoms at intersections and happening accidents.

In the study of Hashem-almadani, it was proved that young drivers (under 24) had lower understanding about traffic signs in comparison to elderly drivers. In fact, the understanding of middle age people about traffic signs is better than elderly people. It was proved that the driving experience (years of driving experience) doesn't have an impact on improving the understanding of traffic sign [8]. Another important problem which leads to inefficient design of traffic guidance signs, is the "font limitation" of designated speed. In fact, a route with very efficient pavement indicators, which are designed according to corresponding standards might have the designated speed (speed limit) = 120 km/h, but because of installation of informative signs with inappropriate size, which reduce their readability in an appropriate duration, they are forced to reduce their speed when nearing the sign. In such cases the designated speed, capacity and density of the same path should be reduced. There is no doubt that the pavement costs for ensuring the designated speed is much higher than costs of design & installation of informative guidance signs along the routes [16,17]. Unfortunately, some traffic signs are located in inappropriate places and the behavioral characteristics of drivers while passing in front of them weren't considered in their positioning. Even drivers with highest eyesight can't see the complete content of traffic signs in a limited duration. In the study performed on 202 of drivers of Dhaka (Bangladesh's capital), which was done based on statistical method and questionnaire distribution, it was proved that drivers had low understanding toward signs meaning. The overall understanding level was reported to be around 50 %. Only four signs (two disciplinary & two warning signs) achieved a understanding score of more than 80 %. The percentage of drivers who correctly identified disciplinary, warning and informative signs was 49, 52 & 55 %

respectively. In this research, only “age” & “knowledge competencies” had the highest impact on positive (yes) answers. The results of this study show a clear need for training the drivers, so they achieve a better understanding and response to traffic signs [18]. Meanwhile in the study of Al-madani et al in Arabian countries of Persian Gulf, the recognition of various traffic signs was estimated to be between 50-62 %. They showed that young drivers, with lower experience, income & academic degrees have lower attention toward traffic signs in comparison to middle-aged drivers, with more driving experience, income & higher educations. The single and married drivers had an equal understanding about traffic signs [8]. In the study of Bayam et al, which analyzed understandability of traffic signs by questionnaires completed by the drivers after accident, it was proved that 25 % of elderly & experienced drivers had problem reading the signs. Other problems such as “location of sign”, “size, clarity of characters” & “message of sign” were also mentioned [19]. A review of works performed by previous researchers shows that most of them tried to explore signs do the drivers know better. Also, they achieved that human-related parameters such as experience can have an impact on sufficient identification and familiarity with traffic signs.

However, in this study, Tehran road drivers based on age, education, gender, experience. SPSS software was used to evaluate the drivers.

2. Methodology

Previous methodologies can be divided to two groups: 1- Descriptive (non-experimental) research, 2- Experimental research. Descriptive research consists of every method which tries to describe the conditions or phenomena under investigation. Descriptive studies might simply being performed for having a better understanding of current conditions or facilitating the decision making process. Most of available studies can be classified as descriptive research, which itself divides into various types [20]. For the current study, a descriptive –survey method is selected which is in accordance to the nature of subject.

2.1. Survey research

Survey research is one special type of data collection and analysis method in which a specific group of participants answer to a set of identical questions. These participant are actually the “statistical sample” of study and their answers are considered as “research data” [21]. Therefore, it is clear that the survey method is a quantitative method, not a qualitative one. According to some sociologists, “survey” is the best methodologies in the field of sociology. The current research also uses survey methodology.

3. Determination of sample size

The statistical population consists of all male & female drivers. The number of female and male drivers are 2130418 & 3010589 persons respectively (these data are collected from Iran’s traffic police organization). The Cochran’s formula is used for determining sample’s size, if it is impossible to neglect the constrained population situation, Cochran’s formula would be written

according to equation 1 [17]. The size of statistical sample at the error level of 5 % is 384 (male & female):

$$n = \frac{N * Z_{\frac{\alpha}{2}}^2 P(1 - P)}{d^2 (N - 1) + z_{\frac{\alpha}{2}}^2 P(1 - P)}$$

Where

n: size of sample

N: size of population

Z: normalized value of standard variable, equal to 1.96 at 95 % significance level

P: the proportion of considered quality in population. If it is unavailable, it can be considered as 0.5. for this value, the corresponding variance would be maximum

q: percentage of subjects in population without the quality (q=1-p)

d: the amount of allowable error (threshold) equal to 0.05

4. Sampling

The identity of research participants is defined based on three criteria: age, education , gender & driving experience. In total, 768 people answered the questionnaire, 11 % with high school degree, 9 % diploma, 38 % Bachelor degree (BS), 27 % MS, 15 % Phd, it the means the male and female participants contributions have an equal proportion that it could that an appropriate result following up. In addition, in this study 50 % of participant are male, while the other half are female.

According to figure 1, more than 27 % of participant have a driving experience of 0-5 years, 24 % have a driving experience of 5-10 years.

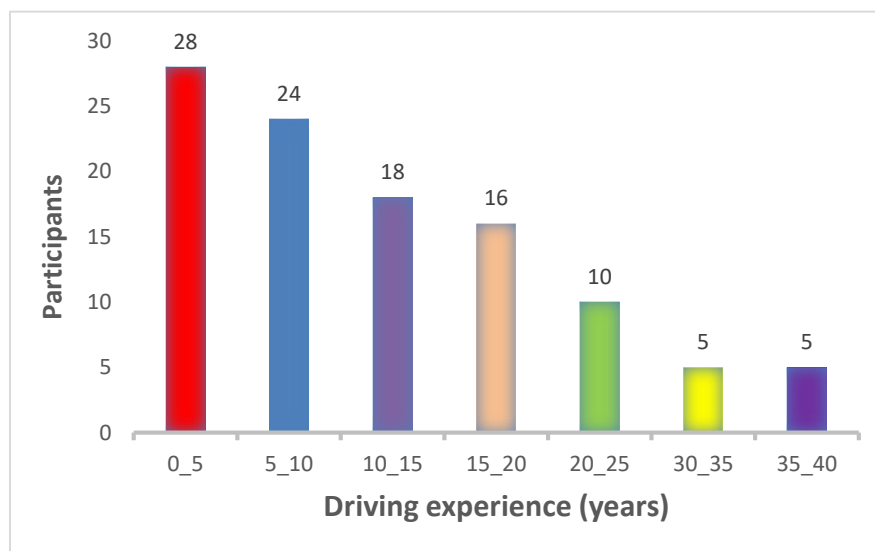


Fig. 1. Driving experience of research participants.

The normal distribution of questionnaire is shown in figure 2. The reason for using normal distribution can be explained like this: if 9 participants select option 1, and 1 person selects

option 4, and the same trend is like this, according to normal test it can be argued that one person don't pay enough attention to the questions and answered them randomly, so these answers won't be used for further analysis and the validity of final conclusions wouldn't be violated.

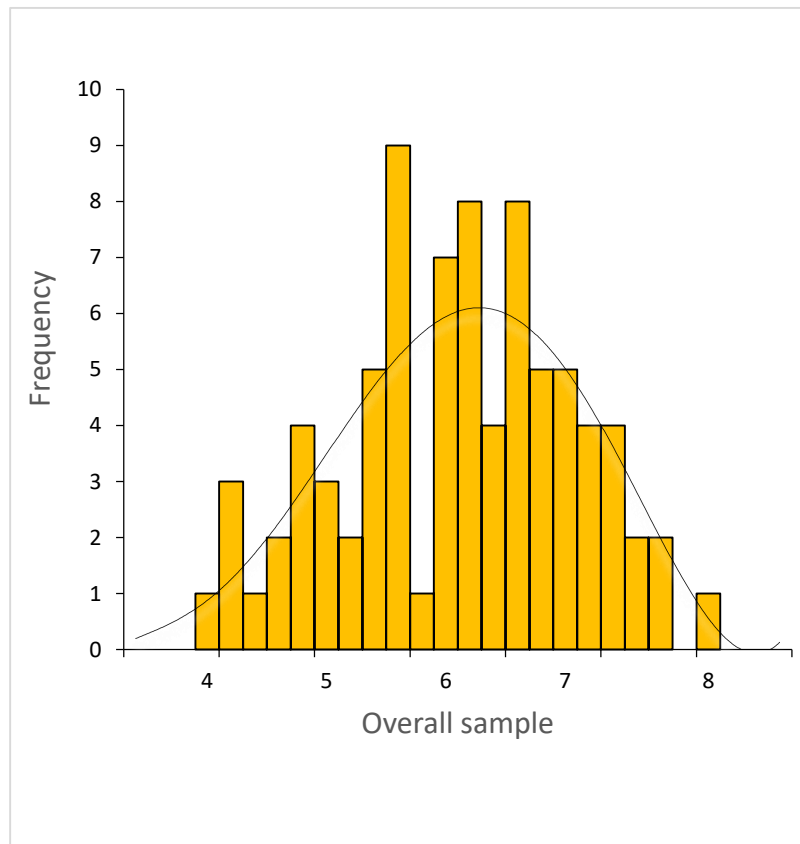


Fig. 2. Normal distribution of questionnaire.

5. Introducing questionnaire

In this research, by using MATLAB software 34 numbers were identified for 556 traffic signs and one number was devoted to each sign. 34 questions were extracted for the questionnaire based on Iran's national guidelines and MUTCD, and four answers were defined for each question. The questions are categorized as disciplinary, warning & informative traffic signs. 7 signs were chosen for disciplinary & warning categories, while 9 signs were selected for informative category. 4 signs were chosen from outside the guidelines.

6. Results

In figure 3, the results of right/wrong answers to each question are shown in percentage. According to the results, the lowest wrong answers were seen for "double entrance stop" and "entrance stop" with 18 %. The lowest right answers with respect to MUTCD guidelines were 75 % for "children playing", "highway crossings", "railway" which is represented by a "stop" sign.

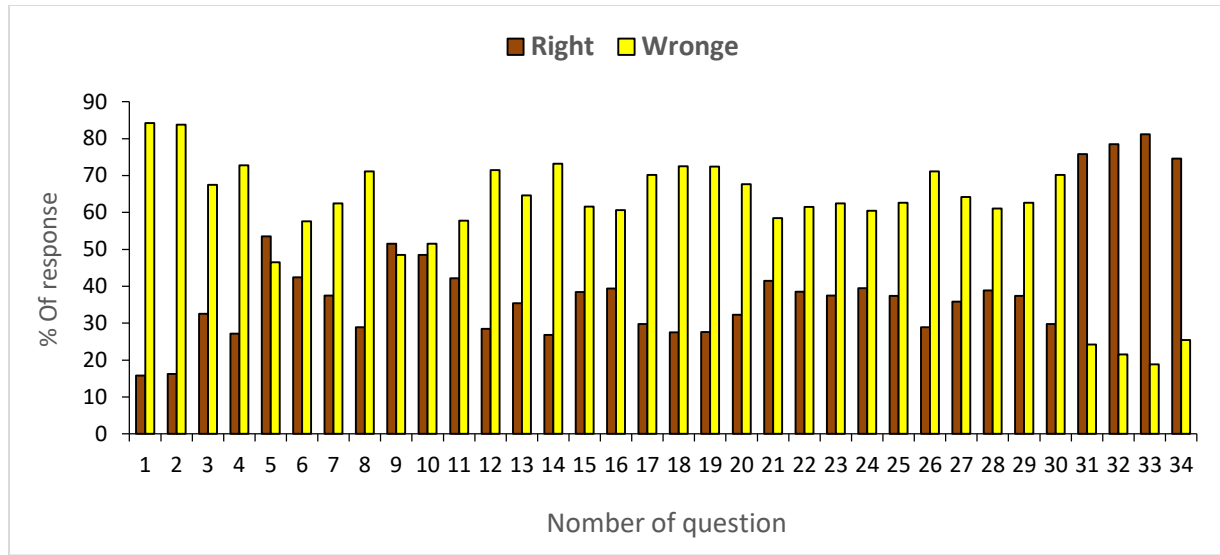


Fig. 3. Frequency of right answers by participants, for each question.

The estimated Pearson correlation coefficient for right/wrong answers is -1. The statistical characteristics for answering the questions (wrong/right answers) are shown in table 1.

Table 1

The statistical characteristics of answers to questions (wrong/right).

Statistical characteristics	Minimum	Standard deviation	Mean	Maximum
Right	18.8	16.17	60.08	84.2
Wrong	81.2	39.91	16.17	15.8

Figure 6 shows the distribution of right/wrong answers according to education level. The estimated Pearson correlation coefficient according to education level is 0.935. In fact by higher education, the percentage of right answers increase.

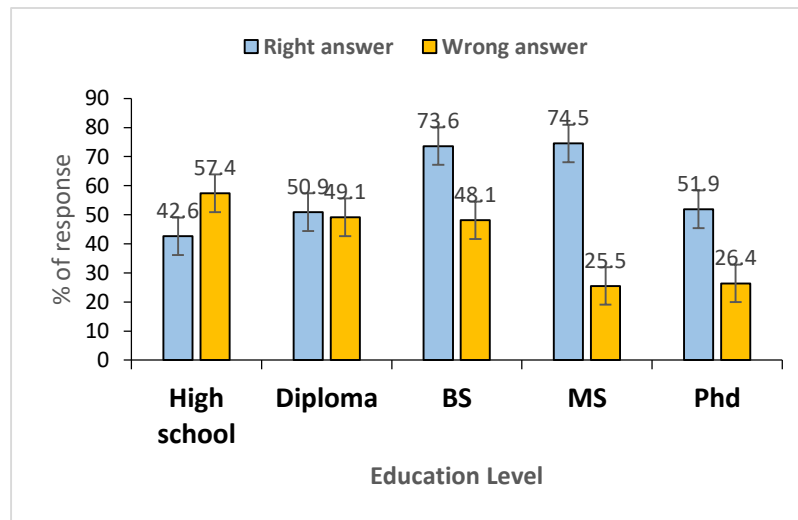


Fig. 4. Frequency of right/wrong answers according to education level.

Figure 5 shows the amount of right/wrong answers according to gender. According to this figure, from a gender perspective, women have a higher level of right answers.

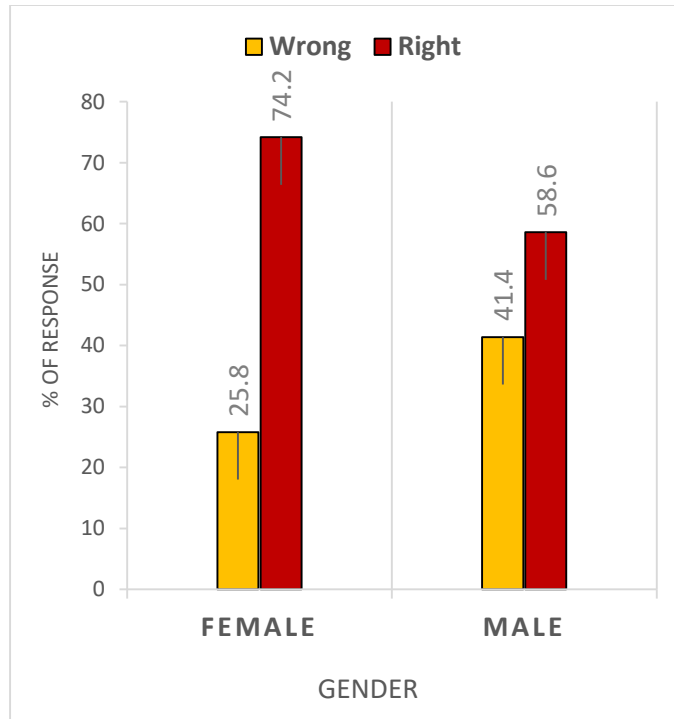


Fig. 5. The percentage of right/wrong answers according to gender.

Figure 6 shows the percentage of right/wrong answers according to driving experience. The Pearson correlation coefficient for right/wrong answers according to driving experience is -0.848, in fact when driving experience increase, the wrong answers also increase.

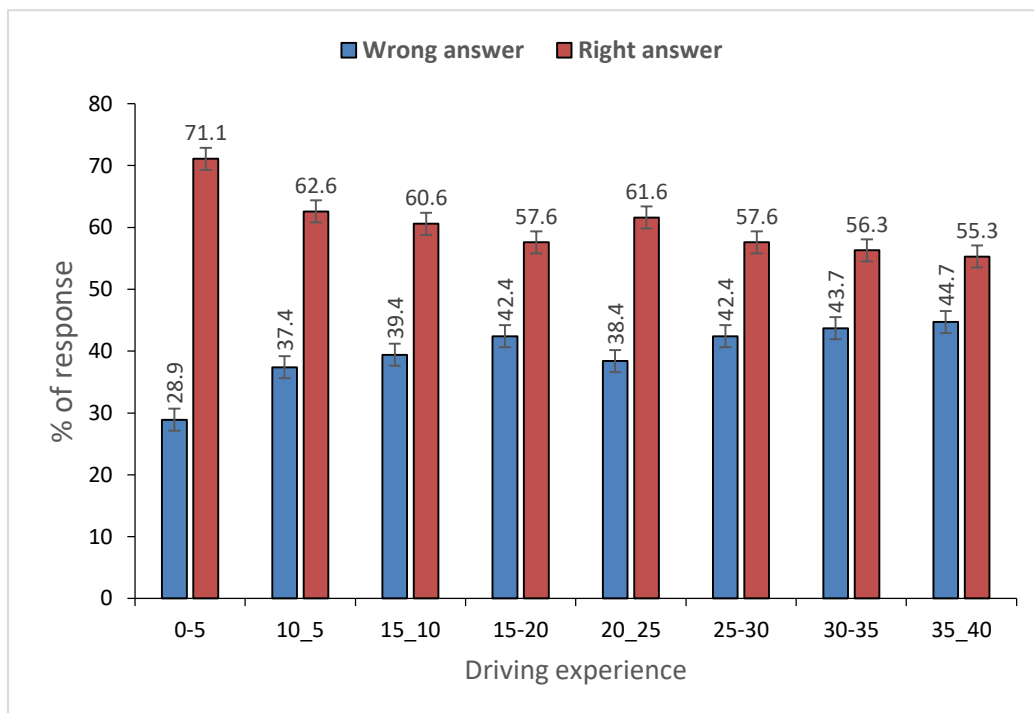


Fig. 6. The percentage of right/wrong answers according to driving experience.

Table.2

an all perspective of results relate to each from figures.

Parameter investigated	Result
Increase driving record	As the driving record increases, the percentage of correct response decreased
Increasing education	As the level of education increases, the percentage of correct answers to the recognition of traffic sign increases
Gender	Men are more likely to give a false answers than women. Detection of the do not-enter sign has the most correct
Type of traffic sign	answers and the traffic signs selected from the MUTCD have the least correct answers

7. Conclusion

In this research which is done for city of Tehran, 34 traffic signs which 30 are Iran's standard traffic signs & 4 are designed according to MUTCD guidelines were selected according to random sampling. The characteristics of questionnaire's respondents are determined according to 4 factors: age, education level, gender & driving experience. 768 people were chosen as questionnaire's respondents. From these people, 11 % have high school degree, 9 % diploma, 38 % BS, 27 % MS, & 15 % Phd.. From a gender perspective, 384 of respondents are men, and 384 are women. The results of this research can be summarized as follow:

From a driving experience perspective, the highest right answer was observed for a group with 0-5 years of driving experience. Given this, as well as the Pearson correlation coefficient estimated for correct and incorrect response (-0/848), it can be said that increasing driving experience is inversely related to the detection of different types of traffic signs. This highlights the need for training courses for people with more driving experience. This can be tested drivers again when they applying for a Certificate Extension and consider training courses for drivers who fail the quota.

According to this study, due to Pearson correlation coefficients estimated for right and wrong answer (0/935) based on education, increased education is directly related to the recognition of different types of signs. As the level of education increases, the percentage of correct answers to questions increases; the most correct answers are for those with postgraduate degrees and then PhDs 74/5 and 73/6 respectively. According to these results, people with lower education should receive more education.

The lowest right response was seen for drivers with 35-40 years of driving experience. It can be argued that there is an inverse relationship between driving experience and correct recognition of traffic signs.

According to this research, higher education has a direct relationship with recognition of various traffic signs. In fact, the higher the education level, the higher the right answers of participants to

questions. The highest right answer was collected from PhD, MS, BS respondents in the same order (74.5, 73.6, 51.9 %).

From a gender perspective, the highest right answers were seen for women. According to our results, 74.2 % of women & 58.6 % of men answered the questions correctly.

Overall, the mean of right / wrong answers are 60.08 & 39.9 % respectively. The standard deviations are equal (both 16.17%).

The lowest wrong answer belongs to “double entrance stop” and “entrance stop” signs with 18 %. The lowest right answer belongs to MUTCD guidelines with signs such as “children playing”, “highway-railway crossing, stop” with almost 75 %. The estimated Pearson correlation coefficient for answering these questions (right/wrong answers) is -1.

The estimated Pearson correlation for respondents’ right-wrong answers according to education level is 0.935. It means that by increase in education level, the right answers also increase.

The estimated Pearson correlation coefficient for right-wrong answers, with respect to driving education is -0.848 which means by increase in experience, the wrong answers got increased.

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