Driver Factors Affecting Traffic Sign Detection and Recall

SAAD A. AL-GADHI, SYED ABID NAQVI, AND ADEL S. ABDUL-JABBAR

Warning and regulatory traffic signs used in Saudi Arabia were evaluated. All of these signs are compatible with those of the 1968 U.N. Vienna Conference on Road Signs and Signals. The project was sponsored by the Saudi Arabian National Traffic Safety Committee and involved a large sample of subjects (10,137 drivers). Twenty-two regulatory and warning signs were used to test drivers for detection and recall. With the help of a police officer the vehicles were directed into a lane, where drivers were interviewed in a systematic way to evaluate the effect of age, experience, profession, education, language, sign type, and road condition on the detection and recall of signs. It was concluded that older drivers have poorer rates of detection and recall of traffic signs than younger drivers. The uneducated drivers have problems in recalling traffic signs. Retired people (>60 years of age) have trouble detecting traffic signs. Native language speakers detect signs more often and commit fewer errors in recall than nonnative language speakers.

Traffic safety has become a global issue in recent years because of the loss of lives and associated accident costs. The authorities responsible for traffic safety have taken extensive measures to achieve safety in many areas of the traffic system; however, more research in certain areas is greatly needed.

The sharp increase in the number of roads and vehicles and in the population in Saudi Arabia has resulted in increased automobile accidents. In 1953, there were only 239 km of paved roads in Saudi Arabia, but by the end of 1991 more than 122,000 km of roads had been constructed, of which 42,000 km were paved. The number of vehicles has increased as well. At the beginning of 1970s, there were approximately 100,000 vehicles in the country; in 1991 this number increased to 5 million, surpassing the vehicles per 1000 inhabitants mark for many European countries (*1*). The population of Saudi Arabia is on the rise, increasing from 10 million in 1973 to 17 million in 1993.

Several studies have been done on automobile accidents in Saudi Arabia (*2,3*). For example, a study (*2*) conducted in Riyadh presented the results of a questionnaire that covered various influential factors in traffic accidents. It was concluded that 57 percent of the accidents were because of traffic rule violations (e.g., improper overtaking, turning, and stopping), and traffic signal or sign violations. Moreover, most accidents were caused by driver error, and an in-depth analysis of various underlying human factor variables is warranted.

Several researchers have addressed the driver factor issues related to driving accidents (*4–7*). The major issues addressed involved accident proneness (*4,8*), psychological relationships (*5,6,9–11,17*), driver behavior (*12,13*), biorhythm theory (*7,14,15*), and risk taking (*16*). Most researchers agree that individual approaches, if considered alone, may prove to be misleading, and a common framework is needed to incorporate the interrelationships and interdependencies.

Another study (*18*) demonstrated that road sign systems do not function in their intended way, that drivers are sometimes blamed unnecessarily, and that signs are generally incompatible with human input systems. The study, which involved 1000 drivers, indicated that on average 47 percent of the drivers detected a road sign. Another study (*17*) reported that the overall probability of a road sign being noticed is less than 50 percent. Finally, a recent study (*19*) on the effect of road sign informational value on driver behavior suggests that the memory for signs is typically poor.

Saudi Arabia is a signee of the 1968 Vienna Road Traffic Convention and has built its traffic system within bounds of the convention. It has also developed appropriate manuals; one such document is Uniform Traffic Control Devices Manual developed by the Ministry of Transportation. The manual sets forth the basic principles relevant to traffic control devices.

This study on traffic signs was undertaken to identify relevant factors affecting the driver's ability to detect and recall traffic signs. Such a study was rarely done in Saudi Arabia and has not been seen in literature in the manner described previously.

This study examined the effect of driver's age, professional training (student, blue collar, white collar, driver, laborer, retired, other), education (illiterate, read and write; primary, intermediate, high school, vocational school, university, higher degrees, others); and language (Arabic, non-Arabic speakers) on the recall and detection of traffic signs. *Recall* is defined as the memory of what has been learned or experienced; whereas *detection* is the process of identifying the object as a sign.

METHODS AND PROCEDURES

Local and foreign literature relevant to traffic signs was searched and reviewed to develop background for the investigators. Proven methodologies in the study of traffic signs were used as presented in the literature with changes needed for the task. According to the field study protocol, 22 signs of the 84 regulatory and warning signs used in Saudi Arabia were selected from an earlier study by the investigators in a laboratory environment (*20*). These signs are shown in Figure 1. Four geographically different test locations were selected in Riyadh. The surveyors for field data collection were selected through an interview process with the criterion that they be proficient in Arabic and English, with any additional language a plus. The signs were allocated to each test location with emphasis on their relevance to the site. The data collection was carried out

S. A. Al-Gadhi, Department of Civil Engineering, King Saud University, P.O. Box 800, Riyadh 11421, Kingdom of Saudi Arabia. S. A. Naqvi, Department of Industrial Engineering, King Saud University, P.O. Box 800, Riyadh 11421, Kingdom of Saudi Arabia. A. S. Abdul-Jabbar, Department of Psychology, King Saud University, P.O. Box 26373, Riyadh 11486, Kingdom of Saudi Arabia.

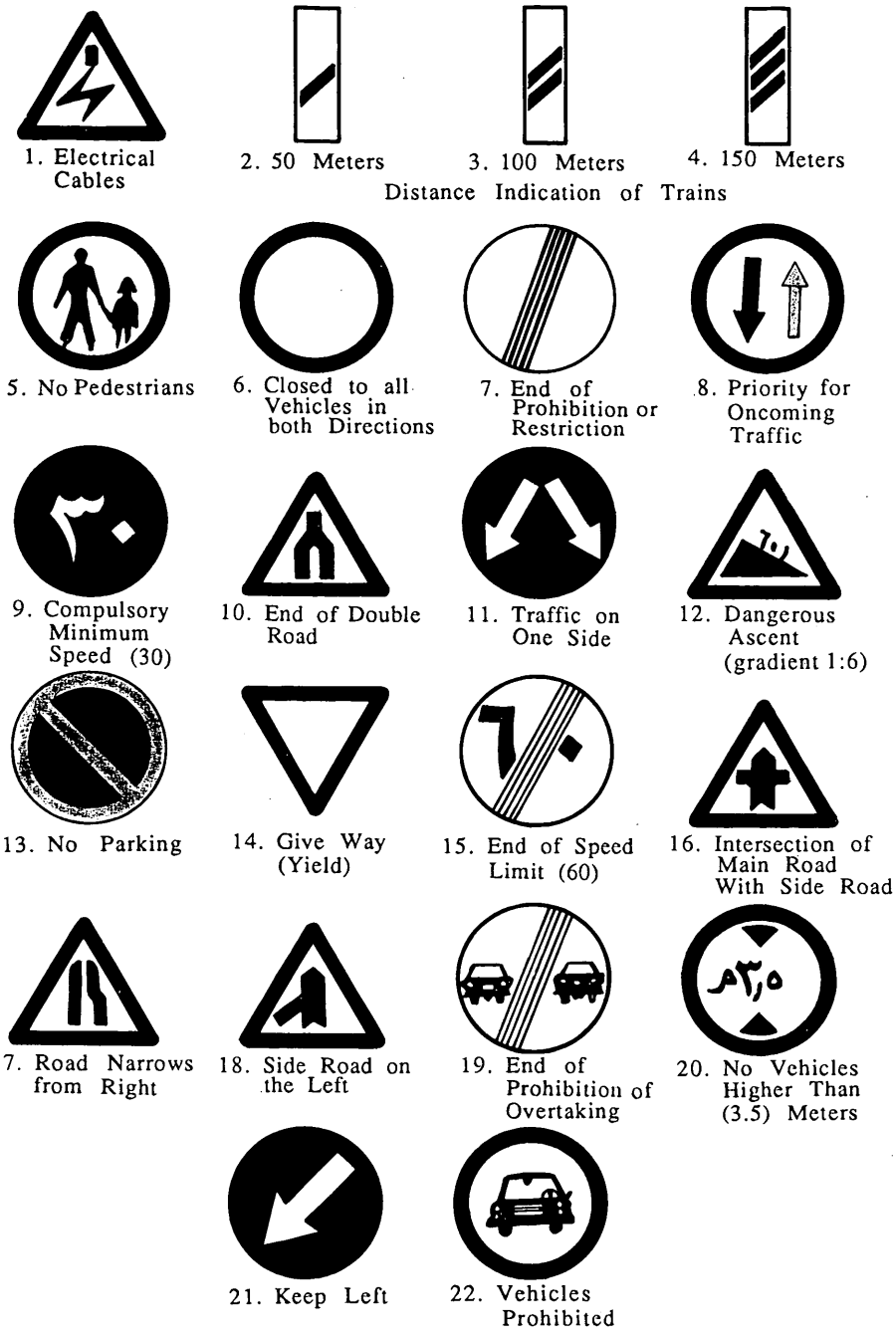

FIGURE 1 Traffic signs used in study.

during the day in two shifts, (9 to 12 a.m. and 3 to 5 p.m.). Surveyors were assigned to each location and were not rotated among sites. At each location, a test sign was placed according to current standards of sign posting used in Saudi Arabia. The sign was set up in such a way that it could be viewed by oncoming drivers from a distance of approximately 400 m (*18*). The test sign was posted so that it was the only sign a driver can see before passing it. The data collection site was set up beyond 200 m from the posted sign (*21*). It was also ensured that there were no other traffic signs in the 200 m span on either side of road. One sign per day was scheduled to be tested with about 400 data sets for each sign based on the experimental design, described later. A traffic police officer was assigned to stop the automobiles at each test site. The vehicles were directed into a lane on right side of the street formed by using cones and other safety devices. The vehicles were randomly stopped and drivers were evaluated on a first-come, first-served basis in the lane, which had the capacity of six automobiles with equal number of surveyors waiting.

As a driver arrived, the surveyor immediately asked, "What was the last road sign you passed?" If the response was incorrect or the driver did not see a sign, the surveyor proceeded to the next question.

Next the surveyor showed a card that displayed set of signs including the test sign and asked "Which one of these signs is the one you just passed?" The objective of this question was to double-check if there was any memory of the sign left. Various combinations of these questions and their results are given in Figure 2.

After initial questioning, information about the subject's age, driving experience, language, education level, and profession was recorded. The levels of each category can be seen in Table 1. The data were analyzed using SAS software on the IBM 3080 mainframe at King Saud University.

In this study there are data on two response variables—recall and detection—and seven explanatory variables (see Table 1). The sample size of approximately 400 for each sign was found statistically appropriate.

The study was conducted during the day. Roads were mostly dry (89.9 percent of time) and visibility was generally clear (99.2 percent of time). A total of 10,137 drivers were randomly stopped; 65.9 percent were native Arabic speakers and the rest were non-Arabic speakers. Other frequency distributions such as subject's age, driving experience, education level, and profession are not given here because of space limitations and can be found elsewhere (*20*).

ANALYSIS AND RESULTS

The response variables recall and detection are binary (taking a value of 0 or 1 only) and require a special technique called logistic regression (*22*). Logistic regression is a statistical method for analyzing the relationship between an observed proportion, or rate, and a set of explanatory variables.

Sign detection was found to be reasonable for this study (65.5 percent). Recall was only 12.16 percent. Table 2 summarizes mean detection and recall by sign. Other significant results are presented as follows.

Detection Model

For this model, five factors had a significant effect on the response variable (with significance level ≤ 10 percent). These factors were sign, age, profession, education, and language (Table 3). The full model involving all the above factors was significant at 1 percent level. Each of the factors, sign, age, education, and language, was highly significant. The significance level for profession was about 1.76 percent—also quite high.

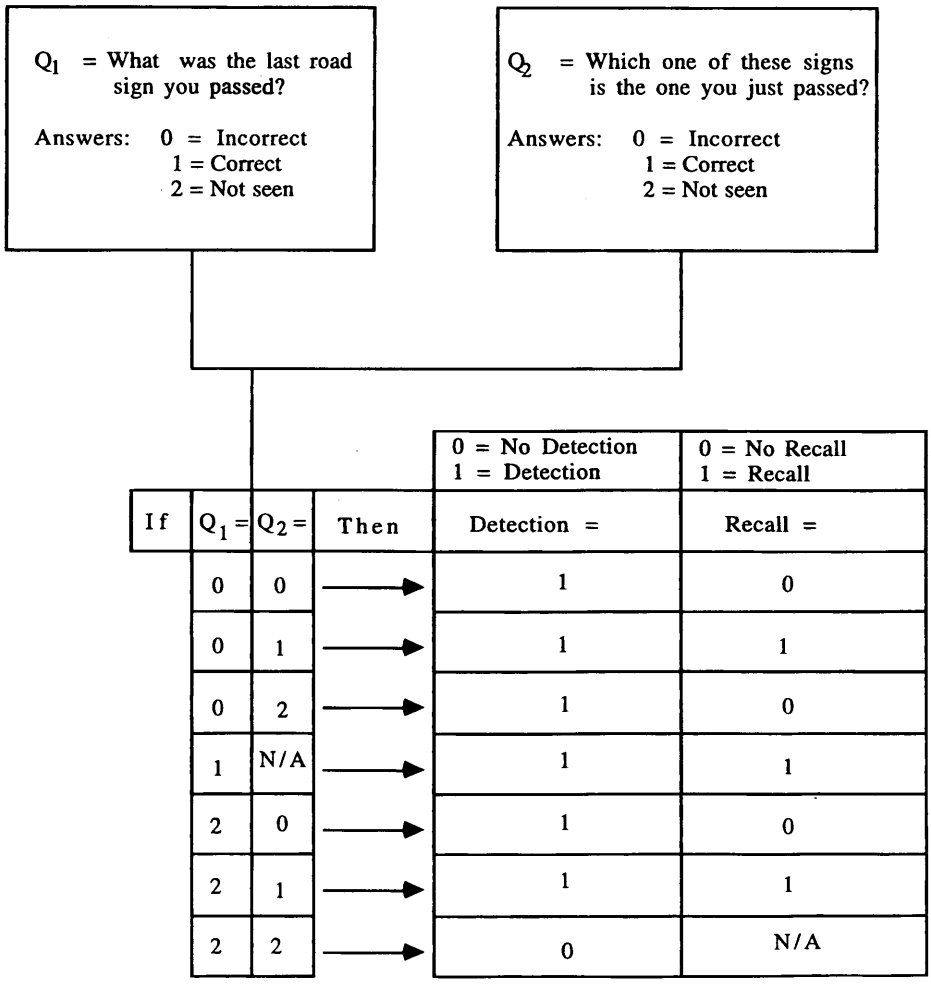

FIGURE 2 Memory logic diagram.

TABLE 1 Variables Used in Study

Independent Variables	
Sign No.	1 to 22
Age	Continuous Random Variable (years)
Road Condition	Wet, Medium, Dry
Experience	Continuous Random Variable (Years)
Profession	Student, Blue Collar (Skilled worker),White Collar (Office worker), Driver (Professional), Laborer (Unskilled worker), Retired, Other.
Education	Illiterate (No education & not literate), Read & Write, Primary (1-6), Intermediate (7-9), High School (10-12), Vocational, University (Bachelors level), Higher Degree (MS, Ph.D.) & Other.
Language	Arabic, Non-Arabic.
Independent Variables	
Detection Recall	

TABLE 2 Sign Detection and Recall Results

Sign No.$	Sample Size (N)	Mean@ Detection (%)	Mean@ Recall (%)
1	464	57.8	03.7
2	339	61.4	04.8
3	312	58.0	0.55
4	292	62.3	03.3
5	416	71.6	36.9
6	449	76.4	18.7
7	452	64.2	16.6
8	525	58.9	08.1
9	752	87.1	05.2
10	405	59.0	06.7
11	440	62.5	25.1
12	417	60.9	07.9
13	456	59.7	14.3
14	427	69.8	12.1
15	402	99.0	06.5
16	467	55.5	33.6
17	457	72.0	23.1
18	435	63.7	18.1
19	441	56.0	08.1
20	573	60.7	12.1
21	447	55.0	08.9
22	569	60.5	12.8
Total	10,115+		
Grand Average		65.5%	12.16%

$ See Fig. 1
\+ 22 Missing
@ Rounded

TABLE 3 Detection Model (Model is Significant at α = 1 percent)

S. No.	Significant Variables*	P value	Parameter	Type
1.	Sign	.0001	+.0259	Discrete
2.	Age	.0001	-.0264	Continuous
3.	Profession	.0176	+.003	Discrete
4.	Education	.0001	+.383	Discrete
5.	Language	.0002	+1.433	Discrete

* significance level $\alpha = 10\%$

The regression parameter for age had a small negative value indicating that mean detection decreases with age but at a very slow rate. Because the factors profession and education were at several levels, a detailed analysis by Duncan's Multiple Range Test was performed. It was found in the profession category that mean detection was highest for students and it was significantly higher (at 5 percent level) than the mean of drivers, laborers, and retired people. However, it was not significantly different from blue and white collar people. The rate of detection among drivers and laborers was not significantly different. The rate of detection among retired subjects was significantly lower than all other profession categories. In addition, it was found that profession and education were not correlated (corr. coeff. = 0.05331, $p = 0.0001$).

The language factor was highly influential in determining detection. Arabic speakers had significantly greater mean detection than non-Arabic speakers.

The mean detection for the education variable was highest for vocationally trained followed by higher education, university, high school, intermediate, and primary. These levels were found not significantly different from one another; however, all the levels were significantly different from illiterate and read and write categories.

Table 2 presents the mean detection rate for various test signs. It can be seen that drivers had most difficulty in detecting Sign 21 followed by 16, 19, 1, and so on. The overall detection rate was 65.5 percent, a rate considered to be reasonable compared with European countries [47 percent (*18*), 50 percent (*17*)].

Recall Model

Only three factors, namely sign, age, and language, appeared to have significant impact on response variable (Table 4). The model involving the above three factors only was significant at 1 percent level. The regression parameter corresponding to age had a very small negative value indicating that the recall goes down with increasing age but at a very slow rate. Non-Arabic speakers committed significantly more errors in recall compared with Arabic speakers even through the Arabic speakers were not better educated. There was no correlation between education and language (corr. coeff. = 0.05024, $p = 0.0001$).

Table 2 presents the mean recall percentages for various test signs. It can be seen that the drivers had the most difficulty in recalling Sign 3 followed by 4, 1, and 2, with the recall percentage under 5 percent. The overall recall rate is also quite low (12.16 percent).

DISCUSSION AND CONCLUSIONS

The driver factors of age, profession, education, and language had a significant effect on detection. The increase in age resulted in decreased detection, and, in the profession category, retired people detected significantly at the lowest rate. This may be because of decrease of memory with age or related factors. Students detected the signs at a higher rate than all other professions. This may be attributed to their young age and better education level. The Arabic speaking drivers' detection rate was significantly higher than that of non-Arabic speaking drivers. This may be because of the presence of an Arabic inscription on some of the signs. These inscriptions may have helped many Arabic readers to detect the signs better. The poor rate of detection for non-Arabic speaking drivers may be because of inattention, lack of training, and so forth.

The overall detection rate (65.5 percent) may be higher than seen in some European countries but still should be better. The reason for not having a very high detection rate may be because of a diversified driver population, lack of driver training, inadequate traffic law enforcement, or sign characteristics (i.e., legibility, readability, conspicuity, location, or maintenance.)

The error in recalling a traffic sign was mainly affected by driver age and language. The decrease in recall for drivers with increasing age was significant. It is understandable because older people were expected to commit more errors as a result of reduced vision, attention, and information processing abilities. The overall increased error rate may have also been attributable to the sign itself and its understandability, as described earlier. The non-Arabic speaking drivers' recall of signs was significantly worse than that of Arabic speaking drivers. This may be because non-Arabic speaking drivers received different sign training in their home countries in addition to the other reasons mentioned earlier.

It can be concluded from this study that older drivers have a lower detection and recall of traffic signs when compared with younger drivers. Uneducated drivers will have problems understanding traffic signs. Retired people (> 60 years of age) have trouble detecting traffic signs. Native language speakers have better detection rates and commit fewer errors in recall compared with non–native-language speakers. It is recommended here that such studies be done in other countries and the findings of this and other relevant

TABLE 4 Recall Model (Model is Significant at α = 1 percent)

S. No.	Significant Variables*	P value	Parameter	Type
1.	Sign	.0001	-0.0085	Discrete
2.	Age	.0693	-0.037	Continuous
3.	Language	.0277	+0.6015	Discrete

* significance level $\alpha = 10\%$

past studies be used to revise or update the relevant road sign standards such as the 1968 Vienna Convention.

ACKNOWLEDGMENT

This work was funded by King Abdulaziz City for Science and Technology and the National Traffic Safety Committee of the Kingdom of Saudi Arabia.

REFERENCES

1. *Highways and Transport—Facts and Figures* (in Arabic). Ministry of Communication, Kingdom of Saudi Arabia, 1993.
2. Lee, K. W. An analysis of automobile accidents in Riyadh. *Journal of the Institute of Transportation Engineers*, Feb. 1986, pp. 35–39.
3. Hasan, S. S., and M. N. Redhwi. A study on essentials of road travelling. *Proc., 3rd IRF Middle East Regional Meeting*, Vol. 4, Riyadh, Saudi Arabia, 1989.
4. McKenna, F. The Human Factor in Driving Accidents—An Overview of Approaches and Problem. *Ergonomics*, Vol. 25, No. 10, 1982, pp. 867–877.
5. Loo, R. Individual Difference and the Perception of Traffic Signs. *Human Factors*, No. 20, 1978, pp. 65–74.
6. Hills, B. L. Vision, visibility and perception in driving. *Perception*, No. 9, 1980, pp. 183–216.
7. Khali, T. M., and C. N. Kurucz. The Influence of "Biorhythm" on Accident Occurrences and Performances. *Ergonomics*, No. 20, 1977, pp. 389–398.
8. Greenwood, M. Accident Proneness. *Biometrika*, No. 37, 1950, pp. 24–29.
9. Goodenough, D. R. The Role of Individual Differences in Field Dependence as a Factor in Learning and Memory. *Psychological Bulletin*, No. 83, 1976, pp. 675–694.
10. Mihal, W. L., and G. V. Barrett. Individual Differences in Perceptual Information Processing and Their Relation to Automobile Accident Involvement. *Journal of Applied Psychology*, 1976, No. 61, pp. 229–233.
11. Summala, H., and J. Hietamaki. Drivers Immediate Response to Traffic Signs. *Ergonomics*, Vol. 27, No. 2, 1984, pp. 205–216.
12. Foot, H. C., and A. J. Chapman. Road Safety and Driver Behavior. *Ergonomics*, Vol. 25, No. 10, 1982, pp. 863–865.
13. Kramer, U., and G. Rohr. A Model of Driver Behavior. *Ergonomics*, Vol. 25, No. 10, 1982, pp. 891–907.
14. Schaffer, J. W., C. W. Schmidt, H. I. Zlotowitz, and R. S. Fisher. Biorhythms and Highway Crashes. *Archives of General Psychiatry*, No. 35, 1978, pp. 41–46.
15. Wolcott, J. H., R. R. McMeekin, R. E. Burgin, and R. E. Yanowitch. Correlation of General Aviation Accidents with Biorhythm Theory. *Human Factors*, No. 19, 1977, pp. 283–293.
16. Svenson, G. Are We All Less Risky and More Skillful than our Fellow Drivers? *Acta Psychologica*, No. 47, 1981, pp. 143–148.
17. Johansson, G., and F. Buckland. Drivers and Road Signs. *Ergonomics*, Vol. 13, No. 6, 1970, pp. 749–759.
18. Johansson, G., and K. Rumer. Drivers and Road Signs: A Preliminary Investigation of the Capacity of Car Drivers To Get Information from Road Signs. *Ergonomics*, No. 9, 1966, pp. 57–62.
19. Fisher, J. Testing the Effect of Road Traffic Signs' Information Value on Driver Behavior. *Human Factors*, Vol. 34, No. 2, 1972, pp. 231–237.
20. Al-Gadhi, S. A., S. A. Naqvi, and A. S. Abdul-Jabbar. *Study of the Effectiveness of Traffic Signs*. Report AT-LW-M47, National Traffic Safety Committee, Riyadh, Saudi Arabia, 1993.
21. Shinar, D., and A. Drory. Drivers Immediate Response to Traffic Signs. *Ergonomics*, Vol. 27, No. 2, 1983, pp. 205–216.
22. Koch, G. C., and S. Edward. Logistic Regression. (Koch et al., eds.), *Encyclopedia of Statistical Sciences*, Vol. 5, 1985, pp. 128–133.

Publication of this paper sponsored by Committee on User Information Systems.