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Motorist understanding of traffic signs: a study in Dhaka city

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Abstract

Driver understanding of some selected regulatory, warning, and informatory signs was assessed through a driver survey. The survey was conducted among 202 Dhaka city drivers. Forty-two (42) traffic signs were evaluated. Of these 42 traffic signs, there were twenty regulatory signs, seventeen warning signs, and five informatory signs. The results indicated that the drivers had a very poor level of comprehension of the meaning of the traffic signs. The overall understanding level, measured in terms of percentage of correct responses, was only about 50%. Only four traffic signs- two regulatory and two warning- were understood by more than 80 percent of the respondents. The percentage of drivers who correctly identified the regulatory signs, warning signs and informatory signs were 49%, 52% and 55%, respectively. The study results indicated that efforts are needed to educate the drivers on the proper meaning and response to traffic signs.

Keywords: Traffic Control Device, Driver Understanding, Questionnaire Survey, Regulatory Sign, Warning Sign, Informatory Sign.

1. Introduction

Traffic control devices (TCDs)- traffic signs, pavement markings and traffic signals- are a vital part of the highway system. Of these three different types, traffic signs are the oldest and most frequently used traffic control devices currently in use. They provide a means of communicating important information about the roadway to the driver. Traffic signs utilize color, shape, symbols and/or words to convey information. However, the traffic signs cannot effectively serve their intended purposes if drivers do not understand the information concerning safe driving behavior that is encoded in the signs (Stokes et al. 1995). In fact, the American National Standard Institute (ANSI Z535.3) and the Organization of for International Standardization (ISO 3864) advice that symbols must

meet a criterion of at least 85% or 67% correct, respectively, in a comprehension test to be considered acceptable (Al-Madani and Al-Janahi, 2002a; Wolff and Wogalter, 1998). Traffic signs have been a topic of considerable interest to researchers during the past few decades. They covered a wide range of aspects related to engineering, traffic safety, educational, and human physical capabilities. Studies on drivers' conception of traffic signs from psychological and demographical point of view are still scare. While a lot of research effort was undertaken in the western world, especially in the United States, the literature review revealed that no study to assess the driver's understanding of traffic control devices in Bangladesh has been reported to date. There is a general public perception that the city drivers do not have a satisfactory level of understanding of traffic signs, and often this is thought to be a major cause of road accidents. Consequently, this study was undertaken to assess the driver understanding of certain traffic signs in Dhaka, the capital city of Bangladesh.

2. Past studies

The Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways (FHA, 2000) provides the basic principles for the design and use of signs, signals, and pavement markings for all public roadways in the United States. Several countries in the world have also developed their own traffic control device manuals which are very much similar to the MUTCD in the USA. Shapiro et al. (1987) identified seventeen MUTCD standards as having a significant need for additional research. It was concluded that many traffic control devices (particularly signs) and warrants are likely to benefit from further evaluation, improved design, or better understanding of driver capabilities and behavior. One of the more extensive studies of driver understanding of TCDs was conducted for the American Automobile Association (AAA) by Hulbert et al. (1979). Hulbert and his associates assessed driver comprehension of several traffic sign symbols, traffic signals and pavement markings in a sample of over 3100 drivers from across the United States. Comprehension levels reported by Hulbert et al. were generally poor, with overall percentages of correct responses to signs, signals, and pavement markings being 74%, 68%, and 45%, respectively. They also found that old drivers were more likely to misunderstand certain TCDs than were younger drivers. Knoblauch and Pietrucha (1986) examined potential deficiencies in approximately 30 U.S. sign symbols and formulated recommendations for their improvement. Certain families of signs were found to be particularly confusing; these included CURVE vs TURN signs, and pedestrian vs school crosswalk signs. The 1981 Texas study (Womack et al. 1981) evaluated 63 traffic control devices. 19 of the 63 devices were identified as needing improvements. The Texas study surveyed drivers by presenting pictures of highway scenes in a test booklet. Subjects were instructed to select the correct meaning of each device from a list of multiple choice answers.

The 1995 Kansas study (Stokes et al. 1995) evaluated 43 traffic control devices in terms of driver's understanding of the meaning of the information encoded in the signs and pavement markings. Both multiple choice questionnaire and open ended questionnaire were used as survey instruments. The study identified some warning and regulatory signs and pavement markings that were misunderstood by the Kansas drivers and proposed some general recommendations for improving driver's understanding of certain TCDs. Parham et al. (2003) studied driver understanding of the current U.S. system of yellow–white pavement markings through a driver survey. The survey was used to evaluate drivers' ability to describe the pavement marking color code, drivers' reliance on pavement marking patterns when interpreting marking messages, and drivers' reliance on pavement marking color when interpreting marking messages. Researchers surveyed 851

drivers in 5 states, with respondents representing 47 states, the District of Columbia, and Puerto Rico. The survey results indicate that drivers tend to use signs and other traffic as the primary cue to determine whether a road is one-way or two-way. A substantial proportion of respondents had an understanding of the use of marking color to differentiate between one-way and two-way roads. Approximately 75% of the drivers surveyed understood the basic concept that a single broken yellow line separates opposing traffic on a two-lane road. The presence of a solid line (either double solid or solid and broken) in the centerline increases comprehension of directional flow to approximately 85%; more than 90% of the drivers surveyed understood that a solid line (either double solid or solid and broken) prohibits passing. Almost 95% of drivers indicated that passing is permitted with a broken line. The survey results indicate that the yellow–white pavement marking system is better understood than previously believed.

Relatively fewer studies have analyzed comprehension of traffic signs by age (Dewar et al. 1994) and other safety related characteristics (Al-Madani and Al-Janahi, 2002b). Ford, Jr. and Picha (2000) found that most of the teenage drivers participating in the survey had some degree of difficulty in understanding the traffic control devices that were evaluated. Out of 53 questions, only nine traffic control devices were understood, in terms of rates of correct response, by more than 80 percent of the respondents. Twenty of the traffic control devices evaluated were understood by more than 60 percent of the respondents. The remaining traffic control devices were understood by less than 60 percent of the teenagers who participated in the survey.

Al-Madani (2000) investigated the influence of drivers' comprehension of signs on accident involvement, citations received and seat belt usage. While knowledge of signs was increasing with seat belt usage, no significant association with accident involvement was observed; even when age was incorporated with the accidents. Similarly, no significant difference with number of citations received was observed. Furthermore, those with no speed citations, or low number of speed citations, were not significantly better than those with high number of speed citations.

Dewar et al. (1994) evaluated age differences in comprehension of traffic sign symbols using 480 volunteer licensed drivers in the USA and Canada. The sample included 85 color slides of standard US sign symbols. Older drivers had poorer understanding than younger ones in 39% of the symbols examined; for the remainder there were no differences with respect to age. In another study, Luoma and Rama (1998) found recall of speed signs not to be affected by drivers' age and sex.

Al-Madani and Al-Janahi (2002a,b) examined the influence of drivers' accident involvement and personal characteristics on their understanding of 28 traffic regulatory and warning signs. A sample of 9000 drivers who were residents of Bahrain, Kuwait, Oman, Qatar and United Arab Emirates was used. Results showed that on average, drivers fully understood only 56% of all signs. The Gulf States, Asian and Arab drivers understood the signs less well, and were not much helped by the use of pictograms rather than written instructions. Male drivers scored higher than female drivers. Age, marital status, experience and accident rates had no obvious bearing on comprehension of signs. The overall conclusion was that personal characteristics, rather than accident involvement rates, are most clearly associated with comprehension capabilities.

3. Evaluation methodology

Driver's understandings of traffic signs were evaluated by conducting a survey among

the drivers in the Dhaka city. In this study, "understanding" was assessed in terms of how well drivers correctly identify the safety-related messages encoded in certain traffic signs. A multiple-choice type questionnaire for each traffic sign evaluated was prepared. In addition to the multiple-choice type questionnaire, the survey form contained a brief introduction about the purpose of the study, and some specific queries regarding the respondents' demographic and driving characteristics. Statistical analyses were also performed to determine if there are any causal relationships between the respondents' understanding of traffic signs and their demographic and driving characteristics.

Figure 1. Twenty regulatory signs evaluated (shown with the sign designation by Roads and Highways Department, Govt. of Bangladesh).

4. Content of survey form and administration

The survey instrument had two parts- the first part contained images of the signs evaluated and the corresponding multiple-choice questions related to each sign. A total of 42 signs were evaluated. The signs were selected based on a) driver's familiarity of the sign, and b) importance the sign so far safety is concerned. Of these 42 traffic signs evaluated, 20 were regulatory signs (see Figure 1), 17 were warning signs (see Figure 2) and 5 were informatory signs (see Figure 3). The second part of the survey form had 12 questions regarding the respondents' demographic and driving characteristics. The survey questionnaires were written in Bengali, the national language of Bangladesh. The survey forms were printed in true color. The responses included one correct response, two possible (yet incorrect) responses, and a "not sure" response. As noted earlier, the survey questions were designed to test understanding of specific aspects of the safety-related messages encoded in certain signs.

The level of automobile ownership is very low in Bangladesh. At the same time there are large numbers of medium and large buses running on the city streets of Dhaka. Often the reckless driving of bus drivers is thought to be the primary contributing factors of road accidents. The survey was conducted among both professional and non-professional drivers. Considering the time and opportunities to interview the drivers, a sample of 200 drivers was thought to be sufficient for meaningful statistical analyses.

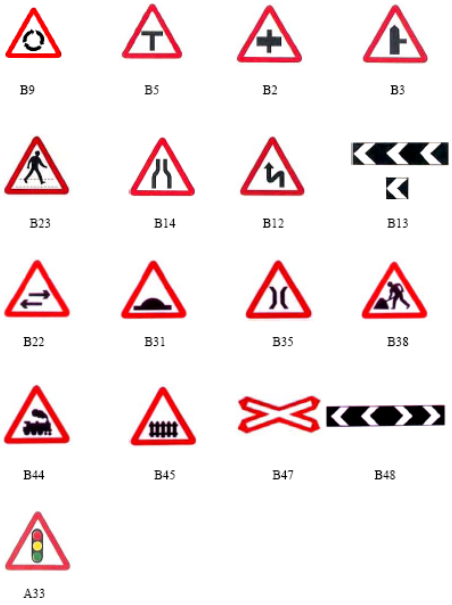

Figure 2. Seventeen warning signs evaluated (shown with the sign designation by Roads and Highways Department, Govt. of Bangladesh).

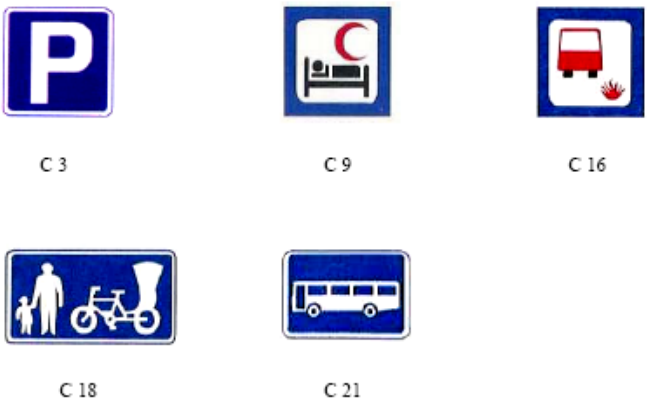

Figure 3. Five informatory signs evaluated (shown with the sign designation by Roads and Highways Department, Govt. of Bangladesh).

The survey forms were pilot tested to evaluate the survey questions and answers, and to identify potential problem in survey administration prior to full scale implementation. The results of the pilot tests indicated that the survey forms were effective and only

minor changes were necessary. In the case of professional drivers, the survey was administered in public places where drivers would have time available to complete the survey. Different bus terminals and truck terminals in and around the Dhaka were selected for this purpose. On the other hand, survey forms were distributed to the educated non-professional drivers so that they can fill on their own. The completed survey forms were then collected from them later.

5. Characteristics of survey respondents

Table 1 summarizes the demographic characteristics of the 202 survey respondents. Out of these 202 respondents, 198 were male and only 4 of then were female. Even though there is no restriction on females driving vehicles, seldom can one see a female driver in the city. The age distribution showed that the survey respondents were mostly young- 65% of the respondents were below the age 35 years and 85% of the respondents were below the age 45 years. Half of the respondents (50%) were in the age range of 25 to 34 years. Almost 80% of the respondents did not complete their high school (10^{th} grade or less), and only 7% of the respondents had bachelor's or higher educational degrees (see Table 1).

Table 1
Demographic Characteristics of the Survey Respondents

Characteristics		Sample Number	Percentage (%)	Total (%)
Gender	Male	198	98	100
	Female	4	2	
Age	Below 18	0	0	100
	18-24	31	15	
	25-34	100	50	
	35-44	60	30	
	45-54	9	4	
	55 and above	2	1	
Education	Tenth grade or below	157	78	100
	S.S.C./H.S.C.	30	15	
	Bachelor's or equivalent	8	4	
	Master's/Ph.D.	7	3	

Table 2 presents the driving characteristics of the survey respondents. The results show that 93% (180 out of 202) of the respondents were professional drivers. Approximately 25% of the respondents were taxi drivers, followed by 23% of bus drivers and 20% of truck drivers. Table 2 also shows that 37% of the respondents had driving experience of over 10 years and more than 60% of the respondents had driving experience of more than 6 years. The survey respondents usually drive within the city and 63% of them drove more than 100 km per day. In general, the respondents also mentioned that they did not have any driving education (89%).

Based on these demographic and driving characteristics analyses of the respondents it would be reasonable to assume that the results of the understanding of traffic signs presented in the following section are applicable to male professional drivers of ages between 25 and 44 years. Efforts were made to select samples which could represent a wide range of demographic and driving characteristics. However, as mentioned earlier, proportion of driving population as compared to the total population of the city is very

low. As a result, increasing the sample size would take a considerable amount of time and effort, and eventually was discarded.

6. Results of driver understanding of traffic signs

The survey was administered to a total of 202 drivers who used to driver in Dhaka, the capital city of Bangladesh. Three types of traffic signs- regulatory, warning, and informatory- were tested. The driver understanding of these three types of traffic signs was evaluated based on the average response rates- correct, incorrect, and not sure. The results of the evaluation are summarized in this section.

Table 2
Driving Characteristics of the Survey Respondents

	Characteristics	Sample Number	Percentage (%)	Total (%)
Drive for Job	Yes	187	93	100
	No	15	7	
Driving Days per Week	One day	2	1	100
	Two days	2	1	
	Three days	14	7	
	Four Days	60	30	
	Five days	45	22	
	Six Days	33	16	
	Seven days	46	23	
Driving Distance (km/day)	Below 30	10	5	100
	31-50	24	12	
	51-100	41	20	
	101-200	46	23	
	More than 200	81	40	
Driving Area	Within city	126	63	100
	Outside city	25	12	
	Both	51	25	
Years Licensed	No license	9	5	100
	Less than 1	15	7	
	1-5	55	27	
	6-10	48	24	
	More than 10	75	37	
License Type	Professional	180	93	100
	Non-professional	11	6	
	Motorcycle	2	1	
Vehicle Type	Passenger car (Taxi)	55	27	100
	Van, microbus, pickup, SUV, etc.	36	18	
	Large truck	2	1	
	Medium truck	38	19	
	Large bus	41	20	
	Medium bus	5	3	
	Three wheeler	23	11	
	Motorcycle	2	1	
Driving Education	Yes	23	11	100

6.1 Regulatory signs

A total of twenty regulatory signs were evaluated in this study. The results of driver understanding of these signs are presented in Table 3. The average understanding (measured in terms of percent correct responses) of these signs was 49% which is very low compared other similar studies conducted elsewhere. Table 3 shows that the following signs were recognized by the drivers satisfactorily- "no use of horns", "no overtaking", "no U-turns", "no rickshaws", "stop", and "one way traffic". All of these signs with high percentage of correct responses, except the "one way traffic"- are prohibitory and have red colors in them. It is reasonable to assume that the color and the simple and self-explanatory symbols used in these signs helped the drivers to choose the correct answer from the set of multiple choices. Even though one-way traffic movement is not at all common in the city, because of the use of "one single arrow" in that sign helped the drivers to choose the correct answer. The responses also showed that the drivers were confused (measured in terms of "percent not sure" responses) about the following regulatory signs- "special speed limit", 16%; "national speed limit apply", 25%; "turn left, one way movement", 14%; "no entry for vehicles", 13%; "give-way or yield", 22%; and "no vehicles over height shown", 22%. The respondents were confused (even though they knew that these are speed limit signs) while choosing the correct answer between the "special speed limit" and "national speed limit apply" signs. Both of these signs apply to speed zoning and are usually seen on highways. These two speed limit signs could perform well in the understanding test if some descriptive texts were included in addition to the color and numbers. The drivers were often confused between "no entry for vehicles" and "stop" signs, and also between" turn left, one way movement" and simple "turn left" signs. The "no vehicles over height shown" and "give-way" signs are common and the high percentage of "not sure" responses simply indicate that the drivers do not understand the meaning of these signs.

6.2 Warning signs

A total of 17 warning signs were evaluated in this study. The results of driver understanding of these signs are presented in Table 4. The average percentage of correct answers of these warning signs was 52% which indicated that the understanding level was very poor. The signs that were understood well by the drivers were "pedestrian crossing", 86%; "road works", 85%; "traffic signals ahead", 69%; "roundabout", 68%, and "road hump", 67%. These high percentages of correct answers can be attributed the existence of self explanatory graphics in these warning signs. The least understood traffic signs were "location of railway crossing" (7%) and "two way traffic crosses one way road" (13%). The "location of railway crossing" sign is often confused with "do not enter" or with "hazardous area, do not enter" choices provided in the questionnaire. The sign should have some symbol of "rail tracks" on it to perform well in such type of comprehension test. The "two way traffic crosses one way road" sign also should have some explanatory short supplementary text for better understanding. One of the other reasons for poor understanding was that one-way street system in Dhaka is not very common.

6.3 Informatory signs

A total of five (5) informatory signs were evaluated in this study. The results are shown in Table 5. The average understanding level of these signs was 55%. This understanding

level was the highest when compared with the understanding levels of regulatory and warning signs.

Table 3
Drivers' Understanding (Percent Correct) of Regulatory Signs

Sign	Meaning of the Sign	Percent Correct (%)
	Stop	67
	Give way to traffic on major road or at roundabout	33
	No entry for vehicles	25
	No trucks	52
	No rickshaws	74
	No vehicles over height shown	38
	No vehicles over maximum gross weight shown	57
	No parking	45
	No stopping	19
	No overtaking	82
	No left turn	61
	No U-turn	74
	Special (restricted) Speed limit	27
	No use of horn	83
	National speed limits apply	35
	Turn left (right if arrow reversed), one way movement	21
	Keep left (right if arrow reversed)	24
	Turn left ahead (right if arrow reversed)	31
	Pass either side	57
	One way traffic	71

Table 4
Drivers' Understanding (Percent Correct) of Warning Signs

Sign	Meaning of the Sign	Percent Correct (%)
	Roundabout	68
	T junction	48
	Major road ahead (crossroads)	47
	Side road right (left if symbol reversed)	60
	Pedestrian crossing	86
	Road narrows on both sides	56
	Double bend first left	36
	Sharp change of direction to the left	30
	Two way traffic crosses one way road	13
	Road hump	67
	Narrow bridge	49
	Road works	85
	Railway level crossing without gate	38
	Railway level crossing with gate	62
	Location of railway crossing	7
	T junction (Turn left or right only)	54
	Traffic signals ahead	69

However, the understanding level of 55% still is unsatisfactory. Most of the respondents thought that the sign "recommended route for pedestrians, cycles and rickshaws" actually indicated a "rickshaw stand" and consequently resulted in a poor understanding of only 22%.

7. Association between demographic and driving characteristics and survey responses

Drivers' responses were further analyzed to see if their demographic and driving characteristics (see Tables 1 and 2) had any effect on their responses. Only age and academic education of the respondents had influenced the responses. The respondents in age groups 35-44 years scored (percentage of correct answers) higher compared to the age groups of 25-34 and 18-24 years. Similarly, respondents with at least bachelor's degree scored higher than the respondents who completed the high school (S.S.C./H.S.C.) as well as who did not complete the high school (10^{th} grade or below). Detail results can be found elsewhere (Razzak, 2005).

Table 5
Drivers' Understanding (Percent Correct) of Informatory Signs

Sign	Meaning of the Sign	Percent Correct (%)
	Parking place	56
	Hospital	74
	Fire station	65
	Recommended route for pedestrians, cycles and rickshaws.	22
	Bus stop	58

8. Limitations of the study results

The use of multiple-choice format places some restrictions on the survey results. Multiple-choice questions eliminate a respondent's freedom to express their own explanation of the meaning of a traffic sign (Stokes et al., 1995). As a result, the responses are influenced by the possible choices. Another limitation inherent in the survey method is the format used to display the various signs under investigation. While color images of the signs were used, the images were not presented in-context (i.e., they were not shown as they would be encountered in the driving environment). Therefore, the respondents could not use "environmental information" as an aid in interpreting the traffic signs displayed on the questionnaires. The method used to collect the sample places certain limitations on the study results. The basic approach used to collect the sample was to administer the survey only at sites where it was anticipated that the number of potential respondents would be large enough to produce a sufficient return in a reasonable amount of time. While a reasonable effort was made to insure the representativeness of the sample, the sample was not collected in a truly random manner.

9. Conclusions

The main objective of this study was to assess the driver's understanding of some selected traffic signs. A total of 42 traffic signs- 20 regulatory, 17 warning, and 5 informatory- were evaluated. The understanding was assessed in terms of how well

drivers correctly identified the safety-related messages encoded in certain traffic signs. A questionnaire-type survey instrument was developed for use in this study. The survey form had two parts- multiple-choice responses for each of the 42 traffic signs evaluated and respondents' background information. The results indicated a very low level of comprehension of traffic signs among the drivers. The percentage of correct responses for all signs combined was only around 50%- 49% for regulatory signs, 52% for warning signs, and 55% for informatory signs. Out of the 42 signs evaluated, only four traffic signs were understood by more than 80 percent of the respondents. These signs are "No Overtaking", "No Use of Horn", "Pedestrian Crossing", and "Road Works". Twelve other signs were understood by more than 60% (but less than 80%) of the respondents- "Roundabout", "Side Road Right", "Road Hump", Railway Level Crossing with Gate or Barrier", Stop", "No Rickshaws", "No Left Turn", "No U-Turn", One Way Traffic", "Hospital and Fire Station". Based on analyses of demographic and driving characteristics of the respondents, it would be reasonable to assume that the results of the understanding of traffic signs presented here are applicable to male professional drivers of ages between 25 and 44 years. Statistical analyses to test the degree of association of demographic and driving characteristics of the respondents with their responses were performed. The results indicated that only respondents' age and academic qualification had some meaningful effects on their responses.

The study results indicated that efforts are needed to educate the drivers on the proper meaning and response to traffic signs. During the study, it was found that driver education and use of a driver's handbook can be the primary ways to teach the meaning of traffic signs. The government organization that has the responsibility for drivers' licensing should be adequately supported; because traffic signs fulfill other driving navigational needs. Other educational programs could include outreach materials such as brochures and videos, campaign or through public media like radio and television or informational Internet web sites. These recommendations should be implemented or pursued through the collaboration of traffic-safety officials, law-enforcement agencies, and transportation professionals.

References

Al-Madani, H. (2000), "Influence of driver's comprehension of posted signs on their safety related characteristics", Accident Analysis and Prevention (32): 575–581.

Al-Madani, H. and Al-Janahi, A. R. (2002a), "Assessment of drivers' comprehension of traffic signs based on their traffic, personal and social characteristics", Transportation Research Part F, (5): 63-76.

Al-Madani, H. and Al-Janahi, A. R. (2002b), "Role of drivers' personal characteristics in understanding traffic sign symbols", Accident Analysis and Prevention (34): 185-196.

Dewar, R.E., Kline, D. W. and Swanson, H. A. (1994), "Age differences in comprehension of traffic sign symbols", Journal of Transportation Research Board (TRR 1456): 1–10.

FHA - Federal Highway Administration (2000), "Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)", Washington, D.C.

Ford, G. L. and Picha, D. L. (2000), "Teenage drivers' understanding of traffic control devices", Journal of Transportation Research Board (TRR 1708): 1-11.

Hulbert, S., Beers, J. and Flower, P. (1979), "Motorists' understanding of traffic control devices", AAA Foundation for Traffic Safety, Falls church, VA.

Knoblauch, R. L. and Pietrucha, M. T. (1986), "Motorists' comprehension of regulatory, warning, and symbol signs", Final Report, Volume III: Appendices, Federal Highway Administration, Washington, D.C.

Luoma, J., and Rama, P. (1998), "Effects of variable speed limit signs on speed behavior and recall of signs", Traffic Engineering and Control (39): 234–238.

Parham, A. H., Womack, K. N. and Hawkins, Jr. H. G. (2003), "Driver understanding of pavement marking colors and patterns", Journal of Transportation Research Board (TRR 1844): 35-44.

Razzak, A. (2005), "Driver understanding of traffic signs" M. Eng. Thesis, Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh.

Shapiro, P. S., Upchurch, J. E., Loewen, J. and Siaurusaitis, V. (1987), "Identification of needed traffic control device research", Journal of Transportation Research Board (TRR 1114): 11-20.

Stokes, R. W., Rys, M. J., Russell, E. R. and Kerbs, J. (1995), "Motorist understanding of traffic control devices in Kansas", Final Report No. KSU-94-7, Department of Civil Engineering, Kansas State University, Manhattan, KS.

Wolff, J.S. and Wogalter, M. S. (1998), "Comprehension of pictorial symbols: effect of context and test method", Human Factors, (40): 173–186.

Womack, K.N., Guseman, P. K. and Williams, R. D. (1981), "Measuring the effectiveness of traffic control devises: an assessment of driver understanding", Texas Transportation Institute, College Station, TX.