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INFLUENCE OF DRIVER'S EXPERIENCE ON TEXTUAL TRAFFIC SIGN EFFICIENCY DEPENDING ON VISIBILITY

ABSTRACT

The research objective is to study the influence of the driver's experience on the efficiency of the textual traffic sign depending on the visibility, that is on the weather conditions. The research was carried out by simulating traffic situation for two different visibility conditions (good and poor) on representative sample of drivers regarding their driving experience.

The research results indicate high dependency of traffic sign efficiency on the driver's experience. The textual traffic sign efficiency is substantially lower in motorists with several years of driving experience and the experienced motorists than those with less experience and extremely experienced motorists, which is explained by motorist's evaluation of the traffic sign significance.

According to experimental results, less than 65% of drivers in low visibility conditions registered the number of words on the traffic sign, and less than 50% the precise content, thus leading to a conclusion that the traffic sign does not satisfy its function in this situation.

KEY WORDS

textual traffic signs, efficiency, visibility, various weather conditions, experimental study

1. INTRODUCTION

Driving a car is a visually very demanding task that will become even more demanding with the introduction of road traffic computerisation. Since modern traffic is becoming an increasingly complex process, which is obvious from the number of connections and dynamics of operations, the road traffic computerisation is becoming a necessity. Thus, the implication of complexity results in the need to increase communication efficiency of the traffic information systems.

In order to increase traffic safety and efficiency, traffic signs are studied as carriers of information. Traffic signs enable efficient and rational use of roads and they provide irreplaceable, timely information that controls the behaviour of all traffic participants. The basic function of traffic signs is the transmission of information to motorists, i.e. traffic participants.

For the traffic signs to perform their basic function and thus regulate traffic, two conditions have to be satisfied:

1. information provided by the traffic sign have to be accepted by the traffic participants, i.e. the participants have to perceive the signs (recognition included),
2. received information, i.e. perception of the sign must influence the motorist's behaviour in accordance with the information carried by the sign,

According to their messages, the traffic signs can be divided into textual, symbolic and graphic signs. The objective of research carried out in this paper is the efficiency of textual traffic signs regarding their dependence on the external weather conditions, particularly fog.

According to the method of traffic sign information processing and according to the motorist's reaction, there are three different levels of driving. At the elementary level the motorist's activities include maintaining the direction and controlling the speed. The second level requires manoeuvres such as turning, overtaking, curve handling, etc. and the task at the third level includes strategic decisions in selecting the route and monitoring the direction based on the signs. At the last level of driving traffic signs affect directly the movement in particular direction, or in restricting the possible operations at the level of manoeuvring.

The efficiency of traffic signs depends, apart from the subjective characteristics of the motorist, also on the objective characteristics, among which great importance is in their legibility. The issue of legibility of textual traffic signs is expressed to a lesser or greater extent, depending on the applied traffic sign system. The study of legibility of all traffic signs, including the textual ones are mainly carried out by measuring some of the numerous influencing values, whereas a certain constant, average value is assumed for the others.

Thus, the dimension of letters, the spacing as well as the number of characters on traffic signs are determined in relation to possible driving speeds, whereas the colour of the letters and background remain constant.

The influence of optical parameters on the legibility of traffic signs is treated mainly with regard to the determined, both physically and temporally constant daily, i.e. night illumination. Illumination varies substantially during the day as well as with the geographic position. Furthermore, optical permeability of the atmosphere depends to a great extent on the local weather conditions (fog, rain, aerosol particles, etc.).

Studying the results of many researches show that highlighting, distinctness and recognisability are the most important measures regarding the design of the sign. The highlighting is a measure which shows how well the sign is sited on the road. The more the sign is highlighted, or the easier it is to site it with regard to other visual stimuli, the better it will serve its purpose. However, highlighting is difficult to measure since a great number of different situations occur on the road. The success of this measure depends decisively on the characteristics of the environment; there is no laboratory-based method that could be applied to measure this variable. The distinctiveness is the measure of successful transfer of meaning to the motorist, and it refers to the purpose it should serve. The direct method of measuring distinctiveness is to determine the accuracy of subjective response, i.e. comparison of meaning the subject links with the sign and the one assumed by the experiment. If these two characteristics are comparable, then it may be concluded that the sign has been understood. This may also be the case if the subject knows how to react as a motorist. The recognisability refers to the identification of the sign content. In those signs which contain only text, this measure is widely known as legibility. Generally, the easier it is to identify the sign's content, the better the sign. To measure recognisability it is possible to use several dependent variables. Two variables often used are the response interval and sign content identification. Recognition distance is the measure of distance at which the content of a sign may be identified.

Motorists analyse the traffic environment and the information about its condition by engaging their perceptive functions, through visual, audio, tactile and vestibule channels. It has been generally accepted that the most important role in the perception process belongs to the visual channel. Some authors estimate the role of visual channel in motorist's perception by a value greater than 90% of the total driving task. No doubt, visual perception is vital for the safety of traffic participants. Visual perception in traffic does not only determine the visibility, but it also depends on the cognition. Perception is closely related to the levels of attention, with the selection and activation of memory elements, as well as with the central information processing leading to judgement and motoric reactions. During driving, perception usually occurs in dynamic conditions and can be described in fact as prediction. Based on what the motorists see they have to predict the conditions that follow using empirical predictions of road situations and the behaviour of other traffic participants. Failure of perception or prediction may have fatal results in traffic.

Since perception of traffic signs is a very complex process, the research applies various methods that mainly originate from experimental psychology and have the objective of finding adequate measures of traffic sign perception.

Study of period of time in which the textual traffic signs are still remembered has shown that the motorists remember the sign for more than 30 seconds. Forbes distinguishes two types of legibility: pure and superficial. Pure legibility refers to "unlimited" time of reading. It usually ranges from 0.5 to 1.4 seconds. On the average, 3 to 4 words are read per second on a traffic sign by the motorway.

2. MEASUREMENT PROCEDURE

Efficiency of traffic signs depends on numerous factors, some that can be objectively measured, but also some that are subjective. As a consequence there is a great number of papers studying traffic signs, but these have not resulted in expected knowledge since they still lack a defined systemic quality. One of the research methods is the laboratory research of traffic sign efficiency using simulation.

Simulation applied in this work belongs to the so-called terminating simulations. These are simulations that end with the occurrence of a certain pre-specified event D. The measures of the system characteristics are defined in relation to the time interval $(0,T_D)$, where T_D is the moment of simulation at which the event D occurred. In case of terminating simulations, the characteristic measures depend on the state of the system at the starting moment 0. Thus, in simulating motorist's visual perception of traffic sign under certain weather conditions, event D occurs when the subject does or does not register the traffic sign during the simulation experiment. The starting point 0 is the traffic scene presented to the subject at a certain time. In terminating simulation the system characteristic measures are obtained as the consequence of simulation which ends with the terminating event. One performance of simulation gives one observation, i.e. one value of output variables describing the system characteristics. When a terminating simulation is performed several times independently, these provide a sample of independent identical distribution of the system characteristics which in turn provides the necessary characteristic estimates.

Regarding fluctuation of output variables of the simulation model, the average values are no sufficient measure of system characteristics. Moreover, the average values themselves are not even sufficient for a precise description of the estimate of expected values of output variables since average values differ from sample to sample.

The estimate of the real value of system characteristics must therefore also contain at least the estimate of reliability interval for the expected characteristics value. This is the interval which contains the expected characteristic value. For the estimate of the reliability interval, the reliability with which it will be realised may be given as well.

The usual approach to the reliability interval structure has been used by performing a fixed number (n) of simulation experiment repetitions. If the obtained estimates $X_1, X_2, \ldots, X_n$ are random variables with normal distribution, then the reliability interval with reliability $(1\text{-}\alpha)$ equals:

$$\overline{X}(n) \pm t \cdot \sqrt{\frac{s^2(n)}{n}} \tag{1}$$

In relation (1) $\overline{X}$ is arithmetic mean, t is reliability coefficient (Student's distribution), and s variance (standard deviation).

Since X_i –s rarely have normal distribution, this interval in fact approximates the reliability interval. The fewer the number of experiment repetitions, and the more the probability distribution of X_i –s is asymmetric, the matching of the expected values with the reliability interval is less than $(1\text{-}\alpha)$ (i.e. the calculated reliability interval contains less than $(1\text{-}\alpha)$ times the expected value X).

With a fixed value n, the obtained reliability interval scope of the output variable depends on the value of variance $s^2(n)$. If the obtained reliability interval is too wide, the magnitude of the sample n that will provide an adequate interval scope needs to be determined.

The procedure for obtaining the reliability interval of desired precision is:

- let γ be the desired value of relative precision of reliability interval $(0 < \gamma < 1)$:

$$\frac{t \cdot \sqrt{\frac{s^2(n)}{n}}}{\overline{X}(n)} \tag{2}$$

Then first these steps will be undertaken:

1. The selected n_0 initial simulation repetitions will be performed and set $n = n_0$
2. Based on the obtained $X_1, X_2, \ldots, X_n$ the following will be calculated

$$\overline{X}(n) \pm t \cdot \sqrt{\frac{s^2(n)}{n}} \tag{3}$$

3. If relative precision is obtained

$$\frac{t \cdot \sqrt{\frac{s^2(n)}{n}}}{\overline{X}(n)} \leq \gamma \tag{4}$$

then the following will be accepted

$$\overline{X}(n) \pm t \cdot \sqrt{\frac{s^2(n)}{n}} \tag{5}$$

as approximate $(1\text{-}\alpha)$ interval of reliability and the procedure is completed.

If the obtained precision is greater than the desired precision γ, one additional repetition of the simulation $(n \rightarrow n + 1)$ will be performed and then returned to step 2.

Experience has shown that close match of $(1\text{-}\alpha)$ is obtained for $n_0 \geq 10$ and $\gamma \leq 0.15$.

In order to obtain as precise conclusions about the whole group of motorists as possible, the sample must be representative. The sample is representative if in its basic characteristics it in fact represents a reduced image of the basic set.

3. THE EXPERIMENT

Basic characteristic of the basic set of motorists are known and regarding age and the motorist's experience well defined. Potential subjects, participants in the experiment are in fact students of the Faculty of Transport and Traffic Engineering, and their age did not permit forming of a representative group based on age. However the representativeness of the sample consisted in the motorists' experience.

Using the usual classification of motorists regarding driving experience, the motorists were classified as: group I – low experience motorists (travelled up to 15,000 km), group II – motorists with several years of experience (between 15,000 and 60,000 km), group III – experienced motorists (between 60,000 and 100,000 km) and group IV – extremely experienced motorists (over 100,000 km). The percentage of motorists classified according to these groups depended on the level of road development and the number of vehicles in a certain region, so that scopes of the mentioned groups of motorists according to driving experience were relatively wide ranging as follows: from 10 to 20% of motorists in group I, 30 to 50% in group II, 20 to 35 % in group III, and 5 to 20 % in group IV. In forming of the groups the mentioned criteria tried to be fulfilled.

Ten groups with twenty motorists each were tested. Every group was shown slides simulating a drive towards an intersection with the traffic sign showing directions towards Karlovac (to the left) and towards Slavonski Brod and Varaždin (to the right). Thus, the so-called third level of driving was simulated. The simulated situation included good visibility conditions, that is, a clear sunny day about noon, and poor visibility conditions – slight fog in early morning hours. In showing the slides the time was taken into consideration according to the relation:

$$T = 0.784 + 0.167 \times N,$$

where N is the number of words on the traffic sign and T is the necessary time to read the message in seconds.

This relation is the result of research performed on a simulator using a system for estimating motorists' visual perception of information (J.J. Collins, and M. McDonald).

Before testing, the subjects filled in a form and the following data were obtained: code of the place of test (for unambiguous connection of motorist's data with the responses obtained during the experiment), date and time of test, age (in years), gender, motorist category (A, B, C, D, E), number of years since the motorist obtained a driving licence, travelled kilometres, data on penalty points, and if any for what reason.

After showing the situation of good, i.e. poor visibility, the subjects filled in a form with the data and answers to the given questions: code of the place of test, slide code (shown before the traffic scene), whether the traffic sign was observed, whether there was a textual traffic sign, if observed then the number of words had to be circled (two, three, four, more) and the text written down.

From the obtained data the following was calculated:

1) arithmetic mean of the set from relation

$$\bar{X}(n) = \frac{\sum_{i=1}^{n} \bar{X}_i}{n}$$

2) sample distribution variance

$$var(\bar{X}) = \frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n}$$

3) standard error of the arithmetic mean estimate of the basic set

$$se(\bar{x}) = \frac{var(\bar{X})}{\sqrt{n}}$$

4) for 95% reliability, i.e. 5% significance, the reliability coefficient t = 1.96 has been taken and the arithmetic mean estimate intervals of the main set calculated according to the relation.

$$\bar{x} = \bar{X}(n) \pm t \cdot se(\bar{x})$$

Based on the obtained results it has been concluded that in studying the influence of the motorist's experience on the efficiency of the textual traffic sign the responses given by motorists with several years of experience and experienced motorists need to be considered.

Table 1 (good visibility)

YES refers to the question whether the subject observed the existence of a traffic sign

number of experiment	II	III	YES	$\bar{X}_i$
1	9	6	14	0.933
2	8	7	15	1.000
3	10	6	14	0.875
4	8	6	12	0.750
5	9	7	13	0.867
6	8	6	14	1.000
7	10	4	10	0.714
8	8	6	12	0.750
9	7	7	10	0.714
10	7	6	12	0.857

$\bar{X} = 0.846 \qquad 0.839 < \bar{x} < 0.853$

Using the relation (2) for $\gamma = 0.011 < 0.15$ is obtained thus achieving the desired precision and not needing any additional experiments.

Table 2 (good visibility)

YES refers to the right answer regarding the number of words contained by the traffic sign

number of experiment	II	III	YES	$\bar{X}_i$
1	9	6	13	0.867
2	8	7	14	0.933
3	10	6	14	0.875
4	8	6	11	0.714
5	9	7	11	0.687
6	8	6	14	1.000
7	10	4	9	0.643
8	8	6	10	0.714
9	7	7	9	0.643
10	7	6	12	0.857

$\bar{X} = 0.793 \qquad 0.784 < \bar{x} < 0.802$

$\gamma = 0.014 < 0.15$

Table 3 (good visibility)

YES refers to the right answer regarding the text on the traffic sign

number of experiment	II	III	YES	$\overline{X}_i$
1	9	6	11	0.733
2	8	7	12	0.800
3	10	6	12	0.750
4	8	6	9	0.643
5	9	7	10	0.625
6	8	6	12	0.857
7	10	4	8	0.571
8	8	6	10	0.714
9	7	7	8	0.571
10	7	6	10	0.769

$\overline{X} = 0.703 \qquad 0.698 < \bar{x} < 0.708$

$\gamma = 0.010 < 0.15$

Table 4 (poor visibility)

YES refers to the question whether the subject observed the existence of the traffic sign

number of experiment	II	III	YES	$\overline{X}_i$
1	9	6	13	0.867
2	8	7	13	0.867
3	10	6	12	0.750
4	8	6	10	0.714
5	9	7	10	0.667
6	8	6	12	0.857
7	10	4	10	0.714
8	8	6	11	0.786
9	7	7	9	0.643
10	7	6	9	0.692

$\overline{X} = 0.756 \qquad 0.752 < \bar{x} < 0.760$

$\gamma = 0.006 < 0.15$

Table 5 (poor visibility)

YES refers to the right answer regarding the number of words on the traffic sign

number of experiment	II	III	YES	$\overline{X}_i$
1	9	6	10	0.667
2	8	7	11	0.733
3	10	6	10	0.625
4	8	6	8	0.571
5	9	7	8	0.533
6	8	6	9	0.643
7	10	4	9	0.643
8	8	6	9	0.643
9	7	7	7	0.500
10	7	6	8	0.615

$\overline{X} = 0.568 \qquad 0.560 < \bar{x} < 0.575$

$\gamma = 0.012 < 0.15$

Table 6 (poor visibility)

YES refers to the right answer about the text on the traffic sign

number of experiment	II	III	YES	$\overline{X}_i$
1	9	6	7	0.467
2	8	7	8	0.533
3	10	6	7	0.438
4	8	6	7	0.500
5	9	7	6	0.400
6	8	6	7	0.500
7	10	4	6	0.428
8	8	6	8	0.571
9	7	7	6	0.428
10	7	6	7	0.538

$\overline{X} = 0.480 \qquad 0.478 < \bar{x} < 0.482$

$\gamma = 0.003 < 0.15$

Table 7

group re. driving experience	good visibility		poor visibility		observed:
	$\overline{X} =$	$< \bar{x} <$	$\overline{X} =$	$< \bar{x} <$	
I, II, III, IV	0.890	$0.880 < \bar{x} < 0.892$	0.780	$0.762 < \bar{x} < 0.798$	existence of traffic sign
II, III	0.846	$0.839 < \bar{x} < 0.853$	0.756	$0.752 < \bar{x} < 0.760$	
I, II, III, IV	0.830	$0.792 < \bar{x} < 0.867$	0.630	$0.610 < \bar{x} < 0.650$	exact number of words on traffic sign
II, III	0.793	$0.784 < \bar{x} < 0.802$	0.568	$0.560 < \bar{x} < 0.575$	
I, II, III, IV	0.705	$0.670 < \bar{x} < 0.740$	0.490	$0.480 < \bar{x} < 0.500$	exact text content on traffic sign
II, III	0.703	$0.698 < \bar{x} < 0.708$	0.480	$0.478 < \bar{x} < 0.482$	

The analysis of the obtained results included also comparison with the corresponding results obtained for the representative set of subjects of all the experience groups (see the paper "Efficiency of textual traffic sign depending on the visibility" – to be published), which provides conclusions on the influence of motorist's experience on the efficiency of textual traffic signs.

4. CONCLUSION

It is clear from the obtained results that the percentage of motorists who observed the existence of the traffic sign is satisfactory both for the clear day, i.e. good visibility, and for the poor visibility in morning hours. It is obvious that substantially fewer motorists with several years of experience and experienced motorists (groups II and III) observe the traffic sign, than the motorists with little experience and extremely experienced motorists. This conclusion refers to all regarding both studied situations of visibility as well as to recording of the exact number of words or the exact text on the traffic sign.

Thus, the motorist's experience has a significant influence on traffic sign perception and the information it carries. Motorists with little experience pay attention to almost any information related to traffic, and the extremely experienced motorists use the empirical prediction of situation and perceive mainly major information regarding traffic including traffic signs. A significant percentage of motorists with several years of experience and experienced drivers (groups II and III) classify textual traffic signs among information that are not crucial for their successful participation in traffic.

According to experiment results, less than 65% of motorists in poor visibility conditions registered the number of words on the traffic sign, and less than 50% registered the exact content. This leads to the conclusion that the traffic sign does not fulfil its function in the given situation.

SAŽETAK

UTJECAJ ISKUSTVA VOZAČA NA EFIKASNOST TEKSTUALNOGA PROMETNOG ZNAKA U OVISNOSTI O VIDLJIVOSTI

Sadržaj istraživanja je nalaženje utjecaja iskustva vozača na efikasnost tekstualnoga prometnog znaka u ovisnosti o vidljivosti, odnosno meteorološkoj situaciji. Simulacijom prometne situacije za dva različita stanja vidljivosti (dobrog i slabog) provedeno je ispitivanje reprezentativnog uzorka vozača glede vozačkog iskustva.

Rezultati istraživanja ukazuju na značajnu zavisnost efikasnosti prometnog znaka o iskustvu vozača. Efikasnost tekstualnog prometnog znaka značajno je manja kod vozača s višegodišnjim vozačkim iskustvom i iskusnih vozača nego kod vozača s manjim iskustvom i izuzetno iskusnih vozača, a što se tumači ocjenom vozača o značaju prometnog znaka.

Prema eksperimentalnim rezultatima je manje od 65% vozača u situaciji slabe vidljivosti registriralo broj riječi na prometnom znaku, a manje od 50% točan sadržaj, te se može smatrati da znak ne ispunjava funkciju u toj situaciji.

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