



Evaluating the Road Environment Through the Lens of Professional Drivers: A Traffic Safety Perspective

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Abstract: In the context of traffic safety, the interplay between the road environment and the human factor emerges as a critical determinant of the severity of road crash consequences. This study was designed to explore the perceptions of professional drivers regarding the road environment, with a particular focus on the elements that either contribute to or mitigate safety risks. A comprehensive survey was conducted, wherein 118 professional drivers from the Republic of Serbia were asked to rate photographs depicting various road environments in terms of safety. The investigation aimed to elucidate the extent to which these drivers recognize and assess road hazards, as well as to examine potential variations in their evaluations based on demographic characteristics. The findings underscore the significant impact of the road environment on traffic safety, particularly highlighting the role of solid obstacles such as trees, pillars, and masonry objects. When vehicles veer off the road, collisions with these obstacles frequently result in exacerbated outcomes of road crashes. The methodology employed in this research involved a quantitative analysis of the survey responses, ensuring a systematic evaluation of the drivers' perceptions. The study contributes to the existing body of knowledge by offering insights into the evaluative processes of professional drivers concerning the road environment, thereby informing strategies aimed at enhancing driver safety.

Keywords: Professional drivers; Road environment evaluation; Traffic safety; Risk perception

1 Introduction

Participating in traffic is a complex activity that requires from all drivers, especially professional drivers, a high level of ability, knowledge, skills, and responsible behavior. These key elements depend not only on traffic knowledge and culture, but also on many other factors. Lack of knowledge, skills, and attitudes, as well as risk perception, can lead to mistakes, the consequences of which can result in road crashes. An important factor in reducing the consequences of driver mistakes is the passive safety of the road environment. When it comes to the dominant characteristics of drivers, many studies [1, 2] point out a strong association between drivers' risk perception and actual involvement in road crashes. One of the misconceptions is that only mistakes or inappropriate driving are the main causes of road crashes, which proves to be incorrect in many traffic situations. The results of various studies on the causes of road crashes emphasize the significant influence of the road factor as well as the road environment, which is reflected in every third road crash [3]. The road and its surroundings are key factors affecting passive road safety. This statement gains weight when considering numerous elements of the road and the environment that contribute to the occurrence and severity of the consequences of road crashes.

Developed countries, guided by this knowledge, have taken significant steps in improving road safety, focusing on improving roads and their environment. Recent studies [4–6] unequivocally indicate that roads and road environments contribute significantly to the consequences and severity of road crashes, often more than raw statistical data show.

In contrast, in underdeveloped countries such as Nigeria, South Africa, and Angola, the road factor is often not adequately recognized as a factor contributing to the severity of the consequences of road crashes.

Many studies [2–4] specifically investigated the influence of road conditions and the road environment on the occurrence of road crashes. On the other hand, several studies [7, 8] contain examples of road crashes with fatal outcomes, with human and road factors being one of the causes. These studies highlight the invalidity of statistical data in Serbia, where driver behavior is often identified as the primary cause, while subsequent expert analyses have shown that the real cause of the crash was inadequate or poorly maintained infrastructure.

Traffic accidents represent a significant global public health issue. The World Health Organization [9] reports a staggering 1.35 million annual fatalities on the roads worldwide. Unfortunately, in the Republic of Serbia, in 2022, 33230 road crashes occurred. In the mentioned road crashes, 553 people died, 3292 people were seriously injured, and 15758 people suffered minor injuries. For 79 road crashes with a fatal outcome, the road and its surroundings are the main causes of road crashes. Professional drivers were involved in 53 fatal road crashes in 2022. The training of professional drivers, together with the other measures set at the European, national and local levels, contributed to a 37% reduction in road fatalities involving trucks between 2003 and 2010, despite a 15% increase in the circulating fleet. Directive 2003/59/EC on the initial qualification and periodic training of trucks and buses' drivers entered into force on September 10, 2003. The goal of the Directive is to enhance road safety in Europe by ensuring a common level of training, and the achievement of the necessary skills and competences for professional drivers to drive their vehicles.

Since early road safety research, it has been accepted that drivers modify their behavior according to their perceived level of risk [6, 10]. Earlier theories held that drivers keep risk constant by adjusting their driving. However, experimental evidence points to the complexity of the relationship between driving and risk. Certain studies have investigated how drivers perceive the road and hazards [7, 10], finding that drivers primarily perceive danger in their central visual field, while experienced drivers have a wider field of vision than less experienced drivers. This research further found that the events and situations rated as risky varied from driver to driver, with the greatest differences among those with a range of experience. Professional drivers are among the most experienced drivers. However, their risk is also directly related to the route they get to drive, which is directly related to the delivery to the given location, which largely depends on the organization of distribution logistics centers [11–13].

The mentioned facts provide the basis for conducting survey research, where the respondents evaluated the safety of the road environment, as shown in the photographs. The goal of this approach was to investigate how professional drivers perceive and evaluate the road environment. Analyses include various demographic characteristics, traffic behavior and comparing driver ratings with those of recognized traffic safety experts. These results represent a valuable contribution to the understanding of risk perception and road safety, with the potential for further improvement of road safety strategies, especially with an emphasis on professional drivers.

2 Methodology

2.1 Questionnaire















The research was conducted through a survey created on the “Google Forms” platform. The survey included 25 questions, with the first group of questions aimed at collecting the respondents' demographic data (gender, age, place of residence, education, etc.). The next set of questions related to examining the characteristics of respondents related to participation in traffic (e.g. category of driver's license) and participation in road crashes (number of road crashes, category of vehicle the respondent was driving when participating in a road crash, etc.). The last group consisted of questions aimed at evaluating the passive safety of the road environment by the respondents.

2.2 Method of Test Conducting

Respondents evaluated the appearance of the road environment, using scores from 1 (unsafe road) to 7 (safe road) based on the photos posted in the survey. The first group of photos is taken from the “Highway Safety Manual Knowledge Base” [14]. These authors illustrated examples for a particular grade of road with photographs. The second group of photos was created according to the design of the photos from the first group, where each photo of the road environment assessment shown in the literature corresponds to the same photo of the road environment, but at a different location. The above-mentioned two-photo approach for the same road evaluation allows the examination of potential differences between the road environment shown in the literature and the actual image of the road environment at another location. Also, such a draft ensures the validity of the results. Respondents who gave opposite answers in the first and second sets of photographs (e.g. for a photograph from the literature that carries a score of 2, the respondent assigns a score of 6 in the first set and a score of 2 in the second set) were eliminated from the survey, considering that they did not pay enough attention when filling out the survey. Photos from the literature and photos used to verify the results are shown in Table 1. The last two months of 2023 are the period in which the online survey was conducted. Truck drivers and bus drivers in public and private companies were surveyed. Respondents did not receive any compensation for their participation. Also, all ethical measures,

rights and discretion of the respondents were respected during the research. Each respondent was tested individually and underwent preliminary trials [15].

Table 1. Display of photos from the literature and control photos

Rating of Road Environment Safety in the Literature (From the Least Safe to the Most Safe Road)	Photo from Literature [14]	Control Photos
Grade 1		
Grade 2		
Grade 3		
Grade 4		
Grade 5		
Grade 6		
Grade 7		

2.3 Data Processing

The data from the questionnaires was entered into a database created in the MS Excel 2022 software package. Statistical analysis of the data was performed using the statistical software package IBM SPSS Statistics v.23, and standard methods of descriptive and analytical statistics were used. At the beginning of the statistical data processing, the reliability of the test (Cronbach's alpha) was determined. Based on the distribution of frequencies and cross-tabulations, a detailed statistical analysis is presented, which includes the connection between the results of the survey and the demographic characteristics of the respondents. The normality of the distribution was tested by histogram inspection and the Kolmogorov-Smirnov test. Since the distributions of all interval variables deviated statistically significantly from the normal distribution, non-parametric methods were used. Kruskal-Wallis and Mann-Whitney rank-sum U-tests were used to assess the significance of the difference. Pearson's rank correlation (ρ) was used to examine the strength and direction of the linear relationship between two variables. The null hypothesis (H_0) is set, which reads: There is no statistically significant difference between the groups, and the working hypothesis (H_a), which reads: There is a statistically significant difference between the groups. The threshold of statistical

significance (α) was set at 5%. Therefore, if $p \geq 0.05$, H_0 is rejected and H_a is accepted, and if $p > 0.05$, H_0 is accepted.

3 Results

In the continuation of the research, the results obtained from the survey are shown, first the results of descriptive statistics, then the comparative evaluation of the road environment for the results obtained for the evaluations from the literature and control photos. Finally, the results of the evaluation of the road environment are given in comparison with the results of the participation of professional drivers in road crashes.

3.1 Descriptive Statistics

118 respondents participated in the survey, of which 8% were female and 92% were male. The average age of respondents who took part in the survey is about 39 years old. The largest percentage of respondents have completed secondary school (75.6%), while the rest of the respondents have only completed primary school or higher education. About $\frac{3}{4}$ of the respondents are from urban areas, while the rest are from rural areas. 24 non-professional drivers also participated in the research, for the purposes of the control group.

When analyzing the vehicle category for which respondents have a driver's license, all respondents have a driver's license for passenger cars, 82% of respondents have a driver's license for trucks, 18% for buses, and 91% of respondents have a license for a trailer. According to the average age of the respondents, the largest percentage has a driver's license between 20 and 30 years old (about 62%). Almost 25% of respondents declared that they participated in a road crash. Respondents who participated in a road crash experienced almost three road crashes on average (the average number of road crashes is 2.82). By assessing the reliability of the instrument for measuring the questionnaire, an alpha coefficient of 0.802 was obtained, which is considered a desirable value in research.

3.2 Comparative Assessment of the Road Environment

Figure 1 shows the average road environment safety ratings given by the respondents for the displayed photos from the literature and similar photos used for the purpose of checking the ratings. It was found that the respondents rated the road environment most closely in accordance with the literature with a score of 3 (average score of 3.21). However, more significant deviations are noticeable in scores of 6 and 7 (average scores of 4.82 and 5.92, respectively).

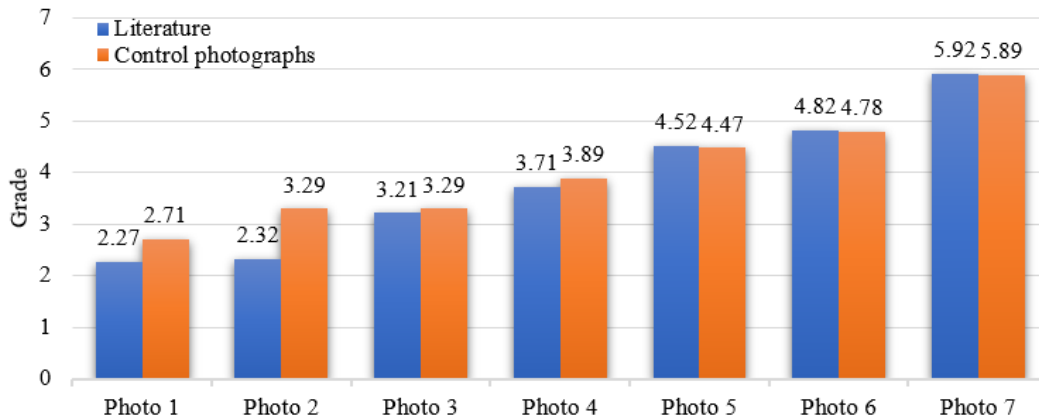


Figure 1. Display of road environment safety ratings by subjects for photos from the literature and control photos

Table 2. Pearson correlation results for respondents' ratings of road environment safety for literature photos and control photos

	Photo 1	Photo 2	Photo 3	Photo 4	Photo 5	Photo 6	Photo 7
Pear. Corr.	0.198**	0.179**	0.427**	0.348**	0.427**	0.448*	0.457**
Sig.	0.018	0.024	0.001	0.002	0.001	0.001	0.001
N	118	118	118	118	118	118	118

The conclusion from these results indicates that, in comparison with the literature, respondents rated less safe road environments with higher scores (scores from 1 to 3). On the contrary, with lower scores compared to the

literature, they rated the roads as safer (scores from 4 to 7). A similar pattern was observed when evaluating the safety of the road environment in control images.

A statistical analysis of the data revealed a correlation between the safety ratings of the road environment given by the respondents to photos from the literature and control photos (Table 2). For each of the ratings, there is a strong positive correlation between the subjects' ratings of the literature photos and the control photos. This additionally indicates that the respondents devoted themselves carefully to the task and applied the same criteria during evaluation.

3.3 Road Crashes and Evaluation of the Road Environment

The results of the Mann-Whitney U test, shown in Table 3, show statistically significant differences between professional drivers who participated and who did not participate in road crashes for the evaluation of road environment safety on the photos from the literature, rated 6 ($Z = 5.114$; $p < 0.001$) and 7 ($Z = 4.724$; $p < 0.001$). It can be concluded that professional drivers who participated in at least one road crash evaluated the passive safety of the road environment with lower ratings than their colleagues who did not experience a road crash. This finding indicates that professional drivers who have experienced at least one road crash have a better perception of the risk to the road environment, which may be important for improving their safety behavior in traffic.

Table 3. Results of the Mann-Whitney U test for professional drivers for the assessment of road environment safety

	Photo 6	Photo 7
Mann-Whitney U	5472.0	4278.0
Wilcoxon W	7889.5	7249.0
Z	5.114	4.724
Asymp. Sig. (2-tailed)	0.001	0.001

3.4 Evaluation of the Road Environment and Age of Professional Drivers

Table 4 shows the results of the Kruskal-Wallis test, which show statistically significant differences in the assessment of road environment safety according to the age of the professional drivers who participated in the research. Namely, for the photos that were rated 3 and 4, the law applies that the said photos were rated with higher ratings by younger respondents, while older respondents rated them with lower ratings. The above results indicate that older respondents perceive the risk of the road environment better and are more careful when driving.

Table 4. Results of the Kruskal-Wallis test according to the age of professional drivers and the safety rating of the road environment

	Photo 3	Photo 4
Chi-Square	42.275	54.457
df	4	4
Asymp. Sig.	0.003	0.001

3.5 Professional vs Non-Professional Drivers

The results of the Kruskal-Wallis test show that there are statistically significant differences between the largest number of examples, for road environment ratings, between professional and non-professional drivers, as shown in Table 5. Statistically significant differences do not exist for extreme traffic environments, i.e. for the most unsafe traffic environment and for the safest traffic environment, as well as for Photo 5. For all tasks, for which there are statistically significant differences, professional drivers evaluate the road environment significantly better than non-professional drivers.

Table 5. Results of the Kruskal-Wallis test according to the age of professional drivers and the safety rating of the road environment

	Photo 2	Photo 3	Photo 4	Photo 6
Chi-Square	32.214	35.223	56.323	53.456
Asymp. Sig.	0.021	0.014	0.001	0.001

4 Discussion

The aforementioned research examined how and to what extent professional drivers perceive and evaluate the dangers of the road environment, as well as how professional drivers perceive possible differences in evaluations of the road environment, considering the demographic characteristics of the respondents. The research results showed that professional drivers showed significantly better scores in risk perception and road environment safety ratings compared to similar studies focusing on young drivers. These results indicate that the experience of professional drivers, especially those who have participated in road crashes, can significantly influence their ability to assess traffic risks.

A study conducted by Boua et al. [16] shows that drivers with a high sense of control over risk tend to perceive road risks as low and to adopt risky behaviors. These results are in line with several studies in the field of road safety that show that control beliefs lead individuals to underestimate road risk. On the other hand, the study conducted by Chen et al. [17] shows that drivers with low annual mileage, complete insurance coverage, and no prior accident experience were more likely to underestimate driving risk. Another study confirmed that truck drivers perceive risk better [18]. In this study, it was found that professional truck drivers have a better perception of risk in the road work zone.

Conclusions from the results suggest that professional drivers rated the risk for the given photos from the literature and for the control photos with similar ratings. This consistency in risk assessment across the two types of photographs indicates that professional drivers applied consistent criteria during evaluation, which further strengthens the validity of their ratings. The risk perception ratings among older professional drivers were particularly notable, as they showed a better risk assessment of the road environment in contrast to the younger group of professional drivers. This result agrees with previous research that suggests that with age and experience, drivers become more aware of potential traffic hazards [19]. Research suggests that experienced drivers generally exhibit superior risk perception abilities compared to novice drivers. However, the underlying reasons for this phenomenon remain inadequately explored in the existing literature [20–23]. While numerous studies have documented the correlation between driving experience and enhanced risk perception skills, further investigation is warranted to elucidate the specific factors contributing to this relationship. Possible factors may include accumulated driving experience, exposure to diverse driving conditions, cognitive processing differences, and the development of intuitive decision-making strategies over time. Therefore, future research endeavors should aim to delve deeper into the mechanisms underlying the heightened risk perception abilities observed in experienced drivers, thereby providing valuable insights for the enhancement of driver training programs and road safety initiatives.

In light of these findings, the improvement of training programs and comprehensive information for professional drivers, especially young and less experienced ones, about traffic risks may be crucial. Also, the identification of factors that contribute to a better perception of risk among older drivers can provide guidance for the development of preventive measures aimed at the entire driving population. This research contributes to the understanding of risk perception and evaluation of road environment safety among professional drivers, providing valuable insight into the factors that shape their road safety behavior.

5 Conclusions

Based on the collected, processed and analyzed data, the following general conclusions can be drawn:

- Professional drivers rate the road environment most closely in accordance with the literature with a score of 3 (average score of 3.21);
- More significant deviations are noticeable in scores of 6 and 7 (average score of 4.82 and 5.92, respectively);
- Professional drivers slightly underestimate the danger on unsafe roads, while there is a slight overestimation of danger on safe roads;
- Professional drivers who have been involved in road crashes rate the road environment as less safe (they rate it with lower ratings) in contrast to professional drivers who have not been involved in road crashes, who rate it with higher ratings;
- Older professional drivers perceive and evaluate the safety of the road environment more objectively, unlike younger professional drivers.

Based on the obtained results, it can be concluded that the respondents showed significant differences in evaluating the road environment safety compared to previous surveys. Research in the field of perception and assessment of the risk carried by the road factor has shown a large number of methodological problems and limitations. A relatively small number of studies have been conducted to examine the very process of risk perception carried by the road factor, in contrast to a large number of studies that dealt with the process of taking risky maneuvers in traffic and assessing the risk of the human factor. From the perspective of road safety, the driver's perception of risk brought by the road factor is a particularly inspiring area, as it provides a greater possibility of manipulation when designing roads and the road environment, namely it is very important how the driver perceives the road and how he assesses the risk of the section itself and the road environment. The essential problem, which is currently not addressed

by either theory or practice, is reflected in the possibility of predicting and quantifying the benefits or harms that can occur through small changes in the driver's behavior. For example, if a change in the road, results in a small but relatively sustainable change in driver behavior, it is difficult to assess the benefits in terms of improved road safety. In the future, research in this area should be designed with the aim of examining how different road elements affect risk perception, how different road environments can affect changes in driver behavior and how it is possible to improve road safety.

Based on the study's results, it is necessary to implement practical measures such as the use of driving simulators in the training of (professional) drivers. This will enable drivers to gain experience in assessing various levels of road safety. Additionally, when designing roads, attention should be paid to road environment safety, with preventive measures taken to remove or reduce elements that may impact the severity of traffic accidents. These suggestions promise not only to improve risk perception abilities but also to promote safer driving among both novice and experienced drivers.

The limitation of this research may include limitations in the generalization of the results since the research focused only on professional drivers in Serbia. Different local specificities and driving conditions in other geographical areas can affect the perception of road safety. Another limitation of the study is the small sample size. Also, the coverage of respondents' demographic characteristics can be expanded to include a wider population of drivers, providing deeper insight into variations in traffic risk perception. Additionally, it is advisable to incorporate objective road parameters, such as road conditions, signs, lighting, and other relevant factors, for quantitative analysis.

Future research directions could include investigating effective preventive measures and training for professional drivers to improve their risk perception and road safety [24]. Monitoring long-term outcomes and changes in driving behavior following the implementation of certain forms of training or interventions can provide useful information for the development of road safety improvement programs for this specific population of drivers. Future research endeavors will include the integration of driving simulation or on-board recorders to observe professional drivers' actual driving behaviors, thus enhancing the understanding of the relationship between risk perception and driving behaviors. Future research directions should encompass a larger sample size.

Data Availability

The data used to support the research findings are available from the corresponding author upon.

Conflicts of Interest

The authors declare no conflict of interest.

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