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Psychological, safety and environmental impact of the Front Braking Light

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Abstract
Ensuring the protection and safety of participants in road traffic is a crucial aspect of transportation. Incorporating innovative elements can play a pivotal role in reducing property damage and mitigating health consequences in the aftermath of traffic accidents. The use of the front brake light has, among other benefits, an environmental impact. Its use reduces unnecessary braking and unnecessary acceleration, thus saving fuel and reducing greenhouse gas emissions from road traffic. This article examines variations in the perceived importance of integrating innovative elements in road traffic concerning the participants' age and frequency of experience with road traffic. A questionnaire was administered to 239 respondents for the research, and statistical hypotheses were tested using non-parametric methods (Kruskal-Wallis test; Mann-Whitney test). Three-quarters of the respondents positively view the introduction of the front braking light in road traffic. The results indicate that respondents' age and experience with the front braking light influence their perception of the innovative element, considering it a beneficial idea and perceiving more advantages than disadvantages for its long-term implementation in road traffic. As age and experience with the front braking light increase, the positive perception of its contribution to road traffic safety also rises. However, the age and experience of the respondents with the innovative element did not significantly affect their assessment of its impact on the smooth flow of road traffic.

Keywords
safety; front braking light; case study; traffic accidents; road transport participant; environmental impact

Introduction

Road transportation stands out as one of the most extensively utilized modes of transport globally, offering various characteristics that render it indispensable for both personal and commercial purposes. Key attributes of road transportation include flexibility, accessibility, door-to-door service, cost-effectiveness, quick transit times, versatility, reliability in local conditions, personal mobility, support for economic development, and last-mile connectivity (Shen & Wei, 2020).

Playing a pivotal role in modern transportation infrastructures, road traffic facilitates the movement of people and goods across diverse locations (Jakobsen et al., 2023), particularly for short to medium distances. Compared to alternative transportation modes like air or sea, road transportation is recognized for its heightened flexibility, cost-effectiveness, and accessibility (Gottlieb et al., 2018). However, it grapples with a safety concern, exhibiting a lower level of safety in contrast to other transport types. Traffic accidents related to road traffic pose a significant societal challenge for every country (Bioulac et al., 2017; Cioca & Ivascu, 2017), stemming from risks and impatience. Factors influencing these accidents encompass inadequate information among pedestrians and drivers, speed mismatches with road conditions, and other elements (Tiwari, 2017; Onkhar et al., 2022).

The European Union and various states aspire to diminish traffic accidents and enhance road safety. According to the World Health Organization (WHO, 2018), road traffic injuries rank as the leading cause of death for individuals aged 5-29, with approximately 1.3 million annual fatalities attributed to traffic accidents. Over half of these deaths involve vulnerable road users such as pedestrians, cyclists, and motorcyclists. Moreover, 93% of global road deaths occur in low- and middle-income countries, despite these nations possessing only about 60% of the world's vehicles. Traffic accidents impose a considerable economic toll, costing most countries 3% of their gross domestic product. Road traffic safety is a primary strategic goal in many nations (Najaf et al., 2018), and it has garnered significant attention for innovations in the field (Arvin et al., 2016).

In this context, an innovative element in road traffic emerges as a unique solution with the potential to reduce traffic accidents and yield positive consequences, such as minimizing property damage, enhancing safety, and improving the health of road traffic participants (Bugaj et al., 2023). The results from pilot testing underscore the importance of implementing this innovative element in road traffic.

The article seeks answers to scientific questions through the verification of defined hypotheses (see section on statistical methods):

- RQ1: Do older road traffic participants perceive the significance of implementing the front braking light as an innovative element in road traffic more positively compared to younger road traffic participants?
- RQ2: Do road traffic participants with more experience with the innovative element perceive its significance in road traffic more positively compared to road traffic participants with less frequent experience with the front braking light?

The structure of the scientific article comprises an introduction highlighting the necessity and originality, defining scientific questions. The theoretical background consists of a critical literature review on innovation in road traffic, emphasizing enhancing road traffic participant safety and reducing traffic accidents. The research methodology outlines the objective, details data collection, formulates statistical hypotheses, describes verification methods, and explains the respondent sample structure. Results are presented clearly in tables alongside the evaluation of statistical hypotheses. In the conclusion, the main research findings are summarized, users of the findings are identified, and limitations are outlined.

Theoretical background

The contemporary world is undergoing rapid changes, and the business environment is evolving accordingly. Interconnected and highly complex elements shape trends, presenting challenges across all sectors. One industry facing such challenges is the road haulage sector, which is compelled to confront significant issues in a relatively short span, leading to profound transformations and evaluations.

A pivotal factor is the escalating volume of goods in international trade, driven by the simultaneous goals of reducing time and costs while raising quality standards. Another challenge stems from increasingly stringent statutory restrictions on emission standards for harmful substances, particularly in anticipation of future legal requirements. The ongoing technological revolution also introduces numerous challenges for industry stakeholders (Hordofa et al., 2018).

Research indicates that various factors contribute to traffic accidents and fatalities (Mutooro et al., 2010; Orfila et al., 2010), including uncertainty among road traffic participants, environmental and infrastructure conditions, and technical vehicle issues (Bon de Sousa et al., 2016). Factors such as fatigue (Halin et al., 2021), alcohol consumption (Hernández-Rodríguez et al., 2022), emotional state, drowsiness, headaches, respiratory diseases, and fever heighten the risk of traffic accidents (Onaiyekan et al., 2022). Driving under the influence of alcohol remains a common cause of dangerous driver behaviour (Alonso et al., 2017), with age, experience,

fatigue, and health conditions significantly impacting road traffic safety. Consideration is also given to policies on age restrictions and the minimum age for obtaining a driver's license (Alonso et al., 2017; Dimitrios et al., 2021; Cicchino & McCartt, 2015; and Peng et al., 2021).

Studies highlight a significant issue in road traffic – the high rate of accidents among young drivers aged 18 to 24 (Cordellieri et al., 2016; Albert et al., 2018). The main causes include risky behaviour, lack of experience, and inadequate focus (Boyce & Geller, 2002; Maltese & Zamparini, 2023; and Hjorthol, 2016). Risky behaviour encompasses speeding, driving under the influence of alcohol, non-compliance with safety rules, and exposure to a higher risk of accidents due to limited driving experience in various road situations (Tolon-Becerra et al., 2014).

Fatigue has a detrimental impact on road safety, diminishing drivers' ability to control a vehicle and resulting in serious consequences (Zaranka et al., 2021; Liu et al., 2021). Tired drivers tend to make more mistakes, such as speeding, lane crossing, frequent braking, or delayed reactions to traffic (Tippin et al., 2009). Fatigue is also associated with health problems like obstructive sleep apnea, affecting 15 to 30% of the population and often remaining undetected and untreated (Franklin & Lindberg, 2015; Islam Bin & Kanitpong, 2008; and da Silva & Braga, 2018.

A common problem in traffic accidents is the lack of information for participants, leading to incorrect decisions and a weakened ability to anticipate and respond to risky situations (Petříček & Marada, 2022; Muhundan & Myounghoon, 2023; and Zhang et al., 2022). Consequently, research proposes innovations to enhance information availability for road traffic participants.

Various groups of innovations are currently being implemented in road transport to reduce traffic accidents. Autonomous vehicles, designed for self-driving without human intervention, are expected to eliminate human factors such as fatigue, alcohol, and insufficient attention—common causes of accidents (Meyer, 2019a). The research focuses on proposed innovations to address the lack of information for road traffic participants.

Autonomous vehicles and intelligent transportation systems form part of long-term innovations. Autonomous vehicles operate without human intervention, eliminating certain human factors, while intelligent transportation systems use information technology to monitor and manage road traffic, enhancing flow and safety (Carlan et al., 2019; Hamadeh et al., 2021; and Mirboland & Smarsly, 2021). Electronic vehicle safety systems, incorporating technologies like camera systems and radar sensors, contribute to safety enhancement and accident prevention. Safer infrastructure, integrating new technologies into traffic signs and lights, aims to minimize accident risks and improve overall road safety (Hordofa et al., 2018; Peeling et al., 2016).

Innovations in education play a crucial role in enhancing road safety. Utilizing new technologies, such as interactive applications, virtual environments, and driving simulators, provides effective tools for driver training, improves reaction capabilities, and contributes to increased road safety (Wu & Lu, 2022).

Equally significant are innovations addressing the reduction of uncertainty for road users. Uncertainty in road traffic, influenced by factors like adverse weather conditions, unpredictable behaviour of other participants, and technical problems, affects risk perception and safety (Mühl et al., 2020). Various authors propose an integrated approach to alleviate uncertainty (Peters et al., 2017; Monzel et al., 2021; and Al-Madani & Al-Janahi, 2002), highlighting the importance of driver experience as a characteristic influencing participants' safety on the road (Gorge et al., 2020; Chayphong & Iamtrakul, 2023; Myers et al., 2019; and Peng et al., 2021).

Research methodology, methods, and data

The article aims to verify the differences in perception of the importance of implementing an innovative element in road traffic in relation to the age and frequency of experience of road traffic participants.

Data collection

The questionnaire was developed in partnership with the University of Zilina and the Bonn Institute for Legal and Traffic Psychology, which conducted a preliminary study on the front brake light in a non-public space at Berlin Tegel Airport. Monzel et al. (2021) provide additional details on the study's findings. In 2023, the University of Zilina continued its research on real-time traffic in Slovakia's Zilina and Trencin regions.

The questionnaire processing preparation phase lasted from 9/2022 to 11/2022. The survey's goal was to find out what drivers thought of front brake lights before they were installed on automobiles. The purpose was to collect data on which sources of information concerning the front brake light were best delivered to drivers. Another purpose of the study was to gather feedback from drivers about their opinions about the influence of the front brake light on road safety before it was installed on vehicles. The poll was conducted on paper, and each driver was contacted individually and asked to complete the questionnaire.

The University of Zilina retains all the completed questionnaires in its archives. The investigation regarding the front brake light was carried out on a voluntary basis, with carriers responding to a media announcement made between September and October 2022. Considering the total pool of 3000 registered vehicles, drivers who submitted their applications earlier were chosen to ensure a balanced representation of heavy vehicle drivers, bus

drivers, and private vehicle drivers. Even though drivers filled out the paper-based questionnaires under the supervision of an interviewer, out of the 312 questionnaires submitted in total, only 239 were fully completed.

Questionnaire and variables

During the research, we did not investigate the reasons why the questionnaire was not completely filled out. However, the most common reason was the omission of some questions, which can be attributed to inattentiveness during the questionnaire completion. The comprehensibility of the questionnaire questions was tested on doctoral students of Zilina University and professional drivers of Zilina University. Based on their feedback, the questions were reformulated to be more understandable. Since all the drivers who participated in the research were drivers from Slovak transport companies, the questionnaire was distributed only in the Slovak language. However, there is also an English version of the questionnaire, which was reviewed by the Bonn Institute of Legal and Traffic Psychology. The questionnaire consisted of closed-ended questions, except for filter questions where the drivers answered how long they have held a driving license and how long they have been working as drivers. To prevent computerized automatic filling of the questionnaire, it was only used in paper form. The questionnaire also included control questions to verify the consistency of the respondent's attitudes.

The respondent had time to complete the questionnaire according to their own needs. In larger companies, multiple drivers were collectively instructed on how to fill out the questionnaire, and then the drivers completed the questionnaire themselves. In companies with a small number of drivers, interviewers visited the drivers individually and provided instructions on how to fill out the questionnaire. Then, the drivers completed the questionnaire without assistance. The time taken to complete the questionnaire was not recorded, and each respondent submitted the questionnaire when the driver deemed that they had answered all the questions.

The questionnaire included the following statements, which are subject to statistical analysis (Q - question in the questionnaire; see also the Appendix): ST1 (Q6) - Have you heard of the front brake light? ST2 (Q15) - The front brake light is a good idea. ST3 (Q16) - In the long term, the front brake light has more disadvantages than advantages. ST4 (Q17) - The front brake light can increase road safety. ST5 (Q18) - The front brake light can prevent traffic accidents. ST6 (Q19) - The front brake light is unnecessary. ST7 (Q20) - The front brake light can cause a traffic accident. ST8 (Q21) - The front brake light improves pedestrian safety. ST9 (Q22) - The front brake light can improve traffic flow.

The possible responses for ST1 were two: "yes" and "no." For the other statements (ST2 to ST9), respondents had to indicate their agreement or disagreement on a 5-point Likert scale: 1 - Strongly disagree, 2 – Disagree, 3 – Neutral, 4 – Agree, 5 - Strongly agree.

Statistical hypotheses and statistical methods

To fulfil the main objective of the article and address the research questions (see also the introduction), the following statistical hypotheses are formulated:

H1: There are no statistically significant differences in the evaluation of the innovation element "front brake light" (H1_ST2; ...; H1_ST9) among respondents based on their age.

H2: There are no statistically significant differences in evaluating the front brake light (H2_ST2; ...; H2_ST9) among respondents based on their frequency of experience with the innovative element.

In the first step, the assumption of normal distribution was tested for selected statements (ST2 to ST9) using the Kolmogorov-Smirnov and Shapiro-Wilk tests (see Table 2). Based on the obtained results regarding the normality assumption, non-parametric tests (Mann-Whitney test and Kruskal-Wallis test) were used to test the statistical hypotheses instead of parametric approaches, such as one-way analysis of variance (ANOVA).

In the second step, descriptive characteristics such as mean, standard deviation, etc., were calculated for the variables within the selected groups of respondents based on their age and experience with the innovation element. Due to the multiple categories of the gender variable (4 variants), the Kruskal-Wallis test (non-parametric) was applied to determine differences in the evaluation of the innovation element in road transport (ST2 to ST9). The Mann-Whitney test (non-parametric) was used to identify differences in evaluations among respondents based on their experience with the innovation element (2 response variants). All results presented in the article were computed using the analytical-statistical software IBM SPSS Statistics ver. 28.

Structure of respondents

The questionnaire (see Appendix) included demographic characteristics of the respondents, such as gender and age. It also collected information on employment status and the number of kilometres driven by the respondents in a calendar year. Out of ten respondents, nine were male (n = 213; 89.1%). The age distribution of the respondents was as follows: up to 40 years - 64 respondents (26.7%); 41 to 50 years - 63 respondents (26.4%); 51 to 60 years - 80 respondents (33.5%); and over 60 years - 32 respondents (13.4%). Other characteristics of the respondents included the number of kilometres driven in a calendar year, the source of information about the innovation element, and the front brake light. The distribution of respondents' answers was as follows: 83 respondents (34.7%) drove less than 10,000 km in a calendar year; 78 respondents (32.6%) drove between 10,001

and 30,000 km; 47 respondents (19.7%) drove between 30,001 and 60,000 km; 29 respondents (12.1%) drove between 60,001 and 100,000 km, and 47 respondents (19.7%) drove over 100,000 km. Half of the respondents (126; 52.7%) indicated that they obtained information about the front brake light innovation from their employer (or manager) or colleagues at work, while the remaining respondents (113; 47.3%) stated that the primary source of information about the front brake light was the media (such as TV, radio, internet, etc.).

Results

The verification of the assumption of normal distribution for the variables is presented in Tab. 1.

Tab. 1. The results of the normality testing for the selected variables.

ST	DCH				KS-test			SW-test		
	M	SE	Var.	SD	Stat.	Df.	Sig.	Stat.	Df.	Sig.
ST2	3.92	0.078	1.314	1.146	0.265	216	0.000	0.816	216	0.000
ST3	2.79	0.089	1.719	1.311	0.185	216	0.000	0.900	216	0.000
ST4	3.97	0.073	1.162	1.078	0.274	216	0.000	0.805	216	0.000
ST5	3.82	0.077	1.274	1.129	0.244	216	0.000	0.851	216	0.000
ST6	2.46	0.083	1.506	1.227	0.207	216	0.000	0.885	216	0.000
ST7	2.63	0.083	1.501	1.225	0.190	216	0.000	0.901	216	0.000
ST8	4.00	0.077	1.288	1.135	0.253	216	0.000	0.798	216	0.000
ST9	3.61	0.073	1.160	1.077	0.210	216	0.000	0.881	216	0.000

Note: ST – Statements; M – Mean; SE – Standard Error; Var – Variance; SD – Standard Deviation; Stat. – Statistics; Df. – Degree of freedom; Sig. – Significance; KS-test – Kolmogorov-Smirnov test; SW-test – Shapiro-Wilk test. Source: own research results.

From the results of the normality testing for the selected statements (see Table 1), it can be concluded that the assumption of the normal distribution is not met for any of the variables (ST2 to ST9), as the significance values are lower than our predetermined significance level of 0.05.

More than 90% of the respondents (n = 216; 90.37%) indicated that they have knowledge and experience with the innovation element in road transport - the front brake light. The number of respondents who are unfamiliar with and have not heard of the innovation element in road transport is 23 (9.63%). Only the attitudes of respondents with knowledge and experience with the front brake light (n = 216) are the subject of statistical analysis. The distribution of respondents according to age is as follows: (1) up to 40 years old - 61 (28.3%); (2) 41 to 50 years old - 56 (25.9%); (3) 51 to 60 years old - 69 (31.9%); and (4) over 60 years old - 30 (13.9%). The distribution based on the frequency of experience with the innovation element (see Appendix: Q7) is as follows: (1) often and very often - 130 (60.2%); (2) occasionally, rarely - 86 (39.8%).

The evaluation of respondents on the selected statements (ST2 to ST9) according to the previously formulated research criteria (respondent's age, respondent's experience with the innovation element) is presented in Tab. 2.

Tab. 2. Descriptive characteristics of evaluating the innovation element in road transport.

ST	The age of the respondent								The experience of the respondent			
	(1)		(2)		(3)		(4)		(1)		(2)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
ST2	4.049	1.443	4.250	1.405	4.188	1.508	4.467	1.279	4.054	1.059	3.709	1.245
ST3	2.902	1.767	2.786	1.692	2.536	1.720	2.733	1.946	2.646	1.275	3.012	1.342
ST4	3.984	1.576	4.393	1.201	4.478	1.119	4.533	1.252	4.038	1.022	3.872	1.156
ST5	3.754	1.680	4.071	1.475	4.217	1.338	4.333	1.322	3.900	1.063	3.698	1.218
ST6	2.410	1.647	2.607	1.681	2.130	1.514	1.933	1.639	2.431	1.148	2.512	1.344
ST7	2.902	1.767	2.607	1.592	2.275	1.644	2.067	1.461	2.554	1.188	2.733	1.278
ST8	3.984	1.576	4.321	1.390	4.275	1.371	4.533	1.252	4.146	1.012	3.791	1.275
ST9	3.754	1.513	4.000	1.321	3.928	1.438	3.867	1.358	3.662	1.038	3.535	1.134

Note: ST – Statements; M – Mean; SD – Standard Deviation; n – number of respondents. Source: own research results.

From the results (see Tab. 2), it can be assumed that the research criteria (age and experience of the respondent with the innovation element) are significant factors in evaluating the selected statements. This assertion will be further examined and statistically analyzed in the following tables (Tab. 3–5).

Tab. 3. Computation of test statistics for the selected groups of respondents.

The age of the respondent				The experience of the respondent				The age of the respondent				The experience of the respondent			
ST		*n*	MR	ST		*n*	MR	ST		*n*	MR	ST		*n*	MR
ST2	(1)	61	95.30	ST2	(1)	130	115.08	ST6	(1)	61	115.41	ST6	(1)	130	107.75
	(2)	56	104.69		(2)	86	98.55		(2)	56	119.70		(2)	86	109.64
	(3)	69	117.41						(3)	69	97.93				
	(4)	30	121.97						(4)	30	97.87				
ST3	(1)	61	114.26	ST3	(1)	130	101.78	ST7	(1)	61	121.08	ST7	(1)	130	105.16
	(2)	56	112.19		(2)	86	118.65		(2)	56	114.04		(2)	86	113.55
	(3)	69	101.43						(3)	69	98.89				
	(4)	30	106.17						(4)	30	94.68				
ST4	(1)	61	93.11	ST4	(1)	130	111.49	ST8	(1)	61	95.47	ST8	(1)	130	114.49
	(2)	56	112.32		(2)	86	103.98		(2)	56	109.03		(2)	86	99.45
	(3)	69	117.46						(3)	69	117.82				
	(4)	30	112.03						(4)	30	112.58				
ST5	(1)	61	94.47	ST5	(1)	130	111.93	ST9	(1)	61	99.18	ST9	(1)	130	110.69
	(2)	56	107.08		(2)	86	103.31		(2)	56	109.79		(2)	86	105.19
	(3)	69	119.34						(3)	69	115.93				
	(4)	30	114.75						(4)	30	107.95				

Note: ST – Statements; MR – Mean Rank; SD – Standard Deviation; *n* – number of respondents. Source: own research results.

The results of the mean rank (MR; see Tab. 3) for the evaluations of the selected groups of respondents indicate differences in perceptions of the individual statements regarding the importance of implementing the innovation element – the front brake light in road traffic.

Now, the focus will shift to verifying statistically significant differences in the evaluations of respondents based on the age of the respondent and the respondent's experience with the front brake light, using non-parametric tests (see Tab. 4).

Tab. 4. Verification of disparities in the evaluation of the innovation element in road transport.

CR	TT	Statements (ST)							
		ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9
AR	KW-test	6.38	1.72	6.36	5.99	5.72	6.35	4.88	2.57
	df	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
	Sig.	0.094*	0.633	0.096*	0.112	0.126	0.096*	0.181	0.463
ER	MW-test	4734	4717	5201.5	5144	5492	5155	4811	5305
	Z	-2.01	-1.99	-0.92	-1.04	-0.22	-0.99	-1.84	-0.66
	Sig.	0.045**	0.047**	0.358	0.300	0.822	0.320	0.066*	0.508

Note: TT – Type of non-parametric Test; CR – Criterion of Research; KW-test – Kruskal-Wallis test; MW-test – Mann-Whitney test; Sig. – Significance; * $\alpha = 0.1$; ** $\alpha = 0.05$; *** $\alpha = 0.01$. Source: own research results.

The results confirmed that there are statistically significant differences in the evaluations of respondents based on age for statements ST2, ST3, and ST7 regarding the innovation element in road transport. Additionally, it was confirmed that there are statistically significant differences in the evaluations of respondents for statements ST2, ST3, and ST8 based on their experience with the innovation element in road transport. The results showed no statistically significant differences in the evaluations of respondents for statements ST4, ST5, ST6, and ST9 based on age and experience with the innovation element in road transport.

A clear evaluation of the formulated hypotheses (SHs) of the empirical research is presented in Tab. 5.

Tab. 5. The evaluation of the formulated statistical hypotheses.

Type of SH	Statements (ST)							
	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9
Sign of SH1	H1_ST2	H1_ST3	H1_ST4	H1_ST5	H1_ST6	H1_ST7	H1_ST8	H1_ST9
E of SH1	Rejected	Supported	Rejected	Supported	Supported	Rejected	Supported	Supported
Sign of SH2	H2_ST2	H2_ST3	H2_ST4	H2_ST5	H2_ST6	H2_ST7	H2_ST8	H2_ST9
E of SH2	Rejected	Rejected	Supported	Supported	Supported	Supported	Rejected	Supported

Note: SH – Statistical hypothesis; E – Evaluation. Source: own research results.

Discussion

The empirical findings have revealed intriguing results. The respondents' age emerges as a significant factor influencing the assessment of the innovative element in road transport, specifically the "front brake light," which was deemed a favourable concept by almost one-third of the surveyed participants (73.6%). Younger respondents (up to or equal to 40 years old) exhibit a lower agreement with this notion (65.6%) compared to older counterparts (e.g., 51 to 60 years old - 75.4%; over 60 years old - 83.3%). Those who frequently observe the front brake light in road traffic (78.5%) express greater agreement with the idea than those who seldom encounter it (66.3%). Experience with the front brake light plays a significant role in shaping this assessment.

Approximately half of the respondents (45.8%) believe that the front brake light does not have more disadvantages than advantages in the long term. The age of the respondent proves to be a crucial factor in this evaluation, with younger respondents (up to or equal to 40 years old) displaying a lower agreement with this statement (41.0%) compared to older respondents (e.g., 51 to 60 years old - 50.7%; over 60 years old - 53.3%). Those who frequently witness the front brake light in road traffic (52.3%) are more likely to agree that it has more advantages than disadvantages in the long term, in contrast to respondents with infrequent exposure (36.0%). Once again, experience with the front brake light significantly influences this assessment.

Three-quarters of the surveyed participants (76.4%) believe that the front brake light can enhance road safety, with a similar percentage (75.5%) indicating that it improves pedestrian safety. Within this context, 68.1% assert that the front brake light can prevent traffic accidents. However, only 56.9% believe that it can enhance traffic flow. This effect of the front brake light is essential, especially from the point of view of the impact on the environment. An increase in traffic flow causes a reduction in fuel consumption, a reduction in traffic emissions and a reduction in vehicle wear and tear (tyres, brake components). The respondents' age and frequency of experience with the innovative element do not significantly impact these statements.

Half of the respondents (49.5%) believe that the front brake light cannot cause a traffic accident. The age of the respondent is a pivotal factor in shaping this belief, with younger respondents (up to or equal to 40 years old) exhibiting a lower agreement with this statement (41.0%) compared to older respondents (e.g., 51 to 60 years old - 58.0%; over 60 years old - 60.0%). The frequency of the respondent's experience with the front brake light does not significantly influence this assessment.

One-fifth of the surveyed participants (21.3%) agree with the statement that the front brake light is unnecessary in road transport. Experience with the front brake light significantly influences this viewpoint, with those who frequently observe it in road traffic expressing less agreement (18.5%) compared to those with infrequent exposure (25.6%). The respondent's age is not a crucial factor affecting the assessment of this statement.

Monzel et al. (2021) conducted a similar study at an airport in Berlin, albeit in a non-public area. The research empirically demonstrated that installing a front brake light on motor vehicles might contribute to increased safety in road transport. However, the authors emphasize the need to verify these results in real-world conditions, as the airport setting may distort the positive impact of the front brake light on road safety.

The innovative element in road transport, represented by a front brake light, holds the potential to reduce traffic accidents in various scenarios, including left turns (Al-Madani & Al-Janahi, 2002), lane changes (Gorge et al., 2020), narrow roadways, and pedestrian crossings (Chayphong & Iamtrakul, 2023).

Conclusions

The article aimed to examine variations in the perception of the importance of implementing the innovation element in road transport, taking into account the participants' age and frequency of experience in road traffic.

As the respondent's age and experience with the front brake light increase, there is a corresponding rise in the positive perception of the front brake light in road transport as a good idea. Additionally, with increasing age and experience with the front brake light, the advantages of its use outweigh the disadvantages. Older respondents tend

to believe less that the front brake light can cause a traffic accident compared to younger respondents. The respondent's experience with the front brake light does not impact the evaluation of whether it can cause a traffic accident. Furthermore, as the respondent's experience with the front brake light increases, the perception of its unnecessary nature decreases. However, the age and experience of the respondent with the front brake light do not significantly influence the evaluation of the innovative element in road transport concerning increasing road safety, enhancing pedestrian safety, and preventing traffic accidents. More than half of the respondents believe the front brake light can improve the traffic flow. It means that it will have a positive environmental impact.

The empirical findings from the case study hold significance for state or public administration, which is responsible for approving technical requirements for motor vehicles. Implementing the front brake light for all motor vehicles has the potential to enhance road safety by reducing accidents and property damage, as well as improving overall road user safety. However, it is noted that the formulated research questions (RQs) are only partially confirmed as they apply to selected statements.

The pilot study has limitations, including data collection being limited to one region (Trenčín Region) in the Slovak Republic and a sample of 239 participants in road traffic. Subjectivity in the evaluation by road users may introduce biases or lead to overestimation/underestimation of the innovative element in road transport. Non-parametric tests were exclusively applied to verify statistical hypotheses, which have lower power compared to parametric tests.

The upcoming main phase of the currently underway research aims to have a more robust sample of respondents. The authors also plan to focus on the possibility of implementing the front brake light on motorcycles. Future publication activities will concentrate on optimizing the configuration of the front brake light, particularly prioritizing factors like light intensity and its placement height on the motor vehicle.

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Appendix

FRONT BRAKE LIGHT - QUESTIONNAIRE

First name and last name:_____

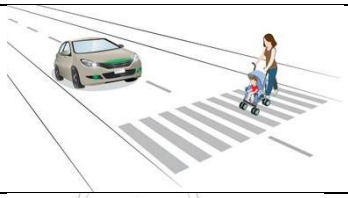
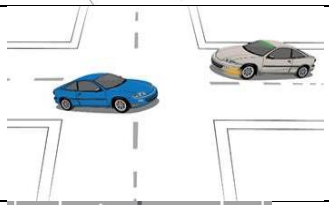
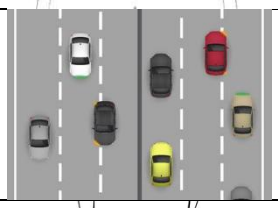
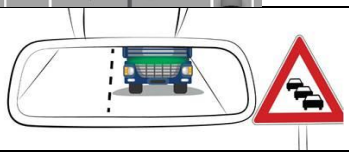
Phone number: _____

Do not fill in

Questionnaire number:.....

Interviewer's name:.....

The personal information, outputs, and conclusions obtained will be used exclusively for the processing of the "Front Brake Light" project and will not be disseminated or provided to any third parties.

Traffic situations When the brake pedal is pressed, the front brake light illuminates to indicate to other road users from the front that the vehicle is braking. Please state your opinion on the potential impact of the front brake light on the following traffic situations:		MUCH MORE MORE DANGEROUS		FBL creates situations. ◄ - - - ►		MUCH MORE SAFER
1.	In the case of traffic intersection between vehicles and pedestrians:	1	2	3	4	5
2.	In the case of traffic intersection between multiple vehicles:	1	2	3	4	5
3.	During overtaking:	1	2	3	4	5
4.	 At a pedestrian crossing:	1	2	3	4	5
5.	 During a left turn:	1	2	3	4	5
6.	 During a lane change on a highway:	1	2	3	4	5
7.	 While decelerating in traffic congestion:	1	2	3	4	5

Please share your opinion on the front brake light.

Please indicate your opinion on the following statements about the front brake light (FBL):		I DEFINITELY DISAGREE.	I DISAGREE.	I DON'T KNOW.	I AGREE.	I STRONGLY AGREE.
8.	The front brake light is a good idea.	1	2	3	4	5
9.	In the long run, the front brake light has more disadvantages than advantages.	1	2	3	4	5
10.	The front brake light can increase road safety.	1	2	3	4	5
11.	The front brake light can prevent traffic accidents.	1	2	3	4	5
12.	The front brake light is unnecessary.	1	2	3	4	5
13.	The front brake light can cause a traffic accident.	1	2	3	4	5
14.	The front brake light increases pedestrian safety.	1	2	3	4	5
15.	The front brake light can increase traffic flow.	1	2	3	4	5

Thank you for your participation in this survey!