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DRIVERS' CONFIDENCE IN ADVANCED DRIVERS ASSISTANT SYSTEMS (ADAS)

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Abstract

Road accidents are a serious social problem, both in terms of public health and the costs associated with it, and as individual tragedies. Efforts to reduce the role of human factors in road accidents include partial or full automation of tasks performed by drivers through various types of advanced driver assistance systems. The question arises as to what characteristics of a technology user determine the degree of their trust in it in the context of the functionality and reliability of this technology. Two research questions related to the assessment of technology users (ADAS) of its reliability and effectiveness of operation and the differentiation of these assessments in individual groups of respondents were adopted. Data were obtained through survey research using the CATI (Computer Aided Interaction) technique. Assisted Web Interview). 155 respondents participated in the study. As a result of the conducted research, it was found that the oldest systems, used for many years - ABS, airbags, inspire the greatest trust among drivers, while the least popular, used relatively recently – line assistance system. The respondent's metrics (gender, age, experience) do not affect the perception of the effectiveness and reliability of ADAS; this may be surprising, because it is commonly believed that young people are more willing to use various types of technological innovations. Many respondents have no opinion on the effectiveness and efficiency of ADAS systems - most often these are people who do not have such systems installed in their cars or have not had contact with them. The most "educated" group in terms of knowledge of ADAS are - which is not surprising - professional drivers, although the number of such respondents whose knowledge is negligible (17%) may be surprising.

Introduction

Road accidents are a serious social problem, both in terms of public health and the costs associated with it, and as individual tragedies. Generally, three categories of accident causation are distinguished: road factors, technical factor - vehicle and human factors. The human factor is generally considered to be the main factor contributing to road accidents, accounting for more than 90% of all accidents (Kharoufah et al., 2018, Dingus et al., 2016, Fagnant and Kockelman , 2015, Elvik et al., 2009).

Efforts to reduce the role of human factors in road accidents include partial or full automation of driver tasks through various types of advanced driver assistance systems. Examples include:

- ABS System (Anti -Lock Breaking System) - a system that prevents the car's wheels from locking while braking,

- Brake Assist System - emergency braking assistant,
- EBD (Electronic Brakeforce Distribution) - electronic brake force distribution system,
- Automatic Emergency Braking (AEB),
- ESP (Electronic Stability Program) Stability Program) - Electronic System for Control and Maintaining Driving Direction,
- BLIS (Blind Spot Information System) - detects cars in the blind spot of the mirror,
- LAS (Line Assist System) - assistant for keeping the vehicle in the right lane,
- Driver fatigue monitoring system,
- TSR (Traffic Sign Recognition) – reading and displaying road signs,
- Airbags,
- Adaptive Cruise Control (ACC) - automatically adjusts vehicle speed to traffic, maintaining a safe distance from the vehicle in front,
- Parking Assistant - makes parking easier by automatically steering the vehicle during parking manoeuvres,
- Lane Change Assistant - advises when it is possible to change lane safely and can intervene if the driver does not respond to warnings,
- Collision warning systems - alert the driver to approaching obstacles to minimize the risk of an accident.

Research into advanced driver assistance systems and more advanced Intelligent Connected Vehicles (ICVs) demonstrate their effectiveness in increasing not only road safety (Masello et al. 2022, Lian 2020, Biondi et al. 2017, Jiménez et al. 2016) but also the efficiency of the transportation system (e.g. parking savings, emission reduction and reduced driver workload (Iyer 2021, Wadud 2016, Zhanf et al. 2011).

There has been a significant decrease in the frequency and severity of road accidents involving vehicles equipped with ADAS systems (Hamid et al. 2023, Hellman , Lindman 2023, Sternlund 2017, Sam 2016).

The positive impact of advanced driver assistance systems has been recognized by the EU. From July 7, 2024, the EU General Safety Regulation II (GSR II) will usher in a new era of vehicle safety. All new vehicles on EU roads must comply with most of the General Safety Regulation II. State-of-the-art safety technologies required by law for new cars, light and heavy commercial vehicles and buses are intended to sustainably increase road safety. Continental is at the forefront of this transformation with technologies and solutions that are driving us toward Vision Zero – the goal of zero traffic accidents. The GSR II outlines several critical safety features that will be no longer optional add-ons but mandatory in all new vehicles in the European Union following a fixed timetable.

Despite objective results confirming the positive effect of such systems on road safety, there is a question about the subjective issue - drivers' trust in the effectiveness, reliability, and user-friendliness of such systems (Huang et al. 2024, DeGuzman , Donmez 2023, DeGuzman , Donmez 2021). This seems to be a key aspect in the context of the desire to have and use such systems in practice.

A very detailed analysis of the concept of trust in general and trust in technology was presented by (Ejdys 2018) and the following definition was adopted.

Trust in technology is the tendency of a technology user to rely on it in a situation of potential risk related to its use, resulting from expected or experienced properties of the technology and environmental factors, and determining intentions regarding the future use of the technology.

Trust in technology can be analyzed in the context of two aspects (Lankton , McKnight , Thatcher 2014): its functionality (the expectation that the technology has desirable features) and its reliability (the tendency to rely on the technology).

The question arises as to what characteristics of the user of the technology (in this case ADAS) determine the degree of his or her trust in it (in the context of the above-mentioned aspects – functionality and reliability).

The following research questions were adopted:

- How do ADAS users rate its reliability and effectiveness?
- What is the variation in ratings across different respondent groups?

Research methodology and results

Data were obtained through survey research using the CATI (Computer Aided Interaction) technique. Assisted Web Interview). Respondents were asked to complete an electronic, structured survey questionnaire developed
using the Google Form tool.

The research was therefore of a quantitative nature, which allowed for the verification of the adopted research hypotheses/statistical processing of data.

The choice of the CATI technique was determined by the possibility of covering a relatively large group of respondents, the anonymity of the research, and the low cost and short time of conducting the research. The research questionnaire was conventionally divided into three parts:

- respondent's metrics regarding age, gender, driving experience, type of vehicle use (whether the respondent is a professional driver), knowledge of/possession of ADAS,
- a group of questions regarding the assessment of two aspects of trust in technology – its functionality and reliability,
- a group of questions regarding user experiences related to the operation/non-operation of such systems.

Preliminary analysis of results

The study involved 155 respondents. The completed questionnaires were analyzed for completeness and logicality of answers. In many cases, the respondents' answers regarding the assessment of trust in the reliability and effectiveness of the ADAS tested were "I don't know". It was decided to classify such respondents into a separate group and formulate an additional research question:

Is there a group of respondents who have no opinion on the reliability and effectiveness of the systems being assessed?

The following tools were selected for analysis:

- descriptive statistics,
- variance analysis,
- test for two means (independent samples).

Assessment of individual security systems

In order to conduct a quantitative analysis of the assessments of the reliability and effectiveness of the functioning of security systems, ranks (numerical values) were assigned to the qualitative responses from the survey: I do not trust - 1, I rather do not trust - 2, I trust - 3, I have complete trust - 4. Figure 1 presents the results of the average (all respondents) assessment of the reliability and effectiveness of ADAS operation.

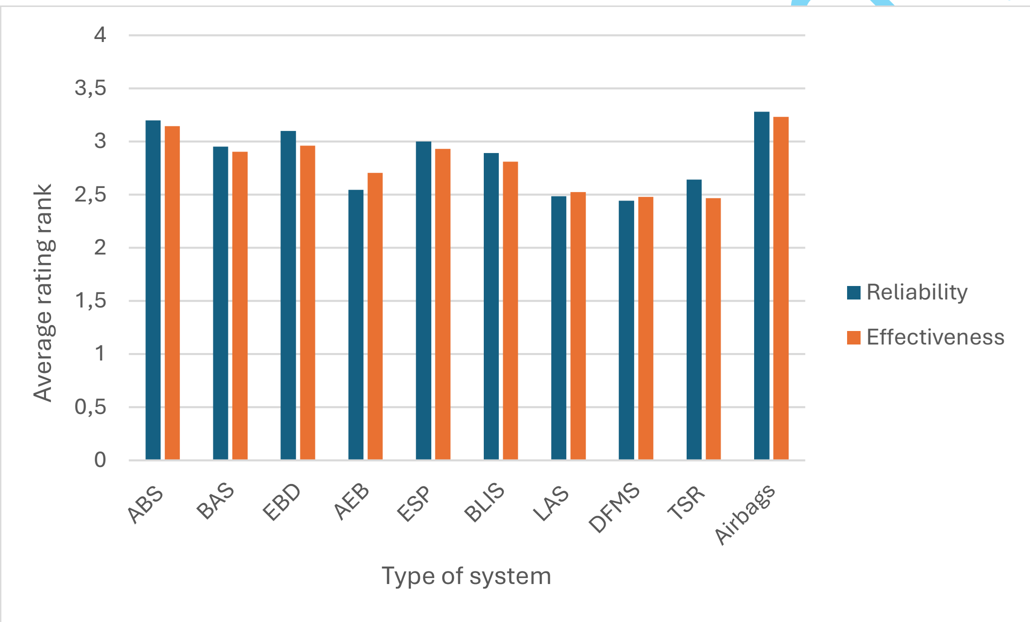

Fig. 1. Average rating of ADAS reliability and effectiveness

It is visible that the average ratings are similar for the individual systems and oscillate around the ratings "I rather do not trust" and "I trust". The ratings for ABS and airbags systems stand out slightly, with an average rating above 3. The respondents expressed the least trust in the LAS and KSZK systems (ratings below 2.5). Users do not have complete trust in any system. The average ratings for reliability and effectiveness are also characterized by a very high correlation. For all types of systems, the standard deviation of the ratings is similar and is about 0.7.

Analysis of ratings in individual respondent groups

In order to determine whether the assessments of trust in safety systems supporting drivers differed in individual groups of respondents, analysis of variance or a test for two means (independent samples) was used. The dependence of the obtained results on the gender, age, experience (number of years of having a driving license) of the respondents and the nature of vehicle use (professional and non-professional driver) was examined. Calculations were performed in the Winstat statistical program. In the case of comparison of results for the characteristics: professional status and gender, the test for two means was used (only two groups for comparison) assuming that we are dealing with normal distributions with unknown standard deviations and that the sample variances are equal. In the comparisons of drivers' age and experience, analysis of variance was used (comparison of 5 age groups). The null hypotheses were the agreement of answers (means of assessments from the studied populations are the same), against the alternative: means in the populations are not the same. Examples of results for the significance test of two means and analysis of variance are presented in Tables 1 and 2.

Table 1

Summary of calculation results for the set – profession (sample 2) – system reliability (sample 1) – professional driver (significance test for two means)

Characteristic	Value
Attempt 1	
Count	117
Average value	2.99
Standard deviation	2.99
Attempt 2	
Count	10
Average value	2.72
Standard deviation	0.45
Hypotheses	
H_0	The means in both populations are the same
H_1	The means in both populations are not the same
Verification of hypotheses	
U statistic value	1.39
Significance level	0.05
Critical Area	Two Sided
Left critical value	-1.96
Right critical value	1.96
Decision	**There is no basis for rejecting Ho**

Table 2

Results of variance analysis – single classification – study of the influence of respondents' age on the assessment of the effectiveness of ADAS systems

Characteristic	Value
Age range up to 25 years	
Count	15
Mean	2.74

Variance	0.38		
Age range 25-35 years			
Count	8		
Mean	2.70		
Variance	0.21		
Age range 35-50 years			
Count	11		
Mean	3.11		
Variance	0.35		
Age range 50-65 years			
Count	17		
Mean	2.82		
Variance	0.36		
Age range over 65 years			
Count	5		
Mean	3.01		
Variance	0.28		
Variance analysis table			
Source of Variability	Degrees of freedom	Sum of squares	Medium square
Age	4	1.24	0.31
Statistical error	51	18.88	0.37
Verification of hypotheses			
H_0	The main effects of factor "Age" are equal to zero (the average effectiveness ratings in the age groups are equal)		
H_1	Not all main effects of factor "Age" are equal to zero (not all age group performance averages are created equal)		
F-statistic value	0.84		
Significance level	0.05		
Degrees of freedom for	4;54		
pValue	0.4943		
Decision	**There is no basis for rejecting Ho**		

In all the variants of comparisons examined, it was found that there is no basis for rejecting the null hypotheses. The analysis did not show any significant differences for the individual groups of respondents in the assessment of trust in the reliability and effectiveness of safety systems in passenger cars.

Analysis of "I don't know" responses

Since the surveys accepted for further analysis also contain numerous "I don't know" responses, an attempt was made to identify the areas of such responses. Two additional research questions were formulated:

- which ADAS systems are least known to respondents,
- is there any group of respondents who have no opinion on the reliability and effectiveness of the assessed systems?

Figure 2 presents the percentage of "don't know" responses in the assessments of the reliability and effectiveness of the functioning of the examined systems.

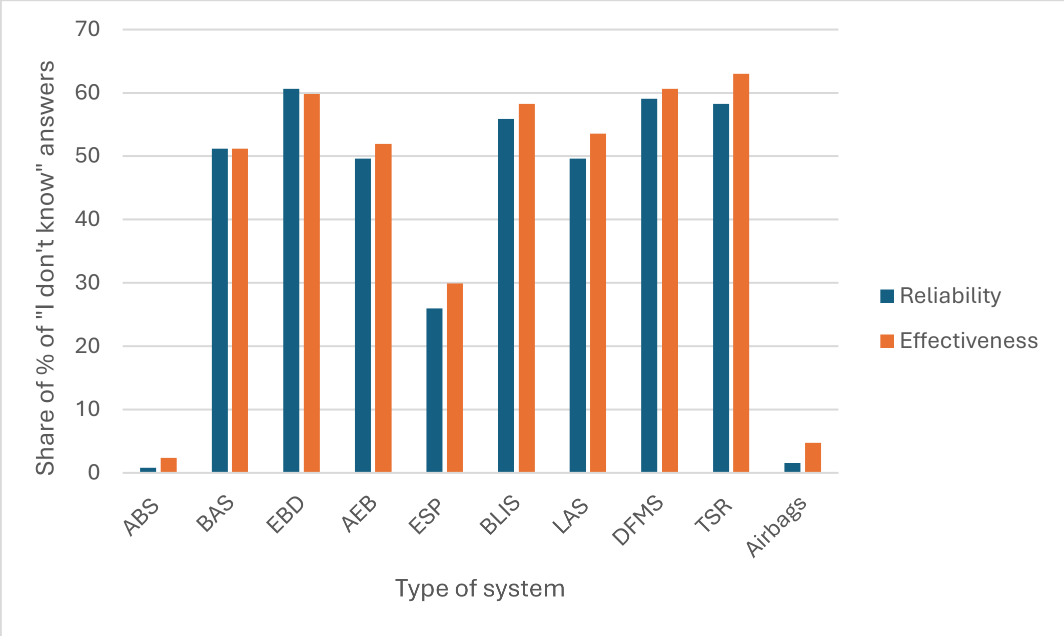

Fig. 2. Percentage of "don't know" responses in the assessment of the reliability and effectiveness of the tested systems.

The analysis of Fig. 1 shows that two safety systems (ABS and Airbags) stand out, for which over 95% of possible ratings were indicated by respondents. The ESP system is also quite well-known to respondents and only 30% of the answers were not completed. The remaining systems were rated only in 40-50%. It should be noted that there is a strong correlation between the lack of answers referring to the reliability and effectiveness of the assessed systems.

The results of the analysis of the number of "I don't know" responses assigned to particular respondent groups are presented in Table 3.

Table 3

Percentage of "I don't know" responses assigned to particular respondent groups

Respondents' Characteristics	% of "I don't know" responses in the evaluation of the systems studied
Age [years]	
up to 25	48
25-35	40
35-50	40
50-65	40
over 65	45
Experience [years]	
up to 5	50
5-15	39
15-30	41
30-40	39
over 40	42
Professional driver	
NO	45
Yes	17
Sex	
Woman	49
Man	40

The analysis of the characteristics of the respondents shows that the share of the "I don't know" answer is quite even in the individual age groups. It should be noted, however, that the largest number of such answers is given in the groups of up to 25 years and over 65 years. This conclusion is also confirmed by the analysis of data on experience, in the group of up to 5 years - 50%, over 40 years - 42%. There is a slight difference in the number of these answers by gender: women 49%, men 40%. The most distinguishing feature in the knowledge of the issue under consideration is the professionalism of the respondents. Professional drivers gave only 17% of the "I don't know" answers, for all possible answers assessing the reliability and effectiveness of ADAS systems.

Many respondents have no opinion on the effectiveness and efficiency of ADAS systems – most often these are people who do not have such systems installed in their cars or have not had contact with them. In the case of the answer "I do not have - a given system in my car", only 32% of these respondents expressed their assessment of reliability and effectiveness and provided evaluative answers to only 24% of the questions asked. A much larger number of assessments are characteristic of surveys in which it was indicated that a given respondent knows or has the assessed system in their car. In such cases, as many as 84% of respondents tried to assess the systems tested, but these assessments were assigned to only 38% of possible answers.

In order to determine whether the issue of whether or not the respondents have ADAS systems affects their average assessment, the test for two means (independent samples) was used (Table 4).

Table 4

Summary of calculation results for the set – I have ADAS (test 1) – I do not have ADAS (test 2)

Characteristic	Value
Attempt 1	
Count	138
Average value	2.88
Standard deviation	0.67
Attempt 2	
Count	47
Average value	1.68
Standard deviation	1.00
Hypotheses	
H_0	The means in both populations are the same
H_1	The means in both populations are not the same
Verification of hypotheses	
U statistic value	7.66
Significance level	0.05
Critical Area	Two Sided
Left critical value	-1.96
Right critical value	1.96
Decision	**Ho should be rejected in favor of H1**

Verification of the hypothesis leads to the conclusion that the average ratings of ADAS systems differ significantly. A higher rating value (2.88) is expressed by respondents who have the tested systems in their cars, in relation to the average rating (1.68) of users who do not have these systems.

Summary and conclusions

The conducted studies have shown that the average trust ratings for ADAS systems are similar for the individual groups of respondents and range between "I rather do not trust" and "I trust". The average ratings for reliability and effectiveness are characterized by a very high correlation. The greatest trust is aroused by ABS and airbag systems, the least by LAS and KSZK systems. Users do not have complete trust in any system. For all types of systems, the standard deviation of the ratings is similar and is about 0.7.

The analysis did not show any significant differences for individual groups of respondents in the assessment of trust in the reliability and effectiveness of ADAS systems. It was found that there is no basis for rejecting the null hypothesis as the consistency of the

respondents' answers (the averages of the assessments from the studied populations are the same).
The analysis of the respondents' characteristics also shows a fairly even share of "I don't know" responses in the individual groups of respondents (40–50%), except for the group of professional drivers, where only 17% of drivers gave the "I don't know" response.

Greater confidence in driver assistance systems is expressed by respondents who have the surveyed systems in their cars compared to users who do not have such systems.

The conclusions from the research are as follows.

1 – the oldest systems, used for many years - ABS, airbags - inspire the greatest confidence of drivers, while the least popular ones, used relatively recently - LAS, KSZK

2 – respondent metrics (gender, age, experience) do not affect the perception of ADAS effectiveness and reliability; this may be surprising, as it is commonly believed that young people are more willing to use various types of technological innovations.

3 – many respondents have no opinion on the effectiveness and efficiency of ADAS systems – most often these are people who do not have such systems installed in their cars or have not had contact with them.

4 – the most "educated" group in terms of ADAS knowledge are – which is not surprising – professional drivers, although the number of such respondents whose knowledge is negligible (17%) may be surprising

Research shows that drivers' trust in safety systems is a complex issue that depends on many factors, including their experience with using the technology.
Drivers who own/know the systems are more likely to trust them. Training and information provided by manufacturers can help build this trust. User experiences can significantly impact perceptions of the effectiveness of safety systems. Positive experiences can increase trust, while negative experiences can erode it. Of course, some drivers may be naturally skeptical of technology, especially if they have not used it before. Concerns about trusting "machines" can affect their perceptions.

Understanding these factors can help manufacturers and designers create systems that are not only effective, but also gain the trust of users.

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