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DEVELOPMENT AND VALIDATION OF THE ADAS ACCEPTANCE TEST (ADASAT): A TAM-BASED INSTRUMENT FOR EVALUATING USER ACCEPTANCE OF ADVANCED DRIVING ASSISTANCE SYSTEMS

DANIELE MOLLAIOLI
DEPARTMENT OF CLINICAL AND EXPERIMENTAL MEDICINE, UNIVERSITY OF MESSINA

CHIARA LA BARBIERA
DEPARTMENT OF HEALTH SCIENCES, "MAGNA GRAECIA" UNIVERSITY OF CATANZARO

ELEONORA RAFFA
VANESSA MUSCOLINO
DEPARTMENT OF CLINICAL AND EXPERIMENTAL MEDICINE, UNIVERSITY OF MESSINA

DEMETRIO LACAVA
DEPARTMENT OF ECONOMICS, UNIVERSITY OF MESSINA

ALESSIA RUGGERI
GIUSEPPE SOLLAZZO
ORAZIO PELLEGRINO
GAETANO BOSURGI
DEPARTMENT OF ENGINEERING, UNIVERSITY OF MESSINA

The increasing presence of Advanced Driver Assistance Systems (ADAS) in modern vehicles underscores the need to assess user acceptance, which is essential for the effective integration of these technologies. This study introduces and validates the ADAS Acceptance Test (ADASAT), a novel questionnaire grounded in the Technology Acceptance Model (TAM). A sample of 347 Italian drivers completed the instrument, which evaluates four TAM constructs: Perceived Usefulness, Perceived Ease of Use, Attitude Toward Use, and Behavioral Intention. Exploratory and confirmatory factor analyses confirmed the theoretical four-factor structure, and the model demonstrated excellent internal consistency, convergent, and discriminant validity. Path analysis supported all hypothesized relationships among TAM constructs. The results confirm TAM's applicability to the ADAS context and highlight the role of perceived usefulness and ease of use in influencing user attitudes and intentions. The ADASAT offers a valid psychometric tool to support research and policies supporting safe, user-centered technology adoption.

Keywords: Advanced Driving Assistance Systems, Technology Acceptance Model, Perceived Usefulness, Perceived Ease of Use

Correspondence concerning this article should be addressed to Daniele Mollaioli, Department of Clinical and Expemental Medicine, University of Messina, Via Consolare Valeria 1, 98124, Messina (ME), Italy, Email: daniele.mollaioli@unime.it

The introduction of advanced systems in road mobility, such as on-board technologies, automated driving, and digitalization of road infrastructure, has transformed the landscape of the mobility experience, with the aim of significantly improving both safety and efficiency. Advanced driver assistance systems (ADAS) comprise various technologies designed to help drivers by providing essential information and aid in the management of several driving functions (Supplementary Table 1). ADAS are intended to enhance driver performance and transport safety by reducing accidents, improving comfort, and mitigating environmental impact (Bosurgi et al., 2023b).

Despite the significant advantages and generally positive initial responses of motorists (Braitman et al., 2007; Cicchino et al., 2015; Eichelberger & McCartt, 2014; Ferguson, 2007), the positive effects of these technologies occur only when drivers fully accept the presence of these devices and integrate their correct use into daily driving situations. The drivers' acceptance of the ADAS can be defined as their response in perceptive terms to on-board technologies and their willingness to adopt and use it while driving. Although this concept is easily understood, research on driver acceptance has changed over time in terms of its definition, model, and measurement approach (Adell et al., 2014; Regan et al., 2002). From a psychological perspective, acceptance results are a complex concept and require the evaluation of several related aspects.

One of the first developed approaches involving the application of models of human behavior to technology acceptance is the Technology Acceptance Model (TAM; Davis, 1989), which is the most commonly used model for evaluating and understanding the dimensions related to user acceptance of technological systems, including ADAS (Rahman et al., 2017).

The TAM is based on the Theory of Reasoned Action (TRA; Fishbein & Ajzen, 1975) , which assumes that intentions to perform a behavior (e.g., the use of a particular technology), namely "Behavioral Intention" (BI), are influenced by certain factors, such as attitudes of the subject toward the use of technology, the perception of usefulness, and ease of use (Davis, 1989). "Attitude Toward Using" (ATT) technology could be defined as the emotional pattern toward using a technology, and according to the TAM model it is influenced both by perceptions of its usefulness and those of its ease of use. Perceived Ease of Use (PEoU) refers to the extent to which an individual believes that using a system requires minimal effort (Rahman et al., 2017). In contrast, Perceived Usefulness (PU) indicates how much the system is perceived to be beneficial and capable of enhancing performance (De Angelis et al., 2017).

Subsequent versions of the TAM proposed that perceptions of PU and ease of use directly influence behavioral intention, eliminating the component relating to attitudes to use (TAM2; Davis, 1989), and inserting other dimensions that directly influence ease of use. (TAM3; Venkatesh & Bala, 2008).

Therefore, evaluating driver acceptance of new ADAS through valid and standardized tools is essential during the development, implementation, and large-scale testing phases. Voinea et al. (2020) developed a TAM-based questionnaire composed of 17 items measured on a 7-point Likert scale to assess drivers' perceived ease of use, PU, and attitude toward an ADAS system. This questionnaire demonstrated high internal consistency (Cronbach's alpha ranging from 0.70 to 0.87) and showed significant positive effects of perceived ease of use on PU and PU on attitude toward the system, which in turn significantly predicted behavioral intention to use the ADAS. Furthermore, the ADAS had a positive impact on driving performance, resulting in a reduction in average speed and an increase in progress, thus promoting safer driving behaviors.

Another simulated driving study evaluated the validity of the TAM in predicting subjects' intentions regarding the use of automated vehicles (AVs), adapted from existing questionnaires, a set of items related to the dimensions of PU, PEoU, and trust. The results showed that PU significantly predicted intention to use AVs, whereas PEoU was not significant when PU was included. Furthermore, the trust dimension showed a high predictive value for intention to use AVs (Buckley et al., 2018).

To date, there is still no psychometrically validated tool for measuring acceptance of the ADAS in Italy. To address this lack, we aimed to validate a psychometric instrument called the ADAS Acceptance Test (ADASAT) in Italian, examine its reliability and validity, and test the relationship between the constructs according to the theoretical models of the TAM. This validated tool will be used to understand the degree of acceptance of the ADAS among drivers, seeking to identify further elements for understanding driving behavior.

MATERIALS AND METHODS

Participants and Sampling

We conducted a cross-sectional study to evaluate the psychometric characteristics and factor structure of the ADASAT among Italian individuals. The research model (Figure 1) was adopted from TAM, which has four factors (PEoU, PU, ATT, and BI). The study protocol was approved by the ethics committee of the University of Messina. An online survey form was developed and disseminated to participants through ad hoc mail lists and social media. Participation was voluntary, and no incentives were offered to complete the survey.

At the beginning of the survey, an information sheet was provided to explain the research aims and participants' rights, including the right to withdraw from the study at any time without any repercussions.

Following their review of the information sheet, the students were instructed to complete the informed consent form, thereby providing their written consent to participate in the study. All precautions were taken to protect participants' privacy, and the questionnaires were completed anonymously. The eligible participants had a driving license, drove a car with at least one ADAS installed, and provided informed consent.

As recommended by Kline (2015), the minimum sample size for validation studies should follow a 10:1 subjects-to-item ratio. Among the 461 subjects who participated in the study, 114 were excluded because they violated at least one of the inclusion criteria. The final sample comprised 347 participants: 176 males (50.7%) and 171 females (49.3%).

Instruments

The ADAS Acceptance Test (ADASAT) was developed based on the Technology Acceptance Model (TAM) and adapted to the context of the ADAS. The questionnaire consisted of 15 items measured on a 7-point Likert scale (1 = Strongly Disagree, 7 = Strongly Agree). The items were designed to assess four main constructs: Perceived Ease of Use (PEoU – 4 items; e.g., Item 7 "Interacting with these systems does not require a lot of mental effort"), PU (PU – 4 items; e.g., Item 1 "Using these systems improves my driving performance"), Attitude Toward Using ADAS (ATT – 4 items; e.g., Item 11 "I am generally in favor of using ADAS") and Behavioral Intention to Use ADAS (BI – 3 items; e.g., Item 13 "I plan to use ADAS systems in the future").

The initial items were generated through a review of the existing literature on TAM and ADAS acceptance, followed by consultation with experts in the fields of human factors and transportation psychology. To ensure the accuracy and cultural relevance of the ADASAT in Italian, a rigorous back-translation process was employed, which was translated from English to Italian and then independently translated back into English by bilingual experts. Discrepancies were resolved through consensus to maintain the integrity of the original instrument.

Statistical Analysis

Face validation was tested to evaluate the comprehensibility of the item sentences and identify any ambiguities or multiple interpretations (Yusoff, 2019). The initial version of the ADASAT was distributed online to a small sample of 30 car drivers, who were asked to rate item comprehensibility on a 4-point scale (1 = not clear at all; 2 = somewhat clear; 3 = quite clear; 4 = highly clear). An index of comprehensibility (Face Validity Index, FVI) was obtained through the proportion of subjects rating an item as either clear (3) or highly clear (4). A minimum FVI value of 0.80 was set as acceptable (Yusoff, 2019).

Consequently, the ADASAT items were administered to the study sample to assess factorial structure and internal consistency.

To assess the normality of the ADASAT items, we analyzed skewness and kurtosis values to verify if they were within the acceptable range of -1 to +1 (Bulmer, 1979).

To confirm and validate the factorial structure according to TAM model, a Confirmatory Factor Analysis (CFA) was performed using goodness-of-fit indices such as the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and the 90% confidence interval (CI) of the RMSEA. CFI and TLI values above 0.90, RMSEA values below 0.08, and the upper limit of the 90% CI of the RMSEA below 0.10 indicate an acceptable model fit (Brown & Moore, 2012).

Following the EFA and CFA, we conducted reliability analysis to evaluate the internal consistency of the Intimometer items. In this study, reliability was assessed using Cronbach's Alpha and McDonald's omega coefficient. Scales with Cronbach's alpha values above 0.70 are considered to have high internal consistency (Bentler, 2017).

Several statistical methods within the framework of confirmatory factor analysis (CFA) were employed to assess the convergent and discriminant validity of the ADAS Acceptance Test. We computed the Average Variance Extracted (AVE) and Composite Reliability (CR) to test the convergent validity. Similar to Cronbach's alpha, CR measures the internal consistency of indicators for a construct. It indicates how well the indicators measure the same construct and is calculated using the following formula:

$$CR = \frac{(\sum \lambda_1)^2}{(\sum \lambda_1)^2 + \sum(1 - \lambda_i^2)}$$

where λ represents the standardized factor loadings of the indicators (Bacon et al., 1995). A CR value above 0.70 indicates adequate internal consistency and reliability.

AVE assesses the amount of variance captured by a construct relative to the variance caused by the measurement errors. It provides a measure of the shared variance between a construct and its indicators and is calculated using the following formula(Dos Santos & Cirillo, 2023; Fornell & Larcker, 1981):

$$AVE = \frac{\sum \lambda_i^2}{\sum \lambda_i^2 + \sum(1 - \lambda_i^2)}$$

An AVE value exceeding 0.50 indicates that the construct explains more than half of the variance of its indicators, thereby confirming convergent validity.

Discriminant validity was determined using the Fornell – Larcker criterion. This criterion involves comparing the square root of the AVE values for each construct with the inter-construct correlations. Discriminant validity was confirmed when the square root of the AVE for a construct was greater than its highest correlation with any other construct, indicating that the constructs were distinct and not excessively correlated (Fornell & Larcker, 1981). This method ensured that the constructs within the ADAS Acceptance Test measured the different concepts and did not overlap significantly.

A structural equation model was employed to test five hypotheses derived from the Technology Acceptance Model (TAM), all of which posit positive relationships between the constructs. Each relationship was modeled as a regression between latent variables to assess the strength and significance of these associations in the context of ADAS acceptance. The tested hypotheses were as follows:

H1. PEoU positively influenced the PU. Hypothesis H1 assumes that the more users perceive an ADAS as easy to use, the greater their perception of its usefulness. This implies that a clear and simple interface may strengthen the belief that using technology enhances driving performance. The expected relationship between PEoU and PU was modeled as positive, in line with existing TAM literature.

H2. PEoU positively influenced ATT. Hypothesis H2 postulates that the perception of ease of use has a positive effect on the overall attitude toward the ADAS. If users perceive the systems as intuitive and not cognitively demanding, they are more likely to develop a favorable attitude toward their adoption. This relationship reflects the assumption that simplicity and accessibility contribute to an overall positive perception of the technology.

H3. PU positively influences ATT. Hypothesis H3 suggests that a higher perception of ADAS usefulness leads to a more favorable attitude toward adoption. If users believe that the ADAS enhances their driving experience by improving safety and efficiency, they will develop a positive attitude toward these systems. In other words, perceived usefulness is a key predictor of technology acceptance.

H4. PU positively influences BI. Hypothesis H4 describes the positive effect of perceived usefulness on behavioral intention to use the ADAS. If participants believe that the ADAS can improve their driving performance, they will be more inclined to plan the use of these systems in the future. This hypothesis highlights the importance of perceived functional benefits in motivating users to adopt new technology.

H5. ATT positively influences BI. Hypothesis H5 postulates that a positive attitude toward ADAS has a direct effect on the behavioral intention to use them. Attitudes toward technology use represent a key construct in determining whether a user intends to adopt technology. A favorable attitude, characterized by trust in the technology and a positive opinion of its benefits, is a significant predictor of usage intention.

To test these hypotheses, a path analysis model was developed to examine the regression coefficients and model fit indices. The indices used to evaluate model fit included the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and the 90% confidence interval of RMSEA. CFI and TLI values above 0.90, an RMSEA below 0.08, and an upper bound of the RMSEA confidence interval below 0.10 were considered indicative of an adequate model fit to the data (Hu & Bentler, 1999).

RESULTS

Table 1 presents the demographic characteristics. The average age of the participants was 24.09 years (SD = 7.09) years. Most of the sample was composed of students (67.4%), followed by employees (27.7%) and a small percentage of unemployed individuals (4.9%). The majority of participants were single (47.3%) or in a relationship (45.3%), while 7.5% were married.

TABLE 1
Demographic characteristics of the study sample

Variable	N / Mean	% / SD
Gender		
Male	176	50.7
Female	171	49.3
Age	24.09	7.09
Relational status		
Single	164	47.3
In a relationship	157	45.3
Married	26	7.5
Occupation		
Unemployed	17	4.9
Student	234	67.4
Employee	96	27.7
Driving Licence		
Less than 2 years	99	28.5
2 – 5 years	152	43.8
5 – 10 years	53	15.3
10+ years	43	12.4
ADAS possession		
ACC	154	44.4
IPAS	311	89.6
AEB	89	25.6
LKS	103	29.7
BSM	44	12.7
ADAS amount	2.02	1.26

Regarding driving experience, 28.5% of the participants held a driver's license for less than two years, while 43.8% held it for two to five years, indicating a predominance of relatively young drivers. In terms of the adoption of ADAS, 89.6% used IPAS, 44.4% used ACC, and 25.6% used AEB. The average number of ADAS used was 2.02 (SD = 1.26), reflecting a moderate degree of technological adoption among participants.
The content of 15 ADASAT items, with mean values, standard deviations, kurtosis, and skewness are listed in Supplementary Table 2.
A confirmatory factor analysis (CFA) was conducted to verify the factor structure according to TAM model. The CFA results showed significant standardized loadings (λ) for all items ranging from 0.706 to 0.895, confirming that the items robustly reflected their respective theoretical constructs. The model fit indices (CFI = 0.985, TLI = 0.981, RMSEA = 0.045) suggest a good fit of the model to the empirical data, confirming the four-factor theoretical structure. Figure 1 summarizes the CFA model and highlights the relationships between the factors and items.

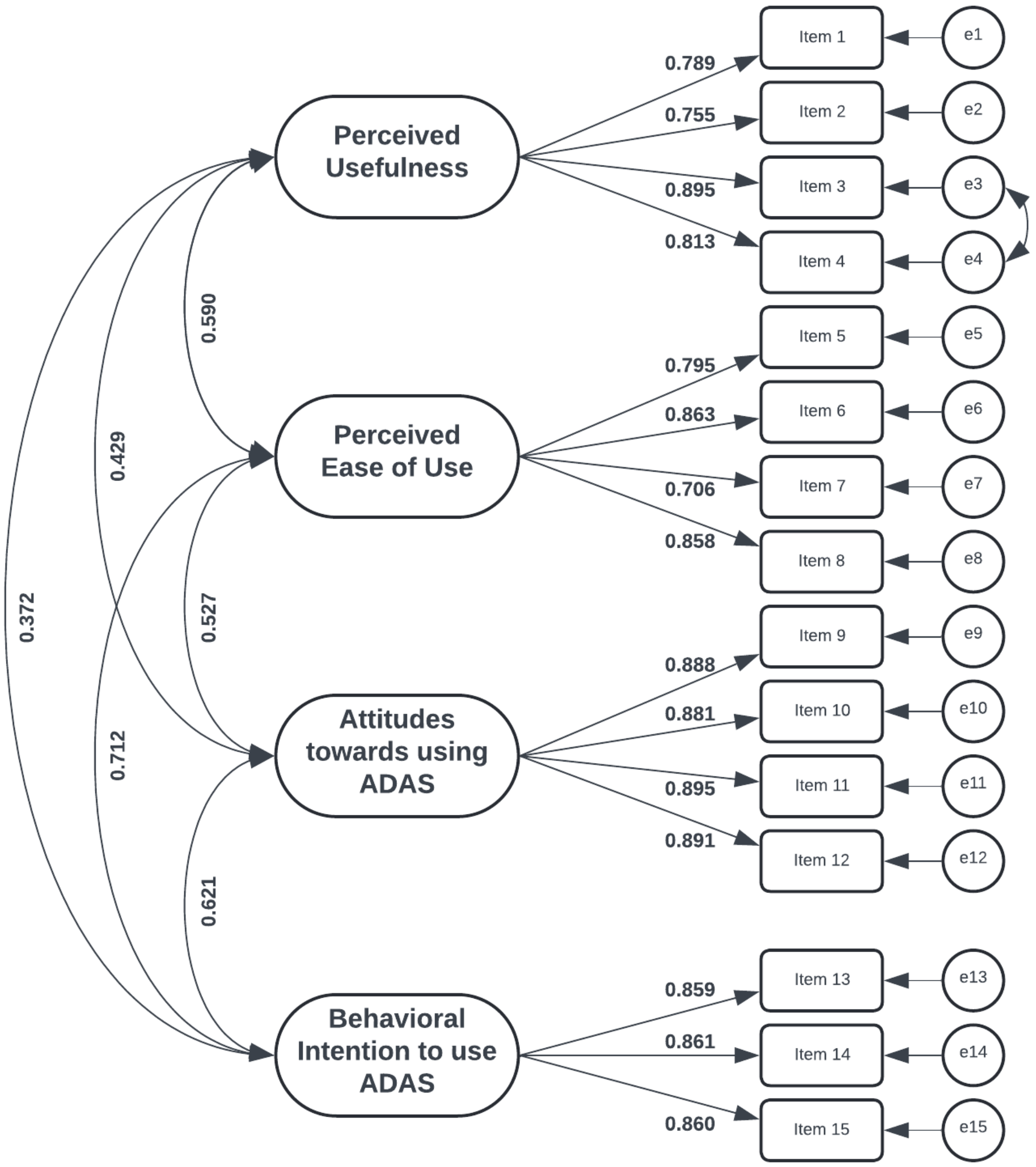

FIGURE 1
Confirmatory Factor Analysis of ADASAT items

Internal reliability was assessed using Cronbach's alpha and McDonald's omega coefficient for each ADASAT factor. The results indicated high internal consistency for all factors, with Cronbach's alpha values ranging from 0.888 to 0.937, and similar McDonald's omega values (Table 2).

TABLE 2
Confirmatory Factor Analysis, Reliability Analysis, and Convergent Validity Assessment of the ADASAT Items

Factor	Indicator	λ	SE	Z	p	CR	AVE	α	ω
Perceived Usefulness	Item 1	0.813	0.080	17.1	<.001	0.888	0.664	0.885	0.887
	Item 2	0.895	0.078	16.0	<.001				
	Item 3	0.755	0.072	20.7	<.001				
	Item 4	0.789	0.070	17.8	<.001				
Perceived Ease of Use	Item 5	0.795	0.064	16.5	<.001	0.893	0.672	0.888	0.892
	Item 6	0.863	0.062	18.3	<.001				
	Item 7	0.706	0.074	16.5	<.001				
	Item 8	0.858	0.061	20.9	<.001				
Attitude toward using ADAS	Item 9	0.888	0.055	20.9	<.001	0.937	0.790	0.937	0.938
	Item 10	0.881	0.052	20.6	<.001				
	Item 11	0.895	0.051	21.1	<.001				
	Item 12	0.891	0.053	21.0	<.001				
Behavioral Intention to use ADAS	Item 13	0.859	0.069	19.4	<.001	0.895	0.740	0.895	0.895
	Item 14	0.861	0.069	19.5	<.001				
	Item 15	0.860	0.069	19.4	<.001				

FIT INDICES

Test for Exact Fit						90% RMSEA CI	
χ^2(df)	p	CFI	TLI	SRMR	RMSEA	Lower	Upper
143(83)	<0.001	0.985	0.981	0.029	0.045	0.032	0.058

Note: λ = Standardized Loading; SE = Standard Error; CR = Composite Reliability; AVE = Average Variance Extracted; α = Cronbach's Alpha; ω = McDonald's Omega

Convergent validity was assessed using Composite Reliability (CR) and Average Variance Extracted (AVE) indices for each factor. The CR values ranged from 0.888 to 0.937, all of which exceeded the critical threshold. AVE values are all above 0.50, with the "Attitude" factor reaching 0.790, suggesting that a considerable amount of variance is explained by the underlying constructs.

Discriminant validity was assessed using the Fornell-Larcker criterion. As presented in Table 3, the square root of each construct's AVE (e.g., 0.815 for PU) exceeded its interfactor correlations, thereby supporting the model's discriminant validity.

Finally, path analysis was conducted to test the five hypothesized relationships derived from the TAM framework. Specifically, H1, which states that PEoU has a positive effect on PU, was supported (H1: $\beta = 0.502$, $p < 0.001$). Hypothesis H2, which predicted a positive effect of PEoU on ATT, was also significant (H2: $\beta = 0.185$, $p < 0.001$). PU has a positive effect on ATT (H3: $\beta = 0.398$, $p < 0.001$) and BI (H4: $\beta = 0.471$, $p < 0.001$). Finally, ATT significantly influenced BI (H5: $\beta = 0.337$, $p < 0.001$).

TABLE 3
Descriptive characteristics and Discriminant Validity of ADASAT factors

		DESCRIPTIVES				CORRELATIONS			
	Factor	Mean	SD	Skewness	Kurtosis	1	2	3	4
1	Perceived Usefulness	4.89	1.42	-0.470	-0.166	*0.815*[a]			
2	Perceived Ease of Use	5.22	1.24	-0.510	0.249	0.502*	*0.820*[a]		
3	Attitude toward using ADAS	4.16	1.14	0.008	-0.340	0.491*	0.385*	*0.889*[a]	
4	Behavioral Intention to use ADAS	4.49	1.42	-0.271	-0.488	0.637*	0.318*	0.568*	*0.860*[a]

Note: * p<0.001; [a] Square Root of Average Variance Extracted (AVE)

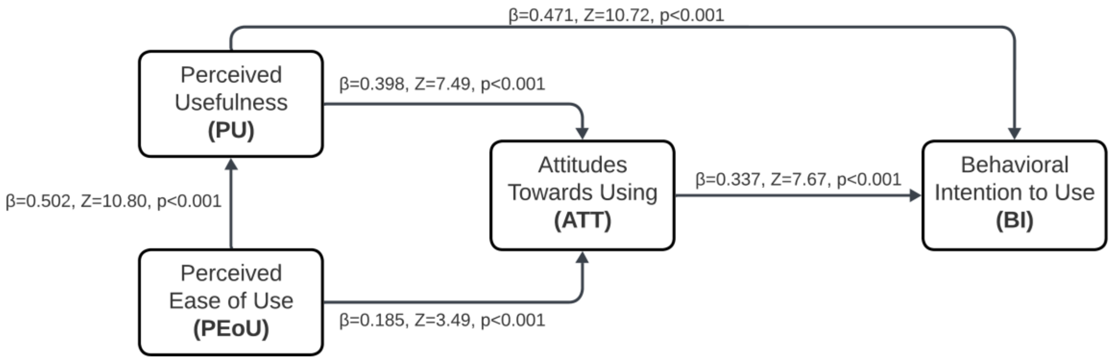

FIGURE 2
Path Diagram of ADASAT factors according to TAM model

Figure 2 illustrates the theoretical relationships among the TAM constructs, displaying the beta weights of the model. The model fit indices (CFI = 0.997, TLI = 0.984, RMSEA = 0.048; 90% CI: 0.000–0.087) indicated excellent alignment between the theoretical model and the observed data, supporting the nomological validity of the proposed framework.

The analysis of the indirect effects derived from the Path Analysis indicated that PEoU influences BI through significantly mediated pathways. The paths mediated by PEoU to PU, PU to ATT, and ATT to BI showed a coefficient of $\beta = 0.067$ ($p < .001$). A larger indirect effect ($\beta = 0.236$, $p < .001$) was found in the link between PEoU and BI via PU. The path mediated by PEoU to ATT and subsequently to BI also proved significant ($\beta = 0.062$, $p = .002$). Finally, the indirect effect of ATT on PU and BI was equally significant ($\beta = 0.134$, $p < .001$).

DISCUSSION

The results obtained in this study support the initial assumptions of the proposed model, providing empirical validation for the application of TAM to analyze the adoption of ADAS among road users. These findings highlight the pivotal roles of perceived usefulness and ease of use in shaping attitudes and behavioral intentions. Regarding the characteristics of the participants in the experimental conditions, there was a balanced sex distribution and an average age of approximately 24 years. The sample, composed primarily of students, reflects a youthful context and thus a high proportion of newly licensed drivers or drivers with limited experience. From a technological perspective, the degree of adoption of ADAS, such as parking assistance and adaptive cruise control, was found to be moderate. However, less than one-third of the respondents reported access to an AEB system. This limited diffusion is likely attributable to economic constraints and insufficient awareness of the benefits of these technologies. Furthermore, the findings underscore the importance of effectively communicating the practical benefits of the ADAS and minimizing barriers related to perceived complexity. Such efforts may facilitate broader adoption, particularly among young drivers, while providing valuable insights from both practical and theoretical perspectives. A recent study (Bosurgi et al., 2023a) showed that objective metrics of driver behavior align closely with self-reported measures of technology acceptance, reinforcing the validity of combining both approaches for a comprehensive evaluation of ADAS effectiveness. While the adoption of certain technologies is already significant, there remains considerable scope for improvement, particularly for less commonly adopted systems, such as AEB.

The reliability of the factor structure and empirical support for the theoretical hypotheses underscores the robustness of the model, suggesting its potential generalizability to broader populations.

Both exploratory and confirmatory factor analyses revealed a clear factorial structure consistent with TAM. The exploratory analysis identified four factors aligned with the TAM dimensions, and the confirmatory analysis validated this structure, demonstrating excellent model fit indices (CFI = 0.979, TLI = 0.974, RMSEA = 0.052). Reliability analysis showed high internal consistency (α = 0.885–0.937), and factor confirmation via CFA indicated a good fit of the model to the data. In particular, the PU and PEoU dimensions have emerged as key determinants of the acceptance of ADAS technologies.

High internal consistency, along with strong convergent and discriminant validity, confirmed the reliability of the measurement instrument and supported the conceptual distinction among the constructs within the model.

Path analysis provided empirical support for the hypothesized relationships among TAM constructs, confirming that both Perceived Ease of Use and Perceived Usefulness play fundamental roles in shaping attitudes and behavioral intentions toward ADAS usage. Specifically, PEoU influenced PU ($\beta = 0.502$, $p < .001$), while PU and ATT affected BI ($\beta = 0.471$ and $\beta = 0.337$, $p < .001$). The direct effects analysis confirmed that Perceived Ease of Use not only positively influences Perceived Usefulness (H1) but also exerts a significant effect on attitude toward using the ADAS (H2). In turn, both perceived usefulness and positive attitudes are key determinants of the behavioral intention to adopt these technologies (H3, H4, and H5).

The overall indirect effect was significant, indicating a strong mediation pathway within the model. The influence of Perceived Ease of Use on Behavioral Intention was further supported by the analysis of three indirect pathways: (1) PEoU ⇒ PU ⇒ ATT ⇒ BI ($\beta = 0.067$), (2) PEoU ⇒ PU ⇒ BI ($\beta = 0.236$), and (3) PEoU ⇒ ATT ⇒ BI ($\beta = 0.062$). The indirect effect of Perceived Usefulness on behavioral intention, mediated by Attitude Toward Use (PU ⇒ ATT ⇒ BI), was $\beta = 0.134$.

Although both the main factors examined in the study were complementary in predicting behavioral intention, PEoU emerged as the sole independent predictor of indirect effect pathways. Previous TAM studies have suggested different weighting between the two constructs: Perceived Usefulness tends to be the primary driver of long-term technology adoption, whereas Perceived Ease of Use plays a more critical role during the initial phases of adoption (Davis, 1989).

PU has consistently been identified as the most influential determinant of intention to use a technology, demonstrating a direct effect on both intention and actual usage behavior. By contrast, PEoU typically exerts an indirect effect mediated by PU; when users perceive a system as easy to use, they are more likely to consider it useful (Venkatesh & Davis, 2000).

In one study (Rahman et al., 2017), the TAM also emerged as the most effective model, explaining 82% of the variance in drivers' behavioral intentions. Attitude toward the ADAS was the most predictive factor, followed by perceived usefulness. The perception of the usefulness and ease of use of the ADAS positively affects the attitude and intention to use. The use of driving simulators elicited higher acceptance levels than online questionnaires, suggesting that direct interaction with technology fosters greater trust in the system.

The internal consistency of the scales was evaluated using Cronbach's alpha (α), which measures the degree of inter-item correlation within each construct.

Among the factors examined, ATT exhibited the highest internal consistency, with a Cronbach's alpha of 0.94, reflecting a strong coherence among items measuring users' general disposition toward the ADAS. PU also demonstrated excellent reliability, with an alpha of 0.90, indicating a high degree of inter-item correlation. PEoU, while slightly lower, still showed acceptable consistency with an alpha of 0.72, confirming that the items within this scale were sufficiently cohesive to reliably represent the construct.

The overall internal consistency of the factors was high, with Cronbach's alpha values exceeding the standard threshold of 0.70 for all factors. This indicates strong internal reliability, with values above 0.90, such as those observed for Attitude and Perceived Usefulness, reflecting excellent consistency. These results suggest that the items within each scale are highly interrelated and effectively capture underlying constructs. The robustness of these measurements strengthens the theoretical validity of the core TAM dimensions. Furthermore, correlation analyses revealed a particularly strong relationship between ATT, PU, and BI ($r > 0.85$), underscoring their central role within both TAM and TPB frameworks (Ajzen, 1991; Davis, 1989; Liao et al., 2023; Pamidimukkala et al., 2025; Xiao & Goulias, 2022). In comparison, PEoU demonstrated moderate correlations with ATT ($r = 0.49$) and BI ($r = 0.42$), suggesting a less dominant yet meaningful influence on user intentions (Hussain & Qureshi, 2024).

The EFA results demonstrated that the items corresponding to each construct clustered appropriately, reflecting a coherent representation of the underlying theoretical dimensions. No significant cross-loadings were observed among the primary factors, confirming the constructs' discriminant validity and conceptual distinctiveness.

CFA confirmed the structural soundness of the proposed model, demonstrating a strong alignment between the observed data and hypothesized theoretical structure. Moreover, it revealed an excellent fit between the theoretical model and observed data. The chi-square test yielded a non-significant result [$\chi^2(83) = 143$, $p < 0.001$], which, although sensitive to sample size, suggests an acceptable model specification. More robustly, CFI was 0.985 and TLI was 0.981, both well above the conventional cut-off of 0.90, indicating a strong model fit. Additionally, RMSEA was 0.045, with a 90% confidence interval ranging from 0.032 to 0.058. These values fell within the acceptable thresholds for RMSEA (i.e., below 0.08), and the upper bound of the confidence interval remained below 0.10, further supporting the adequacy of the model. Collectively, these indices confirm that the proposed four-factor model demonstrates excellent structural validity and closely aligns with empirical data.

The hypotheses and results presented in this study are largely consistent with previous empirical findings, reinforcing the statistical robustness and theoretical relevance of TAM in the context of the ADAS (Davis, 1989; Rahman et al., 2017; Venkatesh & Davis, 2000). Thus, a comprehensive understanding of the interplay

between key acceptance factors is essential for the design and deployment of user-centric technologies in the automotive sector (Ajzen, 1991; Khattak et al., 2024; Venkatesh & Davis, 2000).
Future research should further explore additional constructs, such as trust (Waung et al., 2021; Wu et al., 2011) and perceived safety (PS) (Chen et al., 2024)—factors not addressed in the current study but are potentially critical for deepening our understanding of technology acceptance in real-world contexts. One study showed that PS has greater total effects than PEoU on individuals' behavioral intentions to use AVs: willingness to adopt such systems appears to be directly related to both perceived safety and perceived ease of use, underscoring the importance of these variables in promoting user acceptance (Yao et al., 2023).
Regarding trust, prior research has shown that this factor is crucial for both system acceptance and actual usage behavior, especially when considering a driver's personal driving style (Ghazizadeh et al., 2012; Ma & Zhang, 2021; Waung et al., 2021).
Another study investigated the acceptance of AVs, showing a positive effect on intention to use, which could nonetheless depend on familiarity with the system (Chan & Lee, 2021; Rejali et al., 2023).
Individuals' beliefs about the perceived ease of use of systems can be skewed and weakened owing to the lack of human intervention in FAV usage simulations. Therefore, it is necessary to focus on certain features of the technology regarding the compatibility, trialability, and demonstrability of results (Lin, 2013).
From a theoretical perspective, the validation of TAM as a robust interpretative framework offers a solid foundation for future research on advanced automotive technologies. Further studies should assess the influence of underexplored constructs including privacy protection, network security, and broader safety-related perceptions.

CONCLUSION

This study contributes to the growing body of literature on driver interactions with advanced driving technologies by validating the ADAS Acceptance Test within an Italian context. Grounded in Technology Acceptance Model, the findings confirmed the central role of perceived usefulness and perceived ease of use in shaping driver attitudes and intentions toward adopting ADAS technologies. The questionnaire demonstrated strong psychometric properties including high internal consistency, good factorial validity, and excellent model fit, supporting its application in future research and practice.
Beyond statistical robustness, these results offer practical insights into how drivers, particularly younger ones, engage in vehicle automation. As automotive systems become increasingly integrated into daily mobility, understanding the psychological factors that support or hinder their acceptance is crucial.
In this regard, the ADASAT has emerged not only as a reliable measurement tool, but also as a potential guide for industry professionals, policymakers, and researchers aiming to foster safer, more intuitive interactions between drivers and emerging technologies. Future work expanding on these findings could play a pivotal role in bridging the gap between innovation and user-centered adoption in road safety.

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APPENDIX

APPENDIX 1

Descriptive characteristics of the most known ADAS

Tipology		Description
	**Adaptive Cruise Control (ACC)**	Uses sensors, such as radar or cameras, to detect the speed and distance of the vehicle ahead and automatically adjusts the vehicle's speed to maintain a safe following distance. This system improves driving convenience and safety, particularly in highway settings where maintaining a consistent speed and distance is crucial (Yu & Wang, 2022).
	**Lane Keep Systems (LKS)**	Lane Departure Warning (LDW) and lane-keeping assist (LKA) are designed to prevent inadvertent lane departure, which is a common cause of accidents. LDW systems alert the driver with visual, auditory, or haptic signals when the vehicle begins to drift out of its lane, without the use of turn signals. LKA systems take a more proactive approach, providing subtle steering interventions to help the vehicle stay within its lane if the driver does not respond to warnings. These systems significantly reduce the risk of accidents related to lane departure (Dean & Riexinger, 2022).
	**Automatic Emergency Braking (AEB)**	Automatic Emergency Braking (AEB) systems detect imminent collisions with other vehicles or obstacles and autonomously engage brakes if the driver fails to react in time. This technology aims to prevent collisions or mitigate their severity, thereby contributing to the overall road safety (Yang et al., 2020).
	**Blind Spot Detection (BSD)**	Blind Spot Detection (BSD) systems monitor areas alongside and slightly behind the vehicle that are not visible to the driver, commonly referred to as blind spots. When a vehicle is detected in these areas, BSD systems alert the driver through visual or auditory signals, thereby reducing the likelihood of collision during lane changes (Kim et al., 2023).
	**Intelligent Parking Assistance Systems (IPAS)**	Intelligent Parking Assistance Systems (IPAS) encompass technologies, such as rearview cameras, parking sensors, and automated parking systems. These systems assist drivers in maneuvering their vehicles into parking spaces by providing visual and auditory feedback, or by autonomously steering the vehicle into the space. This technology alleviates parking stress and reduces the risk of parking-related accidents (Fahim et al., 2021).

APPENDIX 2
Content and descriptive characteristics of the ADASAT items

		Mean	SD	Skew	Kurt
1.	Utilizzare gli ADAS migliorerebbe le mie prestazioni di guida. *Using ADAS would improve my driving performance.*	4.83	1.73	-0.609	-0.341
2.	Utilizzare gli ADAS aumenterebbe il mio piacere di guidare. *Using ADAS would increase my enjoyment of driving.*	4.54	1.65	-0.415	-0.478
3.	Utilizzare gli ADAS potenzierebbe l'efficacia della mia guida. *Using ADAS would enhance the effectiveness of my driving.*	4.87	1.66	-0.595	-0.295
4.	Utilizzare gli ADAS renderebbe la mia esperienza di guida più facile. *Using ADAS would make my driving experience easier.*	5.31	1.53	-0.756	0.051
5.	Imparare ad utilizzare gli ADAS mi risulterebbe semplice. *Learning how to use ADAS would be simple for me.*	5.44	1.38	-0.809	0.603
6.	La mia interazione con gli ADAS risulterebbe chiara e comprensibile. *My interaction with ADAS would be clear and understandable.*	5.03	1.36	-0.327	-0.236
7.	Interagire con gli ADAS non richiederebbe molto sforzo mentale. *Interacting with ADAS would not require much mental effort.*	5.00	1.59	-0.401	-0.619
8.	Mi risulterebbe semplice diventare abile nell'uso degli ADAS. *It would be easy for me to become skilled at using ADAS.*	5.38	1.40	-0.604	-0.085
9.	Vivrei positivamente l'utilizzare gli ADAS alla guida. *I would have a positive experience using ADAS while driving.*	4.14	1.29	0.063	-0.401
10.	Credo che gli ADAS aiutino ad essere più impegnati alla guida. *I believe ADAS help me stay more engaged while driving.*	4.11	1.21	-0.031	0.032
11.	Sono generalmente a favore dell'utilizzo degli ADAS. *I am generally in favor of using ADAS.*	4.15	1.21	0.011	-0.217
12.	Trovo che sia una buona idea guidare usando gli ADAS. *I think it is a good idea to drive using ADAS.*	4.23	1.25	0.055	-0.371
13.	Ho intenzione di utilizzare i sistemi ADAS in futuro. *I intend to use ADAS in the future.*	4.50	1.55	-0.239	-0.485
14.	Prevedo di utilizzare i sistemi ADAS regolarmente. *I plan to use ADAS regularly.*	4.49	1.57	-0.167	-0.677
15.	Ho intenzione di utilizzare i sistemi ADAS ogni volta che sarà possibile. *I intend to use ADAS whenever possible.*	4.47	1.55	-0.237	-0.596