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Negative attitudes towards cyclists influence the acceptance of an in-vehicle cyclist detection system [☆]

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A B S T R A C T

The shift towards automation and safer vehicles will increasingly involve use of technological advancements such as Advanced Driver Assistance Systems (ADAS). Nevertheless, these technologies need to meet users' perceived needs to be effectively implemented and purchased. Based on an updated version of the Technology Acceptance Model (TAM), this study analyses the main determinants of drivers' intention to use an ADAS aimed at detecting cyclist and preventing potential collision with them through an auto-braking system. Even if the relevance of perceived usefulness, perceived ease of use and trust on the acceptance of a new system has been already discussed in literature, we considered the role of an external variable such as attitudes towards cyclists in the prediction of an ADAS aimed to improve the safety of cyclists. We administered a questionnaire measuring negative attitudes towards cyclists, trust, perceived usefulness, perceived ease of use and the behavioural intention to use the system to 480 Italian drivers. Path analysis using Bayesian estimation showed that perceived usefulness, trust in the system, and negative attitudes towards cyclists have a direct effect on the intention to use the ADAS. Considering the role of attitudes towards other road users in the intention to use new ADAS aimed to improve their safety could foster the user's acceptance, especially for those people who express a negative representation of cyclists and are even more unlikely to accept the technology.

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1. Introduction

Cyclists represent a small proportion of road users in comparison with motorized vehicles, nevertheless, they are considered to have an important degree of vulnerability due to their lower mass (Schepers, Hagenzieker, Methorst, Van Wee, & Wegman, 2014) and lack of physical protection in case of collisions (European Commission, 2015). Around 25000 cyclists have died in Europe in traffic collisions between 2004 and 2015 (European Transport Safety Council, 2015). Collisions with cars accounted for 52% of cyclists' deaths in the European Union (European Transport Safety Council, 2015). Human error

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could be a factor intervening in such accidents; according to European data (European Commission, 2015), the most frequent causes of collision between bicyclists and other drivers/bicyclists are errors such as taking actions prematurely, performing a manoeuvre in the wrong direction, missing information, or an incorrect understanding of other road users' action.

To improve road safety, the development and use of intelligent transport systems have been advocated (Geronimo, Lopez, Sappa, & Graf, 2010; Vaa, Penttinen, & Spyropoulou, 2007). From the early fundamental innovation (e.g., airbag), more complex and intelligent devices flooded the road safety market. In-vehicle information systems (IVIS) and advanced driver assistance systems (ADAS) have been developed with the clear intent to improve driving behaviour (Brookhuis & de Waard, 2005) and foster road users' comfort and safety (Pauzié & Amditis, 2011), anticipating accidents to avoid them or reduce their severity (Geronimo et al., 2010).

Despite the IVIS, which are focussed on providing secondary task information and communication services, new ADAS are being developed to aid drivers in their primary driving tasks (Pauzié & Amditis, 2011). There are already several ADAS available on the market, for example the "Collision Avoidance System" designed for warning the driver to prevent or avoid a collision, the "Lane Departure Warning System", which helps the driver to keep the vehicle on the road, and the "Autonomous Emergency Braking System" which autonomously brakes the vehicle if the driver does not react in time.

Vulnerable Road Users (VRUs) such as pedestrians, cyclists and moped riders, however, have not generally been addressed when developing ITS (Intelligent Transportation Systems; Scholliers, Bell, Morris, & Garcia-Melendez, 2015). From a quantitative safety impact assessment of five systems, Silla et al. (2016) have found how these new ITS have the potential to significantly improve cyclists' safety. The study showed how cyclists' fatalities and injuries are prevented by the introduction of the investigated systems. When controlling the results for the estimated accident trend and penetrations rates, the prediction for 2030 showed that the systems with the highest impact on safety would be the Blind Spot Detection and the Pedestrian and Cyclist Detection System with Emergency Braking.

In our study, we decided to focus on a type of ADAS designed to detect cyclists ahead of the vehicle, warn the drivers if an imminent collision is about to happen and autonomously brake the car if the driver is not able to react in time. For these technologies to be used by the driver, they need first to be accepted (Burnett & Diels, 2014). Therefore, it is important to understand how acceptance has been considered in the literature and which are its determinants, to make such technologies more effective. As remarked by Adell (2009), acceptance of an in-vehicle system has become the key factor in determining the user's intention to use the system and its consequent success on the market (Regan, Horberry, & Stevens, 2014; Vlassenroot, Brookhuis, Marchau, & Witlox, 2010).

1.1. Acceptance of technology

To understand the determinants of acceptance of new technical innovations such as the car driver supporting systems described before, we make use of the Technology Acceptance Model (TAM) designed by Davis (1989). The TAM model has been used to determine the user's acceptance of a new technology in terms of behavioural intention to use the system (BIU) and the actual system use. In literature, TAM has been found to predict approximately 40% of a system's use (Davis, Bagozzi, & Warshaw, 1989). In a systematic literature review performed to assess whether the TAM predicts actual usage (Turner, Kitchenham, Brereton, Charters, & Budgen, 2010), results shown that BIU has a high proportion of predicting the actual usage of the system. Specifically, BIU has an average proportion of success per study of 0.9 on actual usage. Indeed, several theories in the psychosocial literature assume that intentions cause behaviours. According to Ajzen (2005), changes in behavioural intentions should be translated into behaviour under appropriate circumstances and given adequate control over the behaviour. In addition, there is evidence from a meta-analysis of 47 experimental studies that changes in behavioural intention engender behaviour change (Webb & Sheeran, 2006).

The TAM has been applied in an extraordinary variety of fields (Ghazizadeh, Peng, Lee, & Boyle, 2012; Regan et al., 2014; Turner, et al., 2010). In the last decades, several authors described acceptance and acceptability on different levels (see Adell, Varhelyi, & Nilsson, 2014) and a clear and common definition of what acceptance and acceptability has not been achieved yet (Adell, 2009; Trübswetter & Bengler, 2013; Vlassenroot et al., 2010). However, according to Adell (2009), what seems to be clear is that in the field of transportation and particularly in the area of driver support systems, the challenge is to investigate the behavioural acceptance of the system even when the system is not yet available but still in its early design stages. Indeed, this early evaluation of the system, defined as the acceptability of the system, could help manufacturers to improve the design of the product so that it could be more suitable for the market and to select the best human-machine interface option to alert the final user (Meschtscherjakov, Wilfinger, Scherndl, & Tscheligi, 2009). Acceptability has been used to describe the potential acceptance of the system, a personal judgment before experiencing it (Regan et al., 2014). Vlassenroot et al. (2010) defined the possibility to measure the future intention to use the new system before its actual usage as the user acceptability. In other words, whereas the term user acceptance refers to the actual intention to use the system, the term acceptability refers to the user attitudes and beliefs still before the concrete use of the new device. This means to investigate how the intention to use the future system reflects the behavioural acceptance of the system, and this could be done if the evaluation is based on the individual's perception of the system (Adell, 2009).

According to the TAM, the user acceptance of a new technological system depends on two main factors: the perceived usefulness (PU) and the perceived ease of use (PEOU). The first refers to how much the system is considered helpful in performing the relative tasks, while the latter refers to how much effort is needed to use the system. PEOU and PU are the main determinants of users' BIU the specific system (Davis, 1989).

In the literature, the role of PU on the acceptance of technical innovations, and on the intention to use advanced systems has been widely acknowledged, (Park & Kim, 2014; Park, Kim, & Ohm, 2015). In other words, the more the system is perceived as useful, the more the user will be inclined to use it. In transportation research, PEOU has been recognized as a critical effective determinant of the attitude and intention towards driving support systems (Mallat, Rossi, Tuunainen, & Öörni, 2008; Park et al., 2015). Research has also shown how PEOU has a positive effect on the users' intent to actually use the system (Lee, Hsieh, & Chen, 2013; Teo, Lee, & Chai, 2008). Furthermore, there is evidence that PEOU is an antecedent of the PU which leads to an increased intention to use the system itself (Larue, Rakotonirainy, Haworth, & Darvell, 2015; Venkatesh, 2000; Venkatesh & Davis, 2000).

Conceivably with the systematic review mentioned above (Turner et al., 2010) and consistently with the Technology Acceptance Model, the following hypotheses are proposed:

- H1.** Participants who perceived the system as more useful (PU) will manifest more intention to use the new system.
- H2.** Participants who perceived the system as easier to use (PEOU) will manifest more intention to use the new system.
- H3.** Participants who perceived the system as easier to use (PEOU) will perceive the system as more useful (PU), and, in turn, will exhibit more intention to use the new system.

1.2. Trust and acceptance of technology

To better understand the effect of additional factors such as beliefs, attitudes, and intentions on acceptance, the TAM has been revised and extended (Regan et al., 2014; Venkatesh & Morris, 2000). Those extensions provide a deeper understanding of what influences the acceptance of a system (Larue et al., 2015). Lee, Kozar, and Larsen (2003) systematized several external variables related to the TAM model in literature, through a meta-analysis. Furthermore, Ghazizadeh and Lee (2014) proposed a model for assessing acceptance of driver support systems, in which they aggregated many variables directly influencing the acceptance. The model is based on a list of categories of external variables such as device characteristics, driver characteristics, drivers' behaviour, context, and culture (Davis et al., 1989).

In the last decade, it has been shown that trust has a fundamental influence on the acceptance and adoption of new technologies (Choi & Ji, 2015). In other words, the more the users trust the system the more they will intend to use it (Parasuraman, Sheridan, & Wickens, 2008). This means that trust is considered as a major natural bridge between the users' beliefs towards automation and their intention to use the system (Ghazizadeh et al., 2012; Parasuraman et al., 2008). Ghazizadeh et al. (2012) proposed an augmented version of the TAM that accounts for drivers' trust in an on-board monitoring system. They hypothesized that both PU and PEOU positively affected trust which, in turn, predicts the behavioural intention to adopt the system.

Since previous work emphasised how trust does not fully mediate the relationship between one's own beliefs and the intention to use the system (Lee & See, 2004), Ghazizadeh et al. (2012) hypothesized a significant influence of PU and PEOU on behavioural intention, even after controlling for the effect of trust.

The growing interest on automation comes along with the challenge of marketing a system which the user can rely on (Vaa, 2007). Thus, focussing on the potential acceptance of automated and ADAS for cars is of utmost importance, as it has been shown by Ghazizadeh et al., 2012. When a function hitherto handled by humans, is now controlled and managed by the system it is possible to talk of automation (Parasuraman & Riley, 1997). In the case of automation, standard driving functions and tasks normally handled by drivers are now under the control of the system. Furthermore, users must deal with a new task structure and new responsibilities, along with coordinating and monitoring the tasks (Ghazizadeh et al., 2012). The users are expected to handle such changes to trust the system, accept and internalize those new structure and responsibilities in their pre-existing driving behaviour, which, in turn, should lead to an improved and safer driving performance, that is what the ADAS is designed for (Brookhuis & de Waard, 2005).

When studying automated systems, we need to consider the different levels of automation recognized by the Society of Automotive Engineers (SAE). The SAE defined the main characteristics of the six levels identified for the vehicle automation. In our case, the level of automation for the Pedestrian and Cyclist Detection System with Full Auto Brake system technology could be considered within the level two of the classification provided. Even if the system is supposed to monitor and detect the cyclists ahead on the road, which could make it almost at level three in the SAE classification, this function is strictly related to pedestrian's and cyclist's detection without interfering with the whole variety of driving task.

Based on Ghazizadeh et al.'s (2012) augmented version of the TAM, we proposed the following hypotheses:

- H4.** Participants who further trust the new system under development, will exhibit more intention to use it.
- H5.** Participants who perceive the system as more useful (PU), will further trust the new system which, in turn, will exhibit more intention to use it (mediational pathway).

H6. Participants who perceive the system as easier to use (PEOU), will further trust the new system, which, in turn, will exhibit more intention to use it (mediational pathway).

In our study, we decided to investigate how trust could influence the intention to adopt a specific type of ADAS still under development, as well as if there is an external variable that could influence people to trust a particular autonomous driving support system (Choi & Ji, 2015). Research already stated the need to further understand how individual factors pertaining to drivers' background characteristics (e.g., attitudes) affect their views of ITS technologies, and what implications this may have for successful implementation of ITS products (Rafiyani, 2015). Furthermore, in our case, the system is designed to give priority to protection and safety of road users (i.e., cyclists) other than the final potential customer user (i.e., car driver). Thus, we can define the system examined in this research as an "altruistic ADAS". As previous research already highlighted, the role of attitudes towards a specific category of road users influences the driving behaviour towards that category (Fruhen & Flin, 2015; Johnson, Oxley, Newstead, & Charlton, 2014). Fruhen and Flin (2015) showed that attitudes towards cyclists were associated with aggressive driving towards cyclists. Negative attitudes towards cyclists were more pronounced in non-cyclists than cyclists, furthermore, the more negative attitudes towards cyclists were linked to a higher frequency of aggressive driving towards cyclists. Similarly, the levels of acceptance of policies that attempt to help minority groups are influenced by negative attitudes towards members of that outgroup (Krysan, 2000). Since the impact of attitudes on drivers' intention to use in-vehicle devices such as navigation systems is explored (Chen & Chen, 2009, 2011), we decided to consider also the attitudes that a car driver could manifest towards cyclists into the technology acceptance model, to measure how negative attitudes towards them could impact the intention to use the system.

1.3. Negative attitudes towards cyclists

Attitudes towards cyclists can be understood as a cluster of general feelings and opinions towards cyclists, that is, if they are perceived as legitimate road users or not (Basford, Reid, Lester, Thomson, & Tolmie, 2002; Prati, Puchades & Pietrantonio, 2017). In the book *Cycling Culture* by Cox (2015), cyclists are addressed with words as "minority" (p. 20), "sub-culture" (p. 29), "diversity" (p. 43), and "marginalized" (p. 69) in relation to motorists. Since attitudes are frequently identified in transportation research as determinants of planned behaviours, like mode choice (Goddard, 2016), there is the need to assess their influence on the acceptance of ADAS that mainly address the safety of road users other than the main user.

In a study by Rissel, Campbell, Ashley, and Jackson (2002), the relationship between drivers' attitudes towards cyclists and their knowledge about road rules was explored. In other words, the authors investigated how knowledge about road rules can act as a predictor of attitudes towards a different type of road users (i.e. cyclists).

They found that car drivers showing more negative attitudes towards cyclists were those who were less knowledgeable of road rules. Moreover, Johnson et al. (2014) found out that during a critical manoeuvre, those car drivers that held more positive attitudes towards cyclists were those who drive safer. In a qualitative study by Basford et al. (2002), car drivers were the ones holding more negative views of cyclists. Furthermore, larger vehicle drivers (i.e. heavy goods vehicles and buses) were those who exhibited stronger negative attitudes towards cyclists, not accepting them as legitimate road users. The authors specified that considering the car drivers' attitudes towards cyclists means including also the subjective opinion about the characteristics of cyclists with whom drivers share the road space. In their study, car drivers described cyclists as arrogant, especially when they disregarded the road rules or acted irresponsibly.

According to Kaplan and Prato (2016), drivers confessed feeling frustrated when sharing the road with cyclists. According to Johnson et al. (2014), frustration arose when drivers repeatedly need to overtake cyclists. This relationship between frustration and aggressive driving behaviour when sharing the road with cyclists deserves greater consideration. Significantly, recent studies by Thørrisen (2013), and Fruhen and Flin (2015) highlighted a positive relationship between car drivers' negative attitudes towards cyclists and aggressive driving behaviours towards them. This general overview could be related to what Basford et al. (2002) highlighted. They described how car drivers perceive cyclists as an outgroup, addressing them as a road user category with whom it is difficult to interact when sharing the road and to whom they hold negative and hostile views of cyclists as a category. These results draw the attention to the scenario for which the ADAS involved in our study is designed.

According to Social Identity Theory (Tajfel & Turner, 1985; Turner, 1984), social behaviour can be explained through intergroup behaviour dynamics. One of the main outcomes of intergroup behaviour is that humans are naturally driven to view their own groups (in-group) positively, while associating negative attributes to members of other groups (out-group). Regarding attitudes towards an outgroup, there is evidence that the levels of acceptance of policies that attempt to help minority groups are influenced by negative attitudes towards members of that outgroup (Krysan, 2000). Specifically, if people hold negative attitudes towards outgroup members they are less likely to support measures aimed at protecting them. An evidence of the in-group out-group effect between cyclists and drivers can be found in Goddard, Dill, and Monsere (2016). The study highlighted that commuter drivers have significantly more negative attitudes towards cyclists than towards other drivers. Also, drivers view positively the rule-following behaviour of other drivers while they have a view of cyclists as rule breakers, despite evidence that bicyclists can be even more law-abiding than drivers (Thompson, 2015). As cyclists tend to be perceived as outgroup members by motorized vehicle drivers (Basford et al., 2002; Fruhen & Flin, 2015), it should be expected that drivers that hold negative attitudes towards cyclists may be less likely to accept, appreciate and trust new systems that protect cyclists. Indeed, the cyclists' detection system with auto braking is aimed at preventing collision between

cars and bicycle. Since the cyclists are more vulnerable, as a result, the outcome of the system will increase primarily the cyclists' safety. This means that the user of the system is not the one who will benefit the most of its outcomes. Thus, we can define the system examined in this research as an "altruistic ADAS". This could imply that the attitudes of drivers towards the category whom is going to benefit more from the system (i.e., cyclist) will influence the acceptance of the system. In our study, we considered attitudes towards cyclists as an external factor in the TAM model (Regan et al., 2014; Venkatesh & Morris, 2000) posing it as an antecedent of the behavioural intention to use. Since the augmented TAM conceptualizes the key variables along the development of acceptance of a new technology, we established the following hypothesis:

H7. Participants with negative attitudes towards cyclists will manifest lowered behavioural intention to use the new system.

H8. Participants with negative attitudes towards cyclists will perceive the new system as less useful (PU).

H9. Participants with negative attitudes towards cyclists will perceive the new system as more difficult to use (PEOU).

H10. Participants with negative attitudes towards cyclists will have lower levels of trust in the new system.

The TAM frames the user's intentional process that lead to the actual usage of the system, through the role played by PU and PEOU. Although previous research already explored the amount of variance explained by PU and PEOU in predicting the intention to use the system (Davis et al., 1989), as far as the authors are aware, no works have discussed the technology acceptance process of a system devoted to protecting cyclists, adding an external variable as the car driver's attitudes towards the same target safeguarded by the ADAS. Within this context, this work aims to fill this research gap regarding the acceptance of this specific ADAS, giving fruitful suggestions when considering acceptance of an "altruistic" ADAS.

Following the hypothesis defined before, we conceived the following model in Fig. 1.

2. Methods

2.1. Procedure

The research reported in this paper is survey-based. We posted the link to the survey on Italian Drivers associations' websites, Facebook groups, blogs and forums that were found on Google's and Facebook's search engines using keywords such as "Car Drivers" and "Drivers Association". We reached out 59 Facebook groups and 38 websites, and data were collected from January 16, 2016 to May 12, 2016. To recruit the participants using Internet, we used two methods: (a) firstly, the link which gives the permission to fulfil the questionnaire was directly published on Facebook groups' walls or on websites bulletin boards if available; (b) secondly, an email was written to the website administrators, kindly asking to advertise the

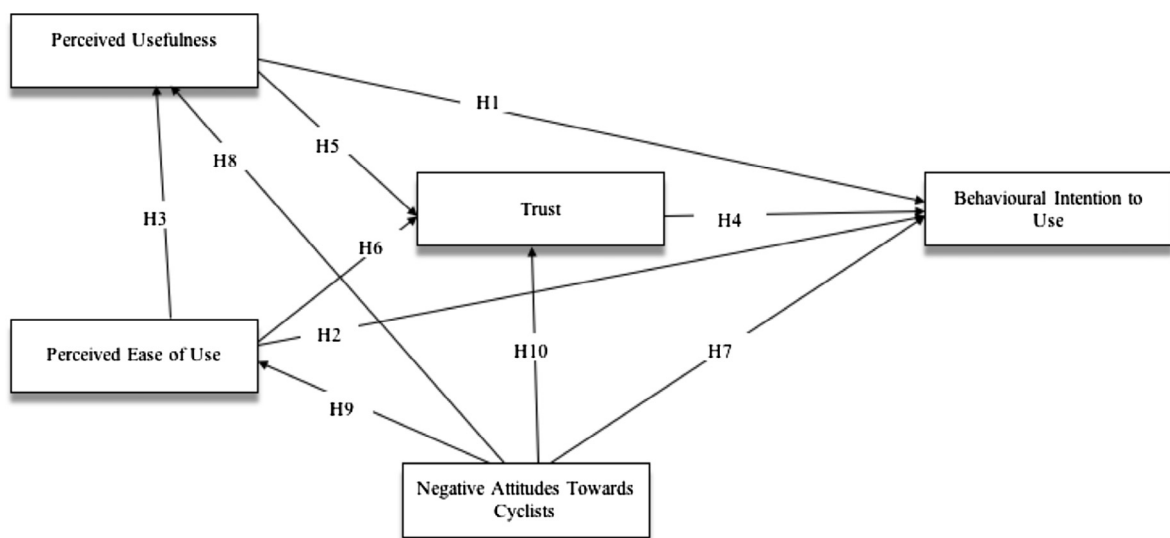


Fig. 1. Hypothesized path model integrating TAM and attitudes towards cyclists.

questionnaire directly on their website, through their social media channels or inside their newsletter. The second method aimed at gaining visibility and attracting even more participants.

2.2. Participants

A total of 480 participants responded the questionnaire. We decided to discard the incomplete questionnaires and the ones in which participants responded incorrectly to the bogus questions (e.g., “I once encountered a spaceship driven by aliens”). After cleaning the data, the remaining respondents were 355 (74.0%). From these, 185 (52.1%) were men, 123 (34.6%) were women and the rest correspond to 46 (13.0%) values missing and one (0.3%) that did not feel identified with any of these categories. The age of the participants ranged from 19 to 76 years old ($M = 36.80$, $SD = 14.11$).

Among these participants, 213 (60.0%) of them was used to drive a car six or more times per week, 34 (9.6%) used it five times, other 21 (5.9%) participants drove the car four times a week, 25 (7.0%) did so three times, 32 (9.0%) of them drove a car twice a week and the remaining 28 (7.9%) participants used the car just once a week. Of the respondents, 276 (77.7%) reported to be also owners of a bicycle. Half of the participants reported that they are not used to riding a bicycle during the week (51.3%), one out of five declared to ride the bicycle once a week (20.6%), whereas the rest of the participants reported to ride the bike more than one time a week (28.1%).

2.3. Materials

To display the new automation system, we embedded in the questionnaire a video footage entitled “Pedestrian & Cyclist Detection” of 1' 06" long and freely available on YouTube. The footage voice-over was in English and Italian subtitles were provided. The video has been designed to provide the viewer with a basic understanding regarding the functionality of the vehicle's safety technology. The video described the system as based on a radar that detects all objects placed in front of the car and its distances thereto, as well as on a camera that distinguishes pedestrians and cyclists from other objects. Once one of these two types of road users is detected, the driver receives an auditory warning with a flashing light on the windshield head-up display, raising awareness of the danger. In case drivers are not able to react, the car is automatically braked. In the end, the voice-over emphasizes that the system helps to increase the safety of unprotected road users.

More specifically, the video portrayed a simulated image of a motorist who is driving in an urban road and immediately approaches both pedestrians and cyclists in front of the vehicle. Both the car driver and the cyclist are going straight forward, the car driver is paying attention to the cyclist ahead. Suddenly, the cyclist swerves in front of the car to avoid a relatively adverse road hazard (i.e., door opening). Fortunately, with the new in-vehicle system, the car fully brakes autonomously, thus defending the cyclist and protecting the car driver from damages and legal consequences.

The audio transcription is provided in the Appendix A in order to give more details about the instructions received by the participants during the video, about what the system was designed for, how it works and what benefits it provides. Moreover, the reader can send an email to the authors if desires to have more information on the video or to request access to it.

In our questionnaire, just right after the video, participants were asked to respond to the items measuring acceptance, PEOU, PU and trust in the system.

2.4. Measures

2.4.1. Negative attitudes towards cyclists

To measure respondents' negative attitudes towards cyclists we included in the questionnaire six items drawn and adapted from the study by [Rissel et al. \(2002\)](#). Participants were asked to point out their degree of agreement with each item using a Likert-type scale ranging from 1 to 5 (1 = *highly disagree*; 5 = *highly agree*). The items examine whether or not cyclists are perceived as competent road users (i.e., “many cyclists on the road have not learned to ride properly”), as irresponsible road users (i.e., “many cyclists take no notice of road rules”), cautious road users (“most cyclists are aware of other road users”), ineligible road users (i.e., “they should use the cycle track”; “cyclists should not be allowed to ride on main roads during peak hours”), or inconvenient road users (i.e., “it is very frustrating to encounter cyclists on the road”). The negative attitudes towards cyclists were measured before showing the video.

2.4.2. Trust

To measure if the respondents would trust the presented technological system we asked them how much they would agree to the following two statements: “I will trust the information I receive from the innovative technology” and “I think I can depend on the innovative technology”. We adapted these items from [Ghazidadeh et al. \(2012\)](#). Participants were asked to point out their degree of accordance on a seven-point Likert-type scale (1 = *highly disagree*; 7 = *highly agree*).

2.4.3. Perceived ease of use

To measure participants' PEOU of the system, we used three items taken from [Ghazidadeh et al. \(2012\)](#). Participants expressed how much they perceived the presented technology as easy to use by replying on a seven-point Likert-type scale (1 = *highly disagree*; 7 = *highly agree*). An example of item would be “I think that the technology showed in the footage will be easy to use”.

2.4.4. Perceived usefulness

PU was measured with six items taken from Ghazidadeh et al. (2012). Participants were asked to point out if they thought that the presented technology could be useful for improving their safety and that of other road users, as well as improving their driving style and making them better drivers (e.g., “I think that the technology showed in the footage will be useful for my safety” and “I think that the technology showed in the footage will improve my driving style”). Items were assessed with a seven-point Likert-type scale (1 = *highly disagree*; 7 = *highly agree*).

2.4.5. Behavioural intention to use

To measure the participants' BIU the described system, we used three items drawn and adapted from Ghazidadeh et al. (2012). Participants expressed their degree of agreement with each one of the items (e.g., “If I had a choice, I would drive a car equipped with the new technology”) on a seven-point Likert-type scale (1 = *highly disagree*; 7 = *highly agree*).

2.5. Statistical analysis

Structural Equation Modelling (SEM) has been used extensively in travel behaviour research and traffic safety (Golob, 2003). The application of SEM is increasingly spread among researchers, in particular for subject areas such as driver behaviour (or more generally, user behaviour), traffic safety, and the application of advanced in-vehicle warning technologies. To test the hypothesized model, we applied path analysis, which is a technique that belongs to the broader category of SEM (Kline, 2016). We conducted all the data analysis using SPSS version 23 and AMOS. To evaluate the quality of the fit of the model, Bayesian analysis provides the posterior predictive *p*-values (Lee & Song, 2004). The posterior predictive *p*-value should be near 0.5 to provide evidence that the model is plausible, that is, little or any discrepancy between data generated by the model and the actual data itself (Gelman et al., 2013).

An examination of the distribution of the variables using the Komogorov-Smirnov test, skewness, and kurtosis (DeCarlo, 1997) revealed the presence of non-normally distributed data. We decided to use Bayesian estimation because of its capability to fit models based on ordered-categorical variables. Bayesian analysis estimates the lower and upper values (also known as Credibility Intervals) within which, with a pre-defined probability, the parameter can be found given the observed data (Zyphur & Oswald, 2013). In other words, once the parameter and the credibility intervals are obtained, one can state that there is an established probability that such parameter is comprised within the credibility interval. Under conventional null hypothesis testing, estimates with 95% credible intervals that do not include 0 are considered statistically significant.

3. Results

3.1. Preliminary analyses

First, we calculated the means of each item from Rissel et al.'s scale (2002) to explore and have a better understanding of which negative attitudes were more frequent among the participants. The most endorsed statements were “many cyclists take no notice of road rules” ($M = 4.22$; $SD = 0.94$) and “many cyclists on the road have not learned to ride properly” ($M = 4.14$; $SD = 0.97$), whereas the following statement, “they should use the cycle track or pay taxes”, turned out to be the least frequent one ($M = 1.64$; $SD = 1.19$).

Table 1 displays the mean scores (and relative standard deviations) and the correlation coefficients. Cronbach's alpha coefficients are provided in parentheses on the diagonal as estimates of internal consistency. The internal consistency of all factors was acceptable. The mean responses obtained for the items belonging to behavioural intention to use, negative attitudes, and trust were above the midpoint. PEOU and PU were around the midpoint. All the correlations were significant except the one between PEOU and negative attitudes towards cyclists.

Missing data analysis revealed that there were 40 participants that had at least one variable item missing. To utilize all available data, we have chosen the full information maximum likelihood approach for dealing with missing data. To test whether the missingness of data was unrelated to any study variable, we used Little's MCAR test. Little's MCAR test obtained for the present study's data resulted in a chi-square = 25,390 ($df = 21$; $p < 0.231$) and allowed us to assume that the missing

Table 1
Descriptive statistics and correlation between variables.

	Range	<i>M</i>	<i>SD</i>	1	2	3	4	5
1. Negative attitudes towards cyclists	1–5	3.07	0.79	(0.70)				
2. Trust	1–7	4.86	1.58	–0.18**	(0.90)			
3. Perceived ease of use	1–7	5.17	1.39	–0.08	0.44*	(0.93)		
4. Perceived usefulness	1–7	4.54	1.35	–0.13*	0.61**	0.36**	(0.85)	
5. Behavioural intention to use	1–7	5.29	1.64	–0.21**	0.73**	0.41**	0.65**	(0.92)

Values on the diagonal are Cronbach's alpha.

* $p < 0.05$.

** $p < 0.001$.

values were missing completely at random (MCAR), that is, that the presence or absence of determined responses was not due to other variables.

3.2. Path model

As Fig. 2 displays, all the hypothesized paths were significant except for that of PEOU on BIU, and that of negative attitudes on PEOU. That notwithstanding, there was an indirect effect (Bayesian Estimate = 0.38, 95% CI 0.29, 0.48) of PEOU on behavioural intention to use through PU and trust. Furthermore, the effect of negative attitudes towards cyclists on behavioural intention to use was also mediated by trust and PU (Bayesian estimate = -0.30 , 95% CI -0.49 , -0.12), thus implying a partial mediation since there was also a direct effect. Finally, the indirect effect of PEOU on behavioural intention to use through trust and PU was significant (Bayesian estimate = 0.31, 95% CI 0.24, 0.39).

The posterior predictive p-value of the Bayesian model was 0.50. This provides evidence that the quality of the fit of the model was good. We used the MCMC method for the estimation of R^2 values of the endogenous variables. The R^2 values for behavioural intention to use the system was 0.61 which means that 61% variation in behavioural intention can be explained by the model. The R^2 values for trust, perceived usefulness, and perceived ease of use were, respectively, 0.44, 0.15, and 0.01.

4. Discussion

The main aim of the current study was to investigate the role of negative attitudes towards cyclists on the acceptance of an in-vehicle cyclist detection system. We believe this study can contribute to the literature by extending the line of research on acceptance of ADAS, especially as it applies to an in-vehicle detection system primarily dedicated to the safety of other road users with whom the road is shared.

We argued that in situations where an intelligent transport system is designed to protect another road user, attitudes towards such category of road user may play a key role in acceptance. Therefore, we posed a model in which, given the determinants of the intention to use a system previously identified by the TAM model, negative attitudes towards cyclists would be predicting intention to use, as well as the other components of the TAM model.

Our results supported all the hypotheses except for Hypotheses 2 and 9. Thus, the process of acceptance of in-vehicle cyclist detection system is influenced by negative attitudes towards cyclists. More concretely, negative attitudes towards cyclists had a negative effect on PU (Hypothesis 8), trust (Hypothesis 10), and behavioural intention to use the system (Hypothesis 7). Moreover, we found evidence of an indirect effect linking negative attitudes towards cyclists and behavioural intention through PU and trust. These results are in accordance with the premise that negative attitudes towards a minority outgroup are associated with lower acceptance of policies that benefit them (Krysan, 2000), in this case, of technological systems that look after them. Nevertheless, we did not find negative attitudes to be a valid predictor of PEOU. As a possible explanation to this phenomenon, we should bear in mind that both attitudes and trust have affective components (Barbalet, 1996; Hitlin & Pinkston, 2013), whereas considering a new technology as easy to use might be more related to a further “rational” assessment of the system. Therefore, we pose that such negative affect or aversion towards cyclists could

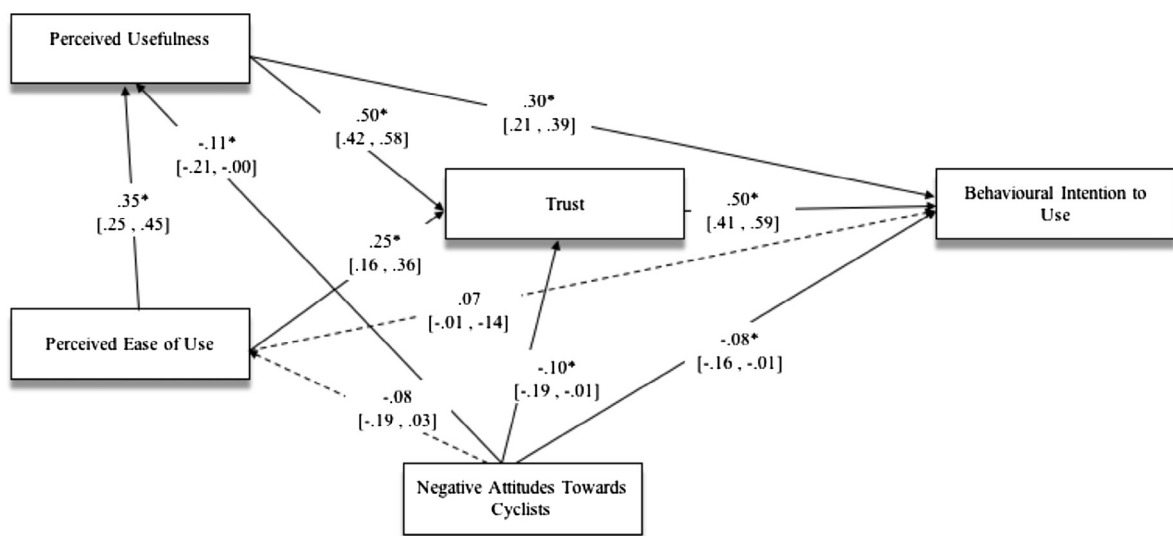


Fig. 2. Bayesian standardized path estimates and their 95% credible intervals (in parentheses) of the hypothesized model. Note. * Estimates with 95% credible intervals that did not include 0 indicate a valid prediction by the antecedent variable. Standardized regression estimates are shown upon each line. Dashed lines show non-significant effects.

more easily transfer to the trust in the system and the perceived final outcome experienced (i.e., PU), and not so much to more cognition-based determinants of BIU, such as PEOU, which refers to the users' perceptions of the process involved to achieve the final outcome of the system (Cho & Sagynov, 2015).

With regards to PEOU, in the present study, we found that PEOU had a significant influence on PU (Hypothesis 3) and trust (Hypothesis 6). A significant indirect effect of PEOU on behavioural intention to use through trust and PU was also found. We did not find PEOU to be a valid predictor of BIU. Not finding this direct effect differs from previous research on the TAM model (Lee et al., 2013; Teo et al., 2008). Furthermore, when accounting for both PU and trust, the analysis revealed a no significant direct effect of PEOU on the intention to use the system, as already highlighted by Ghazizadeh et al. (2012) in their evaluation of the acceptance of an on-board monitoring system among commercial drivers.

Although the fact that PEOU was not one of the main determinants of behavioural intention might be due, in our opinion, to the inclusion of trust may explain this finding. While PEOU appeared to be the most distal variable, trust was the most proximal variable to behavioural intention to use the system. Furthermore, the nature of the system and the context of their use could help in explaining this result. Recent research has shown the importance of driver's control over driving tasks and potential reduction of users' acceptability of the system. Bonnefon, Shariff, and Rahwan (2016) investigated how people react when facing different traffic scenarios in which the autonomous vehicle (AV) should take the best course of action to save whatever can be saved and to minimize casualties. Imagine a traffic situation where the AV acts in a way that is safer for the other road users than the passenger, it could be that this course of action discourages the car driver from accepting the system even if considering it easy to use. This result could concern the automated braking function comprised in the ADAS studied in the present article. The automated braking can act at the expense of the passenger in terms of a rear-end collision. If the present ADAS could make decisions in the benefit of others and at the expense of the passengers, car drivers could perceive this feature as safe only when cars coming after the braking vehicle will be respecting the safety distance and will be able to prevent a rear-end collision. In contrast, the system could be even perceived as dangerous for the passenger safety. In other words, it could be that even if the system is perceived useful because it can prevent an accident with a vulnerable road user, the perceived absence of control over the system and the risk of being involved in another type of collision, may break the direct relationship between perceived ease of use of the system and the behavioural intention to use the system. Thus, leaving the full control of the system to the discretion of the passenger might yield to higher levels of perceived ease of use and acceptance of the system. Nevertheless, this would be in exchange for more risk for eventual VRUs that, even though detected by the system, might collide due to the driver's inability to react in time.

This research brings about implications. Given the role of attitudes towards cyclists in the acceptance of technologies aimed at improving their safety, it might be important for car/technology manufacturers to adopt measures in the direction of changing such attitudes when attempting to increase acceptance of a system.

As already seen in other sectors related to interventions that address social identity, stereotypes and attitudes, policy makers and communities might also perform a role in this by promoting change of attitudes through persuasive communication (Aronson, Wilson, Akert, & Sommers, 2013) and educational interventions at different levels (e.g., Iverson & Seher, 2014; Watson, Kim, & Watson, 2016). Furthermore, in the transport sector, previous studies already underlined how negative attitudes towards other road users could be handled through campaigns focussing on reframing the car drivers' views of an out-group (Fruhen & Flin, 2015) for example emphasizing that cyclists, like drivers, are just people trying to get from A to B. An increase in car drivers' positive perceptions concerning cyclists could also be achieved illustrating the amount of congestion and pollution reduced by cycling rather than driving in cities.

Also, considering the typologies of negative attitudes much endorsed by our sample (i.e., cyclist's competence, knowledge, and experience), public events and car-free days that promote the advantages of bicycling, are good opportunities to gather people together and make them try new experiences with the opportunity to reframe their view of the out-group (Pucher & Buehler, 2008). In other words, by way of compensatory strategies or personal experience as cyclists, car drivers could increase tolerance and comprehension towards that mode (Goddard, 2016).

In addition, a way to achieve this is perfectly represented by a recent training campaign carried out for the employees of the Travis Perkins company (a British builders' merchant and home improvement retailer, already involved in a previous study of Kavanagh, 2014). In that occasion, hundreds of lorry drivers were made to ride bikes on London's roads to make them more aware of how cyclists on the road feel. In this case, it could be interesting to set up initiatives and trials where cyclists and drivers need to cooperate.

Moreover, in the race towards (highly or fully) automated vehicles, other VRUs will eventually be addressed by similar technologies. Thus, measuring and addressing attitudes towards newer minorities of VRUs (Siulagi et al., 2016) would anticipate the need to do so when such technologies are designed. Thus, this would increase the odds to permeate the market.

4.1. Limitations of the present study and future research

Even though the present study could bring meaningful contributions, it is not free from limitations. These limitations could be used as an input for further research on the topic of technology acceptance. First of all, our sample may be subject to the self-selection bias since people responded voluntarily to the questionnaire. Conceivably, drivers who were generally interested in new ADAS technologies could be prompted to click on the online survey link more than others. Further studies should focus on moderating variables related to the sample, for example considering the type of drivers. It could be that among professional drivers, the relationship between attitudes and acceptance of technology may differ. Basford et al.

(2002) reported that professional drivers (both goods and passengers' carriers) showed more hostile and negative attitudes towards cyclists than private car drivers. Future research could focus on increasing the variance explained by the model by incorporating further external factors relevant to transport sector worker's decisions to adopt a cyclist detection system, since it might lead to further findings in the determinants of technology acceptance.

Also, cultural differences could present a limitation to the current study in terms of generalization of findings. Generalization of findings is limited by the fact that participants do not represent car drivers at European level, due to geographic and cultural variability in traffic behaviours and attitudes. In Italy, the bike culture is not very widespread and popular: according to the [European Commission \(2014\)](#), Rome has the lowest score for bicycle modal share among all the European capital cities, and when asked "on a typical day, which mode of transport do you use most often?", only the 6% of Italian citizens answered "bicycle", which is lower than the European mean value (8%). Furthermore, no Italian cities ever appeared in the top 20 bicycle friendly cities classification made by [Copenhagenize \(2015\)](#). In a nutshell, Italian drivers could hold more negative attitudes towards cyclists than drivers from different cultures with higher cycling preference. Cultural differences between drivers may prompt them to develop different attitudes towards cyclists and thus different attitudes about technology. As most studies using a confirmatory approach through the use of structural equation modelling, our study is a "one-shot" study that did not include cross-validation or a split-sample approach. Future studies should attempt to replicate the current results.

Secondly, data collected at the same time using online survey has the potential to suffer from Common Method Variance (CMV), which indicates the amount of variance attributable for adopting the same method to measure related variables. It constitutes a limitation to our study given that we measured all the variables using self-reported questionnaires ([Podsakoff, MacKenzie, Lee, & Podsakoff, 2003](#)).

It is important also to mention that in literature, acceptance has been used interchangeably with the term acceptability ([Regan et al., 2014](#)), but still a conceptual distinction between the two terms can be found. While acceptability has been used to describe the potential acceptance of the system, as a personal judgement before experiencing it ([Regan et al., 2014](#)), acceptance has been described as the user response after experiencing the system ([Schade & Schlag, 2003](#)). In our case, participant ratings on acceptance were collected just after the video and without a possible and concrete test of the system. In this respect, we should bear in mind how the cyclist is portrayed in the video which could have had an impact on how the participant perceived the usefulness and ease of use of the system. In our case, the video portrayed simulated images that may have no impact on participants' ratings due to their neutral characterization. To overcome this obstacle, future research should focus on the possible differences between a pre-usage evaluation of the system and a post-usage evaluation highlighting possible differences in user preferences and perceptions.

It could also be relevant to investigate if altruistic ADAS are accepted and used on a voluntary basis, irrespective of positive or negative attitudes towards the specific groups of road users to whom the ADAS is designed for. We can imagine that a specific design of a car with an innovative "altruistic measure" (e.g., safe bonnets) led people to be willing to accept the system regardless of their attitudes towards other groups of road users. To overcome this limit, future studies should explore how the intention to use a system on a voluntary basis can lighten the impact of attitudes towards groups of road users in the process of accepting acceptance of an altruistic system.

As mentioned before, research has shown the importance of drivers' control over driving tasks and potential reduction of users' acceptability of the system if this was able to make decisions in the benefit of others and at the expenses of the passengers ([Bonneton et al., 2016](#)). Considering the role of negative attitudes towards other vulnerable road users on the acceptance of a system and the moral dilemmas in an autonomous vehicle regarding the course of action to minimize the casualties, future studies might explore the relationship between these dimensions and the behavioural intention to use the system.

5. Conclusions

The purpose of this study was to investigate the role of negative attitudes towards cyclists on the acceptance of an in-vehicle cyclist detection system based on the augmented technology acceptance model ([Ghazizadeh et al., 2012](#)). Our results confirm the role of PU and trust in determining the BIU the system, whereas, when accounting for both perceived usefulness and trust, the perceived ease of use did not directly affect the intention to use the system, as already found in previous study ([Ghazizadeh et al., 2012](#)).

Our findings showed that the process of acceptance of an in-vehicle cyclist detection system is influenced by negative attitudes towards cyclists, which had a negative effect on PU, trust and BIU the system, as well as an indirect effect on the latter through PU and trust. Moreover, the study gives some input for future research regarding the role of the perceived ease of use in the process of acceptance of an ADAS that comprises an automated actuator. It can be that the car's control over driving tasks can be perceived as a potential deterrent of users' acceptability of the system in terms of ease of use, thus highlighting the role of trust in the system as an important intervening variable.

Our results could prime car/technology manufacturers and policy makers when they are designing systems, or planning to introduce measures, to foster safety of those minorities of road users, in the direction of considering also the attitudes towards those road users when attempting to increase the acceptance of a system. Moreover, in the race towards (highly or fully) automated vehicles, other VRUs will eventually be addressed by similar technologies. Thus, measuring and

addressing attitudes towards newer minorities of VRUs, such as segway riders, skateboarders, and electric bike users (Siulagi et al., 2016), could prevent the later need to do so when such technologies are designed and to increase the odds to permeate the market.

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Appendix A.

Find here the transcription of the audio.

“Pedestrian detection warns there is a risk of a collision with a pedestrian and automatically activates full braking power, if the driver is unable to respond. The radar detects any object in front of the car and the distance to it. The camera determines what type of object it is. The system is programmed to calculate if a pedestrian is likely to step in front of the car. In an emergency, the driver receives an audible warning with a flashing light in the windshield, if they are unable to react, the whole braking power automatically applied. The groundbreaking collision warning and autobrake system has been further enhanced. New advanced software makes it possible to extend the technology to detect and break automatically for cyclists as well. The advanced sensor system scans the area ahead, if a cyclist swerves out in front of the car and a collision is imminent, there is an instant warning and full braking power is applied. Once again a world’s first that saves lives by helping to protect unprotected road users”.

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