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

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ABSTRACT

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.

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).