The Social Acceptability of Intelligent Transportation Systems

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ABSTRACT

Understanding how users will respond to new in-vehicle technologies can be a crucial factor in the success of future Intelligent Transportation Systems (ITS) implementations. This study's main goal was to evaluate the social acceptability of different ITS that varied in the control and monitoring levels over vehicle parameters and driver's performance and to describe the most common socio-psychological factors that influence ITS acceptability. We developed a novel ITS acceptability measure, composed by a 51-item questionnaire. The participants had generally high levels of acceptability, independently of the ITS control level over driver's performance. However ITS that exerted more control were regarded as more efficient. We also found gender differences, especially in a "Personal and Social Aims" dimension. Age is positively correlated with participants score on the acceptability index, while education level is showing an opposite tendency. Finally, and critical to ITS development, controlling the car velocity is evaluated as the least preferable ITS feature.

A promising and new measure to reduce drive behaviour related with crashes is the use of Intelligent Transportation Systems (ITS). It is thought that the use of ITS will play a significant role in the increasing of traffic safety in the near future (Vlassenroot, Brookhuis, Marchau, & Witlox, 2010). The term ITS refers to a conjunction of advanced information processing, communications, sensing and computer control technologies to produce systems that are capable of addressing different transportation problems (Young, Regan, Mitsopoulos, & Haworth, 2003). Today we can already find some of these systems in commercialized vehicles and in a range of different in-vehicles ITS technologies as: *Intelligent Speed Adaptation* (ISA); *Forward Collision Warning Systems*; *Following Distance Warning Systems*; *Lane Departure Warning Systems*; *Fatigue Warning Systems*; and *Seat Belt Reminder systems*.

Notwithstanding its technological contribution for road safety increasing, the most important success factor in the implementation of new in-vehicle technologies appears to be the knowledge about how users will experience and respond to these devices (Vlassenroot et al., 2010). Measurements of acceptability, social acceptance, and public support appear to be positively correlated with the ease and success of implementation of a new technology, and under favourable conditions a positive assessment leads to an increased willingness to accept a measure and even to support it actively (Hedge & Teachout, 2000). Furthermore, the acceptance of an ITS is also regarded by researchers and manufacturers as a key factor in the goal's accomplishment of successfully reduce the incident and severity of road crashes (Young et al., 2003).

Despite the recognized potential benefits of acceptability studies for ITS' implementation, these are still scarce during design and implementation phases. Moreover, there is a lack of a unified conceptual model for ITS acceptability's evaluation capable of guide the development of measurement instruments. There is a growing body of literature which provides us several acceptability models for ITS evaluation (eg. Stern, 2000; Schade, & Schlag, 2003), but the lack of a consensual theory and definition of acceptability has resulted in a large number of attempts to measure ITS acceptability, often with quite different results (Adell, 2008). However, in 2010 Vlassenroot and collaborators presented an extensive revision on the subject of ITS acceptability. They conducted a revision of several user acceptance/acceptability models and theories, crossing the dimensions typically related to the acceptability construct, finding 14 indicators considered to be most relevant ones in defining acceptability. These 14 indicators were divided into two major categories: General Indicators – personal related indicators, which reflect one's opinion, knowledge, and beliefs, related to the broad issue in the study (e.g., the role of speeding behaviour on road fatalities); System Specific Indicators – system characteristics related indicators, which reflect one's opinions and beliefs related to the described system or technology (e.g., trust that one has in an image processing based system for distraction detection). Thus, according to Vlassenroot and collaborators we can access the construct of acceptability on an ITS system evaluation if we get a good measurement on these 14 indicators (see **image 1**).

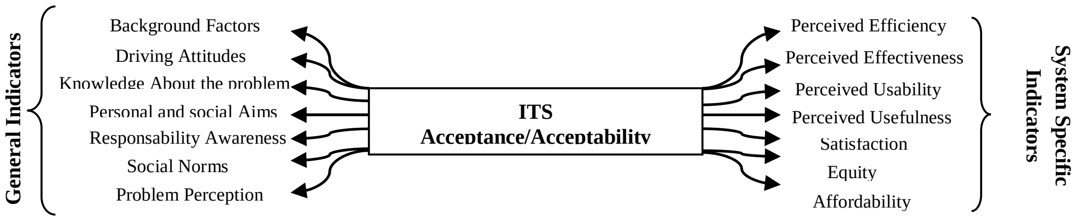

Image 1. 14 dimensions of ITS Acceptability. Adapted from Vlasenroot e tal., (2010).

This study's main goal was to evaluate the social acceptability of different ITS that varied in the control and monitoring levels over vehicle parameters and driver's performance and also to describe the most common socio-psychological factors that influence ITS acceptability. In order to do this, we adopted the model of acceptability given by Vlassenroot et al. (2010) and developed a new ITS acceptability questionnaire taking into account the 14 dimensions of this conceptual model. Despite the adoption of this model, we did not use the same questionnaire, mostly because in Vlassenroot the ITS described for evaluation was mostly concerned with the prevention of car accidents related with speeding. In turn, our questionnaire was designed towards an exploration of the fatigue and distraction problematic. We intended to provide a conceptually validated acceptability's measurement instrument to be use in the evaluation of ITS projected to deal with the broad problems of distraction and fatigue during driving.

METHOD

Questionnaire Validation

Because we developed an entirely new questionnaire, previous to the statistical analysis of the data, we had to check its adequacy to the evaluation of the ITS acceptability construct. In order to do this, we used a statistical method that allowed us to check a questionnaire's *internal consistency* (i.e. the level of correlation between variables that theoretically should be evaluating the same dimension) named *Exploratory Factor Analysis (EFA).*

We conducted a *Principal Components Analysis* with a *Varimax Rotation* and found 13 factors with an *eigenvalue* higher than 1, that explains 81,129% of the total data variance. Thus, the number of latent variables presented in our questionnaire is quite close to the number of dimensions in the acceptability theoretical model. It seems clear that our questionnaire is evaluating something with a number of dimensions similar to those in the ITS acceptability construct as defined by Vlassenroot et al. (2010). With the data from the EFA we were able to create indexes for many acceptability dimensions that were found through factorial analysis. Also, and because the questions in these dimensions were evaluated with the same scale, we could generate a general Acceptability Index (AI) that comprises the sum of all the answers considered relevant in acceptability's evaluation.

Data Gathering

Our ITS' acceptability questionnaire was composed of three parts: a first where we gathered demographic information and information about the respondents' driving attitudes; a second part where we explored other general indicators and knowledge about the problematic of fatigue and distraction; and a third part concerned with the system's specific indicators were we explored those dimensions of acceptability related to the ITS being evaluated. We had two groups of data gathering that differed in the third part of the questionnaire. Each group had a different description of the ITS that they ought to evaluate. In this way, the group called *Only Alert Group* was presented with the following ITS description:

"READ THE FOLLOWING DESCRIPTION CAREFULLY: Consider an ITS system that, through image analysis and evaluation of various driving parameters, is able to monitor the status of the driver. This system seeks signs of fatigue or distraction in the driver and sends alerts when it detects such situations. These alerts can be visual (e.g. warning lights on the dashboard) and auditory (e.g. a voice command to suggest some rest in case of detecting fatigue, or to suggest focus in the case of distraction detection)."

Another group, called *Alert & Control Group*, was presented with the following ITS description:

"*... Consider an ITS system that, through image analysis and evaluation of various driving parameters, is able to monitor the status of the driver. This system seeks signs of fatigue or distraction in the driver and sends alerts when it detects such situations. These alerts can be visual (e.g. warning lights on the dashboard) and auditory (e.g. a voice command to suggest some rest in case of detecting fatigue or to suggest focus in the case of distraction detection). If this ITS system found that the assessment criteria had not changed, .ie., that the warnings were ignored, this* *system would take some active control over the car. This control could reduce and limit the speed as well as keeping the vehicle within range and safe distance from the vehicle in front."*

The ITS' acceptability questionnaires were answered by 77 participants, 31 females and 46 males. 49 of them (17 Females and 32 Males) answered the *Only Alert Group* version and 28 (14 Females and 14 Males) answered the *Alert & Control Group* version of the questionnaire.

RESULTS

The Acceptability Index (AI) is composed by 37 questions to which each participant could respond on a Likert scale of seven points (33 questions) or a Likert scale of five points (4 questions). Thus, the maximum score that a participant could have in this index is 251 points and the minimum is 37 points. The 144 point divides the evaluation on a positive and a negative region. Independent-Samples t-tests revealed no significant differences between the two experimental groups, regarding the AI scores (t (75) = .735, n.s.) and also regarding each of the dimensions presented before, with one exception: we found marginally significant differences in the ITS Perceived Effectiveness (t (75) = 1,83, p<.1), where the "Alert&Control" group ITS is perceived as more effective than the "Only Alert" group ITS. Considering that there are no clear significant differences between groups and that, other than the description of the ITS, the questionnaires where the same for both groups, we analyse all the data in conjunction from now on. Thus, the score distribution on the AI considering all the participants shows us that the mean score was 182.9 points with a standard deviation of 22.8 points. The maximum score was 222 points, the minimum was 124, and we get the first quartile at 163.5 points and the third at 198 points. We can see that the scores' distribution on the AI is shifted towards the positive end of the spectrum, meaning that on the overall both ITS described were well accepted by the participants.

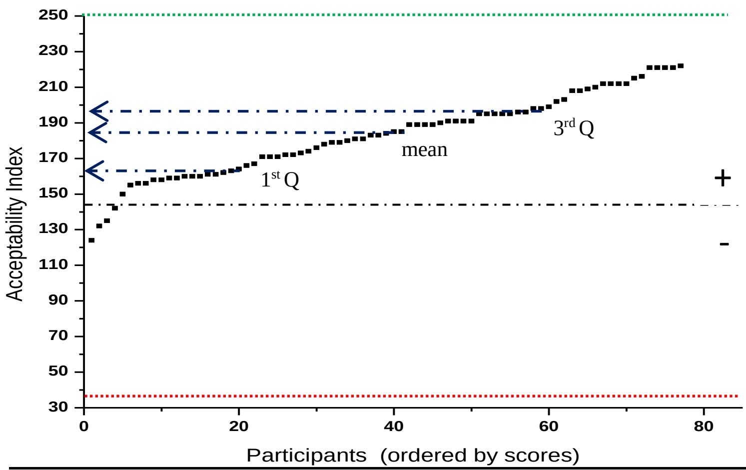

Image 2. Scores distribution in the AI for all the participants.

We [illegible] fatigue and distraction as a problem to driving performance. A paired samples t-test revealed no significant differences between the problem perception related to fatigue and to distraction (t(76) = -1,5, n.s.). Despite this, we can say that, in average, both problematic were well evaluated as influential in traffic accidents. Our participants had a mean score of 18.05 (*S.D.* = 2.2) in problem perception related to fatigue; and a mean score of 17.56 (*S.D.* = 2.5) in problem perception related to distraction, being 21 the maximum possible score.

In terms of statistic correlation, we can see how the scores on the dimensions indexes are correlated, and how they correlate with the AI. Perceived Effectiveness and Perceived Usefulness are quite well correlated between them ($r = .645$, $p<.001$) and with the total AI ($r = .822$, $p<.001$, for Perceived Effectiveness; and $r = .830$, $p<.001$, for Perceived Usefulness). Unsurprisingly, these two dimensions have the highest AI's correlation coefficient. Notwithstanding, we should highlight the fact that all the dimensions are significantly correlated with the AI, with the exception of Negative Attitudes ($r = -.161$, n.s.) and Positive Attitudes ($r = .180$, n.s.). It appears that attitudes towards driving behaviour and traffic safety are not relevant indicators on how one's will accept or not an ITS.

Exploring some demographic information, we can see that there are no gender significant differences in the AI or in any of its dimensions, except for Personal and Social Aims. In this dimension female participants had a significantly higher score (t (75) = -2.04, $p<.05$). It appears to be easier for females to give up on some driving freedoms, as the ability to exceed the speed limit or to disrespect the safety distance, for the sake of a potential increase in safety.

There are also no significant differences on the several dimensions' indexes and on the AI regarding the participant's age. Nevertheless, we can perceive a data tendency pointing towards an increasing in acceptability in older participants. In fact, there is a marginally significant correlation between age and the participant score on the AI ($r_{sp} = .204$, $p<.1$). Regarding the participants education level, a Oneway ANOVA-test revealed differences between the participants' level of education with respect to their AI score ($F(73,3) = 5.929$, $p<.05$). Scheffé post-hoc tests had revealed that participants that only attended until high school have a greater acceptability of ITS systems when compared with participants that went into University. The same post-hoc tests also revealed significant differences on the participants' Acceptability scores, between participants with higher education. Thus, participants with a major degree showed significant higher ITS acceptability when compared with participants with a master degree. It appears that the more educated participants are, the lower is their ITS acceptability. At this moment we can only speculate why this is so. Nevertheless, one hypothesis is that being more in contact with the kind of technology normally associated to ITS, people with higher education are more aware of its limitations or of its impact in the driver behaviour, which can result in a lower ITS acceptability. In fact, there are also some significant differences between participants' education level on some ITS acceptability dimensions that can enlighten us regarding this hypothesis. The Perceived Usefulness ($F(73,3) = 3.078$, $p<.05$) and Perceived Effectiveness ($F(73,3) = 3.906$, $p<.05$) of an ITS is higher for participants that only attended until high school, when compared with the scores of participants with higher education. This can reflect a greater confidence in ITS potentialities in less educated participants. The same type of differences are also seen in the Equity dimension ($F(73,3) = 5.05$, $p<.05$), showing that participants with higher education are more concerned with the eventual loss of privacy and freedom in driving and, thus, less receptive to ITS of this kind.

Considering now some background factors, we found a significant positive correlation between the amount of years having driving license and the AI ($r = .231$, $p<.05$). It appears that more experienced drivers have a greater ITS acceptability; however this conclusion is just valid regarding the amount of years with driving license and not the total of kilometres and hours spending driving.

Finally, limiting speed was consistently evaluated as the less preferable ITS feature when we tried to foresee what would be the less acceptable ones.

CONCLUSION

We found generally high levels of acceptability towards the described ITS. We can see that on the overall, the problematic of fatigue and distraction are well regarded as relevant problems in traffic safety and, therefore, the ITS acceptability appears to be related to the system's efficacy on minimizing these problems. Nevertheless, we can already foresee that some features will not be so consensually accepted. Apparently, systems that controls and limits the car velocity will overcome what some drivers are willing to abdicate for the sake of a safety increment.

Finally, we can say that we were able to develop a valid measurement instrument that can capture the participant's acceptability of a given ITS. Moreover, taking into account the collected data, we can now further tune this questionnaire regarding the evaluation of some acceptability's dimensions that, in our opinion, can be improved.

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