Influences on User Acceptance: Informing the Design of Eco-Friendly In-Car Interfaces

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ABSTRACT
In order to design in-car interfaces in a user-centered way it is necessary to understand users' experiences (UX). Therefore it is beneficial to gain early insight on the user acceptance (UA) of the system under development as a part of a holistic understanding of UX in the car. This paper describes a pre-study on the influence of drivers' characteristics (such as gender, self-concept, opinion) on the UA of eco-friendly in-car interfaces. Five interfaces that support environmental friendly driving were presented in an online questionnaire. No influences of socio-demographic variables and the self-concept components of the driver were found on UA. In opposition to that it is shown that users' wish for technology support and the general attitude towards technology have an influence on UA.

Categories and Subject Descriptors
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Measurement, Design

Keywords
User acceptance, in-car interface, prototype, user study

1. INTRODUCTION
Within research in the automotive context it is crucial to address factors of user experience (UX) in the car. With the ultimate goal of creating a user experience model, user acceptance was identified as a highly important factor of UX to be included in that model. Evaluating the user acceptance (UA) of novel technologies at a pre-prototype phase within the design process is beneficial for the development of interactive systems [3] in order to create a positive user experience. This is especially true for cost intensive in-car interfaces. Recent research has shown that differences in the design of eco-friendly in-car interfaces influence the UA of these systems [8].

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Results of the technology acceptance rating of the eco-friendly interfaces used in this work were already published by [8] focusing on the influence of system design on user acceptance. The presented work differs from [8] by showing a deeper analysis of the gathered data with the aim of identifying the influence of general attitudes and socio demographic data on user acceptance. It aims at identifying subjective factors that influence acceptance ratings of eco-friendly interfaces. Other than in [8] this was done independently from an actual system design.

The presented work focuses on the influence of driver's general attributes as independent variables on the UA of interactive in-car systems. It serves as a pre-study in order to create a user experience model for designing interactive systems in the automotive usage context. Main goal is to identify tendencies in the influence of socio-demographic variables, the user's general attitude towards technology, and the driver's self-concept (perceived type of driver and driving ability) on users' acceptance of in-car systems. Understanding the influences on the UA of eco-friendly interfaces based on driver characteristics will give designers the possibility to deduct implications for user centered design decisions regarding eco-friendly in-car technology.

2. RELATED WORK
Designing in-car interfaces has a long history in the interaction design community (see e.g. [7]). A recent challenge for designing interactive technology for the car is that (fortunately) the awareness of eco-friendly driving is rising. This leads to the development of novel car interaction systems that aim at eco friendliness by supporting the driving behavior (e.g. Honda's Ambient Meter [5]).

In order to make the success of those systems possible it is necessary to investigate the user experience caused by that technology early in the design process. The importance of UA of in-car supportive interfaces was besides others already raised by Comte et al. [1] researched the user acceptance of automatic speed limiters. For researching the UA for those systems in a pre-prototypical stage the technology acceptance model (TAM) by Davis & Venkatesh has proven to be a valid tool [3]. The TAM addresses three scales namely Perceived Usefulness (U), Perceived Ease of Use (EOU) and Behavioral Intention of Use (BI) to constitute technology acceptance. Important is, that the system's attributes are not the sole influences on UA. Further research on the effects of gender and social influence on the technology acceptance by Venkatesh & Morris [8] showed differences in the reasons for the usage decision between genders. Subjective factors in the car context, like the general attitude towards technology that fosters eco-friendly driving, are also possible causes of differences in the UA.

3. RESEARCH GOALS

In order to investigate influences of user characteristics on UA in the car context to inform future interaction designs, the following research goals were defined:

3.1 Socio Demographic Influence (RG1):

RG1 addresses potential influences of socio-demographic variables (gender, age, duration of driver license ownership, frequency of driving) on the acceptance of eco in-car interfaces. Main goal is to find differences in user acceptance between certain target groups.

3.2 Self Concept Influence (RG2):

RG2 aims at identifying influences of the self-concept of the driver (type of driver, ability level of driving) and the importance of eco-friendly driving for the individual user on the acceptance of eco in-car technology. It is assumed that participants who perceive eco-friendly driving as important have a higher UA of interfaces, which support that.

3.3 General Attitude (RG3):

RG3 investigates potential influences of the general attitude towards in-car technology and technology support on the UA. It is hypothesized that the desire to be supported by technology and a general positive attitude towards technology have a positive influence on the UA.

4. SURVEY DESIGN

In order to investigate the research goals, an online survey was set up. The first part included questions towards age, gender, driver license ownership, level of driving skills and opinion about the necessity of eco-friendly driving. Additionally nine questions about a general car technology attitude including three factors with three items each (see table 1 for the items and the factors) were asked. The second part of the questionnaire introduced five in-car interfaces, which were developed for research purpose. A TAM questionnaire was presented for each single system. It took about 15 minutes to finish the questionnaire, which was online for two weeks and distributed over various mailing lists.

4.1 In-car interfaces

All five in-car interfaces used for the questionnaire had the purpose of supporting the driver in driving eco-friendly. The interfaces were created in a pre-prototype form based on different interface concepts already published by car manufacturers (see e.g. [5]). The interfaces were described in a 150 words text and illustrated each with a neutral graphic (see [8] for a detailed description and visualization of each interface).

It is argued that studying the UA of pre-prototype systems leads to valuable insights, even in a very early stage of development. Davis & Venkatesh [3] state that the technology acceptance of pre-prototype systems is predictive for the final system. The relevance of early prototyping strategies in comparison to high-fidelity physical models especially in the car manufacturing world are stressed by Klemmer et al [6].

System 1, called EcoMatic, bases on Honda's Ecological Drive Assist System and consists basically of a button that optimizes several car functions for eco-friendly driving and a display that shows the amount of fuel saved. System 2, called EcoPedal, based on a concept by Nissan, is an acceleration pedal with adaptive counter pressure that reacts when wasteful driving behavior is detected. The EcoSpeedometer (see figure 1) is the third system and inspired by Honda's Ambient Meter. It augments a speedometer with a colored glow, green indicates eco-friendly, orange wasteful driving behavior. The forth system was called EcoDisplay, inspired by Honda's Ecological Driving Assistant. It shows leaves that change in appearance due to the driving behavior and gives detailed information about resource usage. The fifth introduced interface was the EcoAdvisor inspired by Fiat's eco:Drive. It is an acoustic interface giving vocal hints on how to improve eco-friendly driving based on the current status of the vehicle.

Figure 1: Example visualization of system3: EcoSpeedometer. Left (green) indicates an economical; right (orange) a wasteful driving behavior.

The presented systems differed from each other through several characteristics. They required a different level of interaction due to more or less automation. Systems also addressed a variety of user's senses, delivering visual but also acoustic and tactile information. Additionally, different levels of interference with the primary task, i.e. driving, were offered by the systems.

4.2 Procedure

The distribution of the questionnaire via the university network offered a good starting point to gain data from participants with a reasonable distribution in age and gender. The sample size of 67 participants can be considered as sufficient for the first statistical analysis presented later on. However, this survey cannot be considered as representative in a strict statistical sense.

As the survey was distributed via the university newsletter to people with an educational background, which is above the population's average is likely to have injected a bias towards a more positive response behavior. However, with the sampling method used for this survey („convenience sampling"), the theoretical grounding by the TAM, and the visual representation of the eco drive interfaces, one gets an approximation of the truth and thus a data basis suitable for conducting factor and regression analysis.

5. RESULTS

67 participants (36 female, 31 male) in the age range of 19 to 75 years (M = 32 years) participated in our study. They possessed a driver license for 15.52 years (SD = 9.50) in average. Approximately 59% of the participants drive a car at least several times a week, 20% drive at least several times a month, whereas 21% drive more seldom.

As a first step in the analysis process, the scores for each scale of the TAM (BI, EOU, and U) for each individual system were computed. Furthermore a 'general' score for each scale was computed, which was the average rating for each subtest over all presented systems (see table 2). It is supposed that eventual

Table 2: Influence of the three general technology acceptance factors (WTS, HTB, GAT) on the TAM scores for all individual systems and the 'total' score – explained variance (adjusted R²) and strength of influence (β) are depicted [p<.01]**

Factor	System1	System2	System3	System4	System5	Total
BI	(R^2 = .244) WTS: .508**	(R^2 = .125) WTS: .353**	(R^2 = .278) WTS: .539 **	(R^2 = .175) WTS: .435**	(R^2 = .137) WTS: .391 **	(R^2 = .357) WTS: .510 **
EOU	-	(R^2 = .142) GAT: -.398**	(R^2 = .287) GAT: -.548 **	(R^2 = .100) GAT: -.341 **	(R^2 = .160) GAT: -.419 **	(R^2 = .196) GAT: -.457 **
U	(R^2 = .355) WTS: .605 **	(R^2 = .240) WTS: .504 **	(R^2 =.155) WTS: .413 **	(R^2 = .143) WTS: .397**	(R^2 = .303) WTS: .562 **	(R^2 =.393) WTS: .634 **

specific influences of system properties are less marked in this overall score. It will be therefore the main criterion variable. Additionally the individual results for each system are presented in order to prove that obtained results are not simply due to findings from one singular system.

Regarding RG1 we conducted several linear regression analyses using all socio-demographic variables as possible influencing factors for the scores of the TAM's subtests. As we had no a priori preferences, which socio-demographic factor would be most influencing, we used in all regressions the stepwise method. None of the postulated socio-demographic variables (gender, age, duration of driver license ownership, frequency of driving) were found to have influences on the TAM scores (cf. RG1).

Following RG2 another linear regression was computed adding the self-concept of the driver as possible influencing factor. Only the importance to drive eco-friendly was found to have an influence for the BI score in several systems and for the total score (system 3, 5 and total with β = .260, .295 and .272 respectively – cf. RG2).

Table 1: Items of the car technology acceptance scale and their respective assignment to the obtained three factors (R^2 =.613). Factor loadings < 0.20 were suppressed for better legibility.

	WTS	HTB	GAT
1) I want novel technology to improve my driving behavior.	**.792**		-.345
2) People should always keep the upper hand over technology. (R)	**.740**		
3) I want novel technology to help me drive more eco-friendly.	**.659**	.384	-.357
4) I don't want to be instructed by technology. (R)		**.778**	
5) More technology in the car improves safety while driving.		**.702**	-.546
6) While driving, people are a higher security threat than technology.	.282	**.536**	
7) Novel technology can enrich my life. (R)			**,808**
8) Novel technology can help me to improve my driving. (R)	-,561	-,210	**,730**
9) I am critical towards novel technology.	-,324	-,247	**,724**

For RG3 a factorial analysis (PCA with oblimin rotation) was conducted to show the factorial structure of the car technology acceptance scale, which was used for this study in order to answer RG3. As can be seen in table 1, the three proposed factors were identified: Wish for Technology Support (WTS), Human Technology Balance (HTB), and General Attitude towards Technology (GAT). Composite scores for each of the three factors were computed and used for further analysis. The obtained factorial structure is strongly supporting the postulation of the three factors. Only item five and eight loaded on two factors, which was interpretable due to the wording of the questions (see table 1).

In order to potential influence of the car technology acceptance factors (RG3) on UA, they were used in a redone regression analysis (see table 2). It was found that WTS (Wish for Technology Support) had a significant influence on the Behavioral Intention of Use (BI) as well as for the Perceived Usefulness (U) score of the TAM for all systems including the overall score. With this single variable, 35.7% of the variance in overall BI and 39.3% of the variance in overall U could be explained. As can be seen in table 2 the influence of WTS was moderate to strong positive suggesting that the more a person wants to be assisted by technology, the more likely the user will state to use a system (BI) and perceive the system as useful (U).

The GAT factor (General Attitude towards Technology) emerged as being influential for the factor Perceived Ease of Use (EOU) for all systems with the exception of system 1 and could explain 19.6% of the EOU scale. Here a moderate to strong negative impact of GAT on EOU can be demonstrated. This means that the more negatively a person's attitude toward technology is, the less easy to use this person will rate a system. However, it is necessary to note that the portion of explained variance and the strength of influence of WTS and GAT fluctuated substantial between the different systems (see table 2).

6. DISCUSSION

Overall the study showed that the general attitude towards technology is influencing the UA of in-car systems while the other used measures appeared not to have an influence.

Looking closer at RG1 there was no influence in terms of socio-demographic aspects on the technology acceptance identified. The demographic data of the target group had less importance compared to the technology attitude and became irrelevant when the three attitude factors (WTS, HTB, GAT) were partialled out. Gender influences on the acceptance of a software solution (see e.g. Venkatesh et al. [8]) could not be replicated in this sample.

Regarding RG2 it was found that the perceived importance on eco-friendly driving was influencing the Behavioral Intention of Use of three of the five systems. Not surprisingly this indicates that users who see eco-friendly driving as desirable are more likely to report that they will use a system that supports eco-friendly driving. However, this finding vanished, after considering in-car technology acceptance scale factors in the regression equation. This means that the perceived importance does not contribute additional variance, when the more general factors of technology acceptance are taken into account.

Coming to RG3 it was shown that the wish for technology support (WTS) factor was influential on Behavioral Intention of Use and Perceived Usefulness in all systems and the total score. WTS is directly addressing technology as a tool for eco-friendly driving which might explain the higher amount of influence of WTS compared to the perceived importance of eco-friendly driving. Interpreting the results it can be assumed that WTS serves as an influencing factor because users are more likely to have the intention to use supportive technology, when they wish for support. Important for the design of in-car interfaces therefore is that users want support by the functionality the system offers (e.g. drive eco-friendly). This finding indicates that socio-demographic aspects like age and gender are less important for technology acceptance than the general wish for supportive technology. Similar to the results of Gefen [4], who finds that general disposition to trust influences the system trust, the presented results show the necessity of researching the disposition to technology support before assessing the user acceptance of driver assistant systems.

Another result relevant for RG3 is that the perceived ease of use (EOU) is influenced by the general attitude towards technology (GAT). More critical user perceived the usage of this technology as less easy. This might be explained the following way: Users with a negative attitude towards the presented technology perceive it as more tedious to interact with the system. This makes them perceive the interaction to be less easy even if they did not have a chance of actually using any of the systems. Designing interactive systems for the car in a way that reduces the criticism towards technology has the potential to positively influence the perceived ease of use.

7. CONCLUSION AND FUTURE WORK

The presented work shows a pre-study on user characteristics influencing the acceptance of eco-friendly in-car technologies. Its goal was to identify tendencies of user characteristics influencing the UA as a first step towards an automotive user experience model, which will inform future designs of eco-friendly technology in the car. No influences of socio-demographic variables were identified. This finding could be the result of our used methodology, namely the presentation of systems in a pre-prototypical state in an online questionnaire. The low degree of detail in the representation and interactivity may have caused the exclusion of system properties that would have led to differences between socio-demographic groups. Additionally the sample might not have been representative for the high variety of drivers.

The results showed that a significant, but only limited, amount of variance could be explained by the general disposition towards technology and its factors. Due to the fact that we found relatively high differences in the influence of wish for technology support (WTS) and general attitude towards technology (GAT), future research should be directed towards identifying reasons for these variances. The general attitude towards technology is influential but the variances indicate that variances are also caused by other factors.

Based on the promising results a study will be set up which aims at investigating a representative sample of users in the study area. This will make it possible to study the effects we found in this work in order to establish a user experience model for the automotive usage context. This further line of research will also include working prototypes to examine whether the features of our research situation (i.e. pre-prototype) have led to an overestimation of the influence of the anteceding general car technology attitude on the user acceptance. As users were not able to experience certain elements of a system, they may have relied more on their general attitude towards technology then on the actual design when rating the systems.

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