Adjunct Proceedings of the 5th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI ,13), October 28–30, 2013, Eindhoven, The Netherlands.

Influences of Socio-Demographic Factors, Personality Traits and Car Usage on Cooperative Guidance and Control

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ABSTRACT
This article investigates the relations between different user groups and the perception of a cooperative approach of guidance and control of highly automated vehicles. Results of a user study regarding the influences of user characteristics, such as personality traits, gender, education, driving experience, and driving habits, on preferences for cooperative guidance and control are reported and discussed.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces—*Haptic I/O, User-centered design*; H.1.2 [**Models and Principals**]: User/Machine Systems—*Human factors*

General Terms
Human Factors, Experimentation

Keywords
User diversity, man-machine systems, cooperative guidance and control, highly automated, socio-demographic factors, personality traits, car usage, driving experience

1. INTRODUCTION
In the last decades mobility gained an enormous impact on everyday life. Distances regarding commuting, business trips, and private obligations are continuously increasing. At the same time the user group of individual traffic is becoming more and more heterogeneous. A user study was conducted using a simulator to reveal the different expectations on cooperative guidance and control due to gender, education, personality traits, such as communicativeness or openness, and driving experience and habits.

2. STUDY
A user study was conducted in a driving simulator with a horizontal FOV of about 80 degrees and an active sidestick as control device. The driving scene was a section of a three-lane highway with fellow cars. The **cooperative guidance and control** concept [1, 3, 5] was the H-mode [3] inspired by the design metaphor of horse and rider [2]. H-mode is a holistic haptic-multimodal approach to cooperative guidance and control, where the control is dynamically distributed between driver and automation [3, 4].

In total 20 people ($10f, 10m$) participated in two test series. **Participants** were aged between 19 and 34 years with an average age of 24.5 years (SD=3.8, M_f=24.4, M_m=24.5) and held a driving license. The two-hour **study** included a preliminary questionnaire regarding socio-demographic data, personality traits, and car usage. The second part particularly aimed at user participation in the design process [4]. The last part was a two-stage evaluation with a 10-minute training in between. The participants rated items, such as perceived safety, on a 7-point semantic differential scale. The results of the preliminary questionnaire and the evaluation after the last simulator drive are most valuable for investigating correlations with user groups since participants gained high familiarity with the system. In the following the correlations are reported and discussed.

3. RESULTS
The data analysis revealed important correlations between socio-demographic data, personality traits, car usage, and the perception of the cooperative approach of guidance and control. As the number of participants was limited to 20, the results might not be representative for the overall population but provide essential indications for further studies. The correlations were quantified using Spearman's correlation coefficient, r_s, and the t-test.

3.1 Socio-Demographic Factors
The study revealed numerous correlations between **gender** and the perception of the cooperative approach of guidance and control. Men answered the general item of the overall perception of the approach more positive (t=1.857, p=0.08). Women rated higher on the haptic option of fluid transition between automation levels by gripping strength (t=−1.958, p=0.066). Due to small **age** variance no correlations were found whereas several effects regarding education were revealed. **Education** measured by the highest educational achievement correlated significantly with perceived safety (r_s=0.461, p=0.041), perceived ease of driving, and perceived controllability of the vehicle especially due to automation level transitions (r_{s_e}=0.475, p=0.034; r_{s_c}=0.530, p=0.016), although there were no correlations for subjectively perceived learnability and ease of system use.

AutomotiveUI'13, October 28–30 2013, Eindhoven, Netherlands.
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3.2 Personality Traits

The personality traits were rated on a 5-point Likert scale. *Communicativeness* and *openness* – defined as average of the items *general openness for new experiences* and the highly significantly correlating item *open-mindedness for new technical developments* (r_s=0.728, p=0.000) – showed the most interesting influences on the evaluation of the approach of cooperative guidance and control. **Communicativeness** includes not only communication skills, but also enjoyment of communication, which is basic for cooperation. Someone might expect that especially highly communicative people enjoy cooperative approaches but communicativeness also implies a higher need for communication. In general, communicativeness and estimation of the cooperative approach tend to correlate negatively including some significant cases, such as subjective contentment while driving with H-mode (r_s=−0.456, p=0.043) and especially the perceived safety while driving temporarily fully automated (r_s=−0.445, p=0.049). The reason might be the comparatively low interaction between driver and system in this automation level. Another explanation might be the perceived imbalance of control distribution in favor of the system, which is supported by the negative correlation between communicativeness and how comfortable participants felt with the control distribution (r_s=−0.412, p=0.071). Other significantly negative correlations were found for mode awareness (r_s=−0.525, p=0.017), transitions using buttons on the interaction screen (r_s=−0.454, p=0.044), and the overall understandability of the interaction screen (r_s=−0.459, p=0.042), which is in line with the above mentioned explanation of higher needs and expectations regarding communication. Though not significantly correlating with the general estimation of H-mode, **openness** correlates significantly negative with the comfortableness of participants while using the highly cooperative automation level of highly automated driving (r_s=−0.452, p=0.045). It also correlates negatively with the perceived safety (r_s=−0.403, p=0.078). In future work it is interesting to investigate the relations between automation level perception, openness, and additionally participants' general need for security as highly automated driving is in general perceived to be the safest level ($M_{assisted}$=4.3, $M_{highaut}$=6.1, $M_{tempaut}$=5.7).

3.3 Car Usage

Car usage includes the aspects *driving experience* and *driving habits*. **Driving experience** is deduced from the *average mileage per year* and the highly significantly correlating *driving frequency* (r_s=0.655, p=0.001). The strongest relation between driving experience and the perception of the cooperative approach of guidance and control was found in how much easier driving was experienced by less driving people in the cooperative approach than without assistance in the simulator (r_s=−0.468, p=0.038). The perceived quality of cooperation between participant and system correlated negatively with driving experience (r_s=−0.458, p=0.042). For all levels of automation, the same tendency can be found. Participants with low driving experience reported the biggest benefits including feeling pleasant, perceived safety and control distribution. The weakest correlations were found for assisted driving, while highly automated and temporarily fully automated driving had strong negative correlations with driving experience. Driving experience correlated significantly negative in the automation level highly automated with perceived safety (r_s=−0.451, p=0.046) and contentment of the participants with the control distribution (r_s=−0.455, p=0.044). Besides driving experience **driving habits** revealed important correlations. People who *enjoy driving across the country* tend to devalue the utility of the system (r_s=−0.403, p=0.078) whereas people who mainly *drive from A to B* were more positive about the quality of cooperation (r_s=0.424, p=0.063). People using the car mainly for *routine drives*, which highly correlates with driving experience (r_s=0.592, p=0.006), rated the predictability of the system significantly low (r_s=−0.448, p=0.047). Any small deviation from their routine might be perceived exaggerated. For the interaction screen a significantly negative correlation was found (r_s=−0.535, p=0.015). Not surprisingly, people stating to *enjoy the activity of driving* tended to rate comparatively high on only assisted driving (r_s=0.402, p=0.079) and had a significantly good mode awareness (r_s=0.545, p=0.013), which is contrary to the influence of communicativeness (see above). The less people *drive alone* the more they enjoyed the control distribution of the very cooperative automation level of highly automated driving (r_s=−0.503, p=0.024). In future work it should be investigated if this was a result of sociable character in general.

4. CONCLUSION

The study revealed numerous important correlations between aspects of cooperative guidance and user characteristics, especially regarding the socio-demographic factors gender and education, the personality traits communicativeness and openness, and the car usage aspects driving experience and habits. These results indicate a need for a flexible, versatile driving assistance that easily adapts to the expectations of different user groups. Future studies need to be performed in order to investigate these influences with a larger number of participants to deduce specific design recommendations.

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