My Phone, My Car and I - And Maybe a Traffic Light Assistant

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***Abstract*—In the context of a project regarding a traffic light assistant on smart phones, a survey about ownership, usage in relation to traffic and car issues as well as acceptance of a potential traffic light assistant was carried out. The survey was conducted as a paper-based poll as well as online. 694 people took part. The user's need to browse social media while driving, as is sometimes mentioned in distraction debates, could not be found. The idea of a traffic light assistant on a smart phone (as a guide to the next green phase, or inform the driver to decelerate the car early) had different acceptance rates among males and females, and was more acceptable to men.**

Keywords-nomadic devices*; *smart phones*; *survey*; *usage*; *vehicle

I. INTRODUCTION

In the project KOLIBRI (Kooperative Lichtsignaloptimierung Bayerisches Pilotprojekt; engl: cooperative optimization of traffic signal control Bavarian pilot project) [1], an application-oriented vehicular system is prototypically developed and tested. The system, a traffic light assistant, is intended to inform the driver of a car about upcoming traffic signal states so he can adjust his driving behavior.

The project develops two different ways to deliver messages to the driver: an onboard system integrated into the instrumentation of a demonstration car and a system to inform the driver via a standard smartphone that can be installed in any car. The data is transmitted over existing 2nd and 3rd generation mobile networks (GMS, UMTS) from the traffic lights to a central server. The demonstration car or a mobile phone requests appropriate data files from the server and displays the proper speed recommendation or other messages for the next traffic light approach.

The four partners of the project are responsible for different duties. The Institute of Ergonomics at the Technische Universtität München is in charge of the human machine interface (HMI) and evaluating the system in a simulator and real field trials. The institute found the information of drivers via smart phones a promising solution and is focusing on it.

Information communication via smartphones would not involve significant extra costs for installation or purchasing. Nowadays, smart phones are widely used. Due to the use of the assistant in the car, care must be taken for suitability while driving. Ergonomic requirments, e.g. gaze durations and acceptance, led a particular human machine interface (HMI). The details are discussed in [17] and [18]. In addition to simulated and real field experiments, a parallel survey was carried out to find out more about the existing prerequisites for a traffic light assistant via smart phones. How widespread are car mounts for mobile phones? How often they are used? Would a traffic light assistant via smartphone be accepted?

The following methodology section describes the tools used for the poll and characterizes the group of test subjects. The results section shows the findings, based on the sequence of the questions in the survey. The results are grouped into subsections (Phone Type, Personal or Professional, Car Mount for Mobile Phone, Mobile Phone Usage, Car Related, Acceptance of a Traffic Light Assistant).

II. RELATED WORK

Early contribution in the field of traffic light assistance can be found in the project *Wolfsburger Welle* [2], [3]. Also Australian traffic engineers experimented in the 80's with traffic light related speed advices and identified potential benefits. [8], [9] compared an in-vehicle system to dynamic traffic signs along the road in a driving simulator experiment and found subjective preferences for the variable message signs and objective advantage for the in-car display. In [10], different HMIs for an on-board system were tested and an integration into the speedometer seems to be an adequate solution. The interface idea of the *Wolfsburger Welle* was (modified) adopted in the project TRAVOLUTION (Audi AG) [11] and the German project *aktiv* [12], [13]. *aktiv* used for the driver information a personal digital assistant (PDA) with WiFi connection to the traffic lights. The drawback of this approach is the limited connection range, to get data from a traffic light. Experimental data for the coverage and handshake times can be found in [15]. The WiFi connectivity for traffic light assistance (under different vehicle speeds) was also examined by [14]. The

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use of already installed communication networks (GSM, UMTS) within the project KOLIBRI overcomes the limited coverage range of dedicated short range communications. Another approach, that uses the camera of a smart phone and image processing, is proposed by [16]. For this, the phone (with the camera) must be installed with view to the road. This is likely to mask the driver's field of view. Within KOLIBRI the only constraint is an acceptable GPS signal for the smart phone. On rural road this is not a restraint.

III. METHOD

The survey was carried out on paper questionnaires as well as online, using the *LimeSurvey* online system at the end of 2011 and beginning of 2012. Participants for the paper based pool were mainly acquired at the Technische Universtität München (Campus Garching). For the online survey the link to the pool was disseminated by email and through the university's Facebook page.

Twenty-five questions made up the questionnaire. It took about 10 minutes to complete.

The analysis presented here considers 373 replies to the paper-based form and 321 answers to the online survey (78 incomplete or blank forms were eliminated), for an overall total of 694 participants.

The paper based participants were 76% male and 24% female, aged between 16 and 64 with an interquartile distance from 20 to 24 (median 22).

The online survey was filled in by 87% males and 13% females, aged between 17 and 74 with an interquartile distance from 20 to 26 (median 22).

The results from both sources are reported together and are not further split up nor are analyzed independently. Thus the overall group has an average age of 23.9 years (SD 6.9) and the gender is 81 percent male and 19 percent female. The average annual mileage is 9883 km (SD 12585). Driver's licenses were obtained at an average age of 17.7 years (SD 1.4).

IV. RESULTS

A. Phone Type

As shown in Figure 1, 43% of the phones run on a proprietary operating system, 23% are based on the (proprietary) iOS, 31% are Androids and 3% of users did not answered, or have no mobile phone. The figure does not explicitly distinguish between 'smart phones' and conventional mobile phones, because definitions are evolving and there are many in-between devices. It can be concluded that all of the Android and iOS devices (i.e., iPhones) are 'smart phones', plus some of the others.

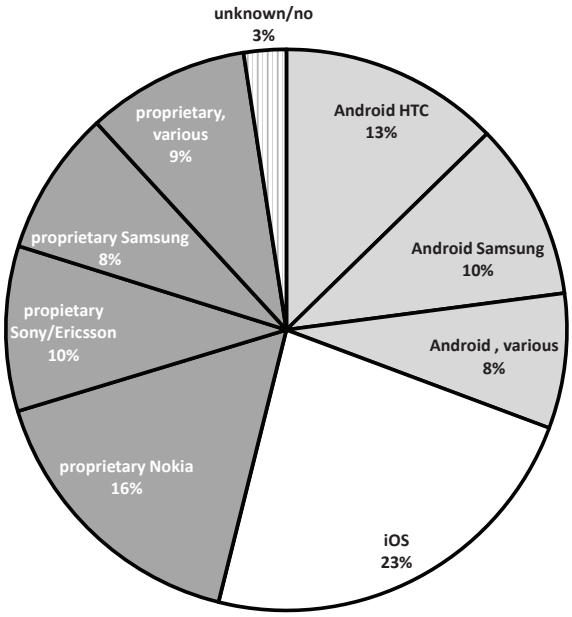

Figure 1. Phone types

B. Personal or Professional

Asked for the main reason (personal or professional) to use their mobile phone 95.7% answered *personal* and 3.5 % *professional* (0.8% undefined).

For 90%, the main reason to use a car was for *personal* use, and *professional* use for 6.5% (3.5% undefined).

52% said they used the phone in the car for *personal* reasons, while 3.5% used it for *professional* reasons and 42.4% never/seldom used it in a car (1.7% undefined).

When asked about the main type of car used, 4.9% had no car, 56.3% bought a used one, 29.2% bought a new car, 5.1% rented a vehicle and 4.3% have a company car.

C. Car Mount for Mobile Phone

For the safe use of a traffic light assistant, cradles in the cars would be a prerequisite. Asked about such a phone mount, 82.3% of the participants had no car holder for their phone. The traditional mounting method of a suction cup is used by only 11%, and 5.3% use other ways to mount the phone in the car (1.4% undefined).

Figure 2 shows the mounting locations for the phone holder. 45% of users who mount their phones use the middle area of the windshield.

When asked how frequently the phone is fixed in the holder while driving (Figure 3), one-third of the already small number of holder users mount the phone only for long distances.

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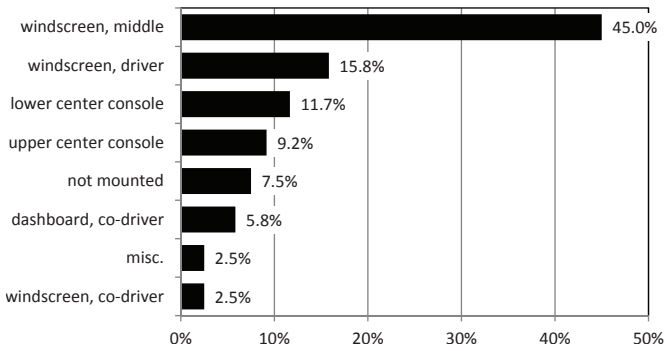

Figure 2. Location of phone holder

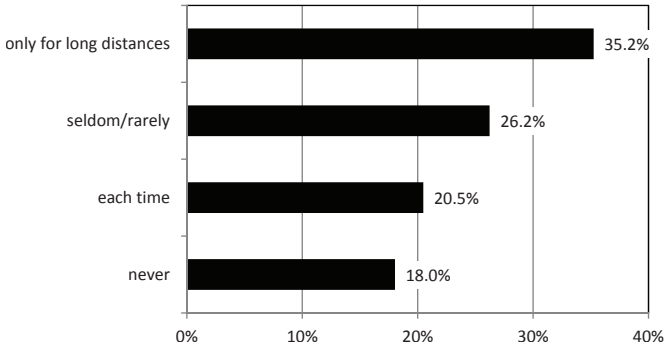

Figure 3. Frequency of holder use

The main reason most people do not have a phone mount (Figure 4) is that they do not see any need for one.

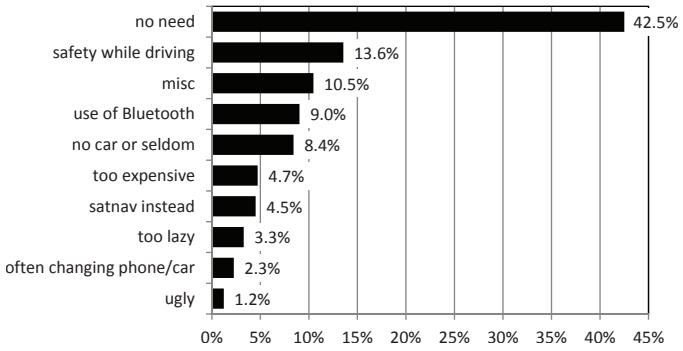

Figure 4. No Phone Holder because...

D. Mobile Phone Usage

The starting age of cell-phone usage was calculated based on how long the subject had used the mobile phone and the age of the person. Figure 5 shows that most begin at the age of 14.

The 'years per phone' (Figure 6) were calculated based on how long the subjects had been using a mobile phone and how many different phones the subject had during this time.

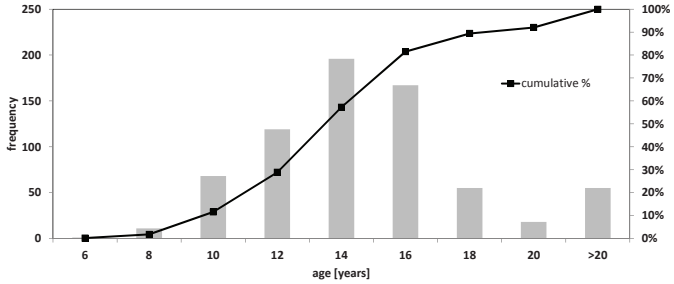

Figure 5. First use of mobile phones at age of...

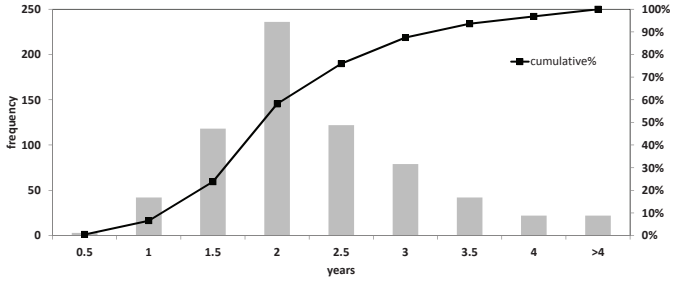

Figure 6. Service life [years per phone]

Figure 7 shows the median number of apps that Android and iOS users have downloaded to their phone (with interquartile distances). Android users have typically 10-30 apps downloaded, while iOS users loaded 20-70 apps. The mean value for Android and iOS users is 40 downloaded apps (SD 63).

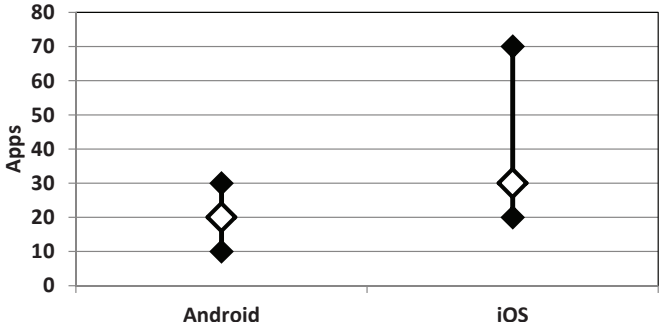

Figure 7. Typical number of apps downloaded (median and interquartile distance)

Subjects were asked to name the three apps they use most often, with the most frequently used app listed first. Figure 8 only shows an analysis of the most frequently used app. An analysis including all three named apps is shown in Figure 9 (apps equally weighted, independent of their usage priority). Some of the apps were grouped. The following provides further explanation for clusters that are not self-explanatory:

- *news* means dedicated news from newspapers, tv stations and so on.

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- *misc information* are things like tv programs, Wikipedia, phone books, etc.
- *tools* are apps that give their users an additional value like a flashlight, alarm, calculator, etc.
- *system apps* are system-related tools like battery monitors, data counters, etc.

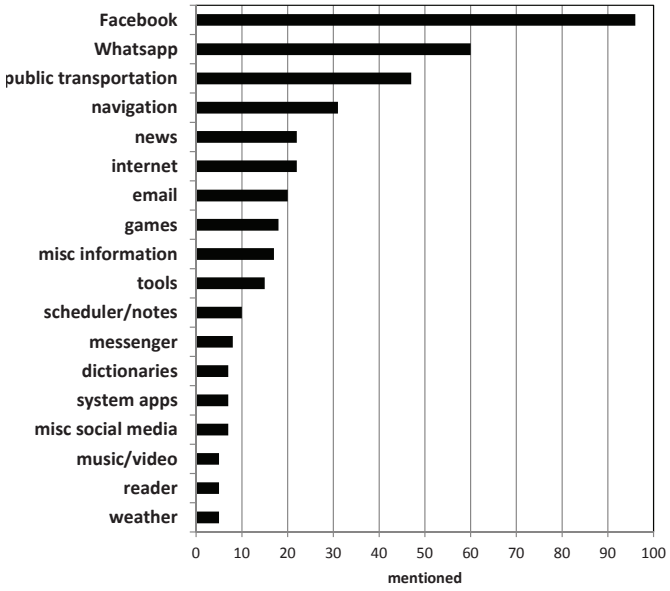

Figure 8. Question about most often used apps (first named app only)

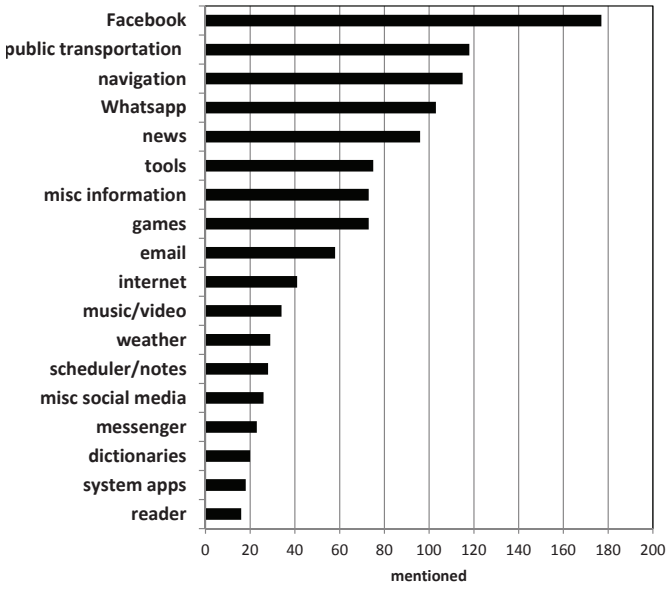

Figure 9. Question about most often used apps (up to three mentioned apps per test subject)

E. Car Related

Participants were asked which car-related apps they are using. 495 people did not use such apps. Various navigation apps were mentioned 182 times. Other named apps, with the number of occurrences in brackets: radar warnings(5), jam information(5), Drive Now(3), ADAC(1), BMW m-meter(1), Porsche gforce(1), Mini Connect(1), Dynolicious(1), OBD(1), BMW TV(1), fuel prices(1), mbservice(1), carpooling(1), parking(1).

The subjects could reveal with which devices their cars are equipped (Figure 10). The traditional CD/radio is by far the most often mentioned one, followed by external satnavs and music players.

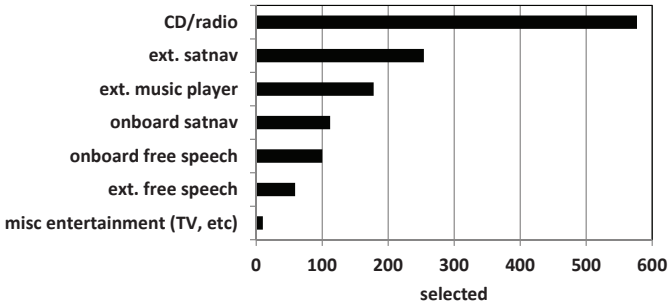

Figure 10. Car is equipped with...

Asked which phone function is the most frequent used while driving (Figure 11), the phone function is on top, followed by ‘none’, SMS and music. The option ‘named app’ is further classified in Figure 12. The app mentioned most often, by far, is navigation. Whatsapp and Facebook play only a minor role (each mentioned three times, in total by five different persons). Apps mentioned only once, and so not included in Figure 12, are: photos, flight information, music, GPS speedometer, Shazam, Siri, parking help, number plate information. It should be also noted that driving with a radar warning system is forbidden in Germany.

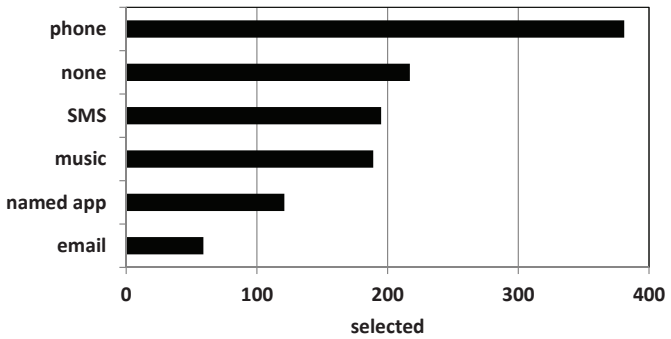

Figure 11. Functions used while driving a car

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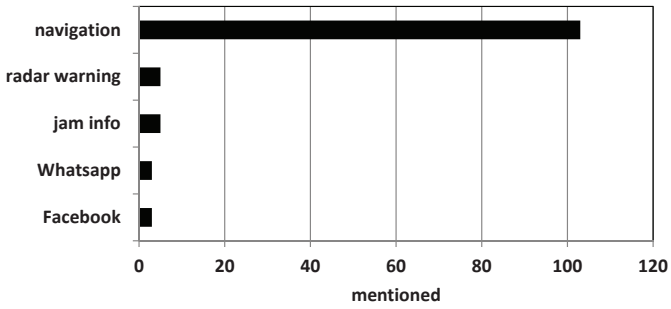

Figure 12. Apps used while driving

F. Acceptance of a Traffic Light Assistant

The test subjects were asked if they would have safety concerns if a future smartphone app could provide information about upcoming traffic signal states (traffic light assistance) and if they were to use the app themselves. Most of the males (84%) answered 'no' (no worries about safety). 62% of females share this opinion.

The question was then slightly altered: Would you have concerns about safety if other drivers were to use a traffic light assistant app? This question reduced the males' lack of concern to 66% (no worries about safety) and 57% for females.

The question as to whether a traffic light assistant app would be used by the participant was answered positively by 78% of the males and 51% of females.

The maximum price the participants would be willing to pay for a traffic light assistant app is bimodal, with peaks at zero euro and five euros (Figure 13).

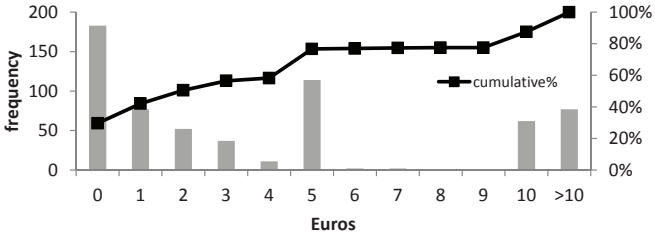

Figure 13. What people would pay for a traffic light assistant app

If a new car had an onboard traffic light assistant, the acceptable extra charge for the system is also bimodal, with peaks at zero and 100 euros (Figure 14).

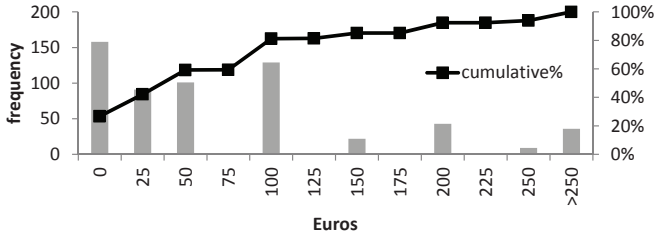

Figure 14. What would be paid for an onboard traffic light assistant system

V. Discussion

The distribution of operating systems in this study is similar to findings in other studies: [19] reported 33.6% Android and iOS 22.2% for Germany in December 2011. And [20] found 31.2% Android and 20.7% iOS for Europe. Based on the results of [21], it can be assumed that the proportion of Android smartphones is increasing. The often-used practice of implementing one app native for both systems (iOS and Android) would apply to half of the mobile phone population in this survey.

The young age, the high percentage of males and the main use of phones and cars for personal purposes in this survey is likely due to the academic, student-heavy population at the technical university.

One requirement for safely providing driver information via smartphones is having an appropriate mounting method for the phone in the car. Currently only about on in five people has a car mount for the phone and only one-fifth of these use it during each car ride. An introduction of a driver information system must also advertise good practices for mounting locations (no field-of-view occlusions and no significant deviation from the line of sight).
Most people had no phone mount because they do not see a need. Nevertheless, the high level of willingness to use a traffic light assistance system could be a chance to promote the safe integration of mobile devices into the car.

The main age for start mobile phone usage in this study seems to be 14. From data shown in [22], the actual starting age of mobile phone usage for German children seems to be somewhere between the age of 10 and 13.
Most of the time, phones are used for about two years. This could be an artifact of the contract strategy of German network providers. The contracts are generally limited to two years and are bundled with a phone.

iPhone users seem to download more apps to their phone. This is in line with [23], which found that iPhone users download 48 apps/month and Android users 35 apps/month. A higher app activity for iPhone users was also reported by [24] (37 installed apps on iPhone versus 22 apps on Android). It would be interesting to find out whether this is due to generally higher user activity, easier app installation or reasons based on the phone itself: are

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Androids better equipped with OEM preinstalled programs? Or are the users wiser and realize that they will never use more than a couple of apps? [25] found that users installed an average of 24 apps and used 9 in the last month.

No matter how the answers for the most often used apps are analyzed, Facebook is always in first place. Facebook was also found to be the favorite app in [24]. In [20], Facebook is not the favorite app, but ranks among the top apps. The next four places in this survey change order depending on the analysis technique (Figure 8 and Figure 9), but the candidates are the same: whatsapp, public transportation information, navigation and news. Navigation was also found to be an important app in the above studies. Some differences between the previous studies and this survey: In this survey, music and weather do not play an important role; on the other hand, the information about public transportation is important here and was not mentioned in the other studies. [26] also found Whatsapp and Facebook to be top-ranking in Germany.

The most often used function of the mobile while driving is the phone, different apps play only a minor role. If an app is used while driving it is likely a navigation app. The social media referred to as driver distractions ([27], [28]) are unimportant and are used to the same degree as already forbidden radar warning systems. The vast majority of road users are responsible drivers. Another survey found that 20% of driver would use Facebook while driving if it could be controlled by speech [29].

The acceptance of a traffic light assistance system by females is surprisingly low, compared to males answers. Most men also see no safety issue. This should also be addressed if a traffic light assistant were to be introduced. The driver must be aware of his or her responsibility while driving. From the results it is likely that the early adopters will be males.
Due to the high willingness to use the system, the peaks at zero euros for an acceptable price could be a sign that people wish to use it for free. For an app this could maybe be realized through various distribution models (goverment grant, advertisement, etc). For an car onboard system it would be not feasible to get it for free. Questions about an appropriate price are also used in simulator studies and real field trials. It will be interesting to see how real-life experience with such a system influences the perceived value.

VI. Conclusion

For the traffic light assistant project it is likely that a first native app will be implemented for Android, maybe followed up by an iOS implementation. The high (male) willingness to use the system should be a chance to promote safe integration of mobile devices into the car and to raise awareness among all stakeholders about responsibility while driving. Given that a majority of participants does not have a suitable mounting option and seems to be uncritical of distraction issues, implementing this attractive app could be an opportunity to provide users with relevant information about these topics within the application.
From the small number of users found in this data the ‘social media while driving’ issue does not seem to be worth discussing at this time. This opinion is in contrast to [28].

It is important that systems are technically well designed, in terms of hard and software, and also ergonomically sound. [8] reported that usefulness of a system and the satisfaction with its use were highly anticipated by test persons. These expectations reduced after driving in a simulator with the traffic light assistance system. Another aspect is long-term use of the system in addition to motivation to use it. Through all stages of the project, human factors and ergonomics plays a major role. It is here suggested to gather subjective ratings from customers and users of systems both at an early development stage and along the way. The next step is to analyze the goals and tasks of the user, in order to gain a better perspective on the additional tasks required by the use of the system. The final step is the technical implementation of the system. Ergonomic and human factors is not a discipline for quick usability tests in a late development stage, but rather it must be involved from the beginning.

VII. Outlook

Previous studies reviewed the traffic light assistant in a driving simulator and actually prototypically tested it in real. The survey data documented in this paper will be mentioned and related to the results found in these studies. Recent experiments address the mental demands of a traffic light assistant, the gaze behavior and subjective measures.

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