Design challenges of an In-Car Communication System UI

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Introduction

The rapid development of In-Car communication systems in recent years has enabled diverse information supply also in automobiles. The advantages of these systems may be obvious, but to apply telematic applications extensively in traffic and especially in-car environment calls for knowing the possible drawbacks and the means to minimise them.

The research project in Nokia investigated different methods of implementing an In-Car communication system, and different user interface solutions for them. The aim of the project was to exclude unusable, and find useful and usable user interfaces for an In-Car communication system and test them with users.

In this paper I will explore some of the present challenges of In-Car communication system UI design. In the final paper will go through a case study of a Nokia research project, and finally I will present some design implications concerning general UI design of an In-Car communication system.

1. *Usability and in-car communication systems*

The design of an In-Car communication system follows the product development process as well as the user centred design process of an ordinary software product in many ways. However, the area of transport telematics is fairly new, and not all the principles adopted from traditional usability engineering are appropriate as is. It is a fact that an In-Car communication system is an example of a *safety-critical product*. The usage environment poses a lot of strain to the development process of an In-Car communication system, and the safety limitations of the device itself and its user interface have to be strict. Transport psychology, which explains the human behaviour in traffic situations, must be used as an aid of design and testing phases. As an additional challenge there are only a few industry conventions in designing In-Car communication systems.

The usual analysis of the driving task distinguishes three hierarchical levels: strategic level (navigation), tactical level (manoeuvring) and operational level (control, keeping the car on the road). The strategic level usually consists of the general trip planning, including for example the route decision and determining the actual goal of the trip. To fulfil these strategic information needs of the driver, more complex In-Car information systems have been designed including navigation systems, but they were excluded in this research. For operational level tasks it is characteristic that they require frequent visual observation from the driver, but nevertheless they are usually performed quite automatically. A machine or system like an In-Car communication system can influence operational level tasks especially if the usage of a such device requires visual resources or it needs to be used with hands. Thus an In-Car communication system may introduce a potential safety risk. The tasks in tactical level require more attention than the tasks in the operational level, because they include more explicit decision making. Thus these tasks are more vulnerable to the mental workload associated with In-Car systems, such as interference of the messages from the In-Car system and strain from the In-Car communication system. [2,3]

To design and test an In-Car communication system and its UI is indeed very challenging. The success of an In-Car communication system will depend on how the user, i.e. the driver of the car, will be taken into account from the very beginning of the design phase. The information flow and the mental workload of the driver will increase dramatically when new In-Car communication systems are introduced. Accordingly, the driver's situation will change as dramatically, if the increased information is not dealt with a systematic approach during the design. In literature, this approach is called a driver oriented solution. [1]

The workload of the driver is a factor in the attention which the driver pays to messages from any system introduced in-car environment. In the case the workload is high the message content from the system may be ignored or even lost. An In-car UI must be designed so that it exploits all ways of simplifying driver interaction,

due to the restrictions from the usage environment. To achieve this we must get more familiar with the driving environment and what applications and features we should offer to the driver, and in what manner. The most relevant issues in implementing a In-Car UI are presenting things to the user in a simple and understandable way and distracting the driver from driving as little as possible. [4]

When designing an In-Car communication system there are even physiological, psychological and social properties of the driver which may present limitations related to safety of using the In-Car communication system. Physiological limitations are for example bad visual performance in night traffic, bad peripheral vision, and low capacity for time sharing. These limitations can influence for example to the display selection. Psychological limitations include human limitations acquired during our life and our limited capacity to process complicated and extensive information in a short or limited time. This in its turn may restrict the dialogue; the presentation of it and the versatility of it. Sociological limitations concern for example the lack of normal communication, because the car as a separate and moving spatial context impairs the normal human interaction and communication possibilities. [5]

The distinct usage environment of an In-Car communication system should be taken into account very carefully in usability testing, too. When compared to the usability tests in a normal car and in traffic environment the simulator tests give more freedom in the test process. Nevertheless it is certainly a challenge to usability-test an In-Car communication system UI without a car and a real driving situation. However, in an early phase of design cycle it is a must in order to be able to decide whether new information really meets the driver's needs or if it is only an irrelevant piece of information. There are several different approaches to implement the testing phase without going to the car. One can conduct usability tests with an ordinary PC demo, or use a PC with a touch screen. To add the driving experience to this one can use driving simulators for PC. These all are suitable solutions for rapid prototype testing. [6]

Based on the above arguments known from the In-Car UI literature, the Nokia research project was targeted to give more detailed information of the possible mental workload to the driver, and what kind of UI solutions would be preferred by the drivers. The usability of the different In-Car communication solutions was verified by implementing several different types of interactive demos and running usability tests. The aim was to determine how the drivers would handle the different communication systems in a simulated driving situation. This was done with the help of interactive demos, touch screen and a PC game which simulated driving a car. Special attention was paid to needed amount of help in performing the tasks, performance times and "critical" errors in driving with the simulator.

2. *Case study: Determining usability of an In-Car communication system*

The main attention of this study was paid to the guessability and imperceptibility of each In-Car communication system UI solution. Our aim was to find out confirmation to some fundamental things in what seems to be the most important in the interaction design of an In-Car communication system, i.e. what kind of things are possible for the driver to do without influencing the driving task too much. The test subjects were strongly emphasised to have driving the simulator as their primary function, and handling the demo as well as finishing the task as secondary one. They did not receive any training of the demos, but they were allowed to examine the demo for a while before performing the tasks. Additionally some subjective information and user preferences was gained from the users in the final interview. The management of the information visible on the screen with different types of input devices was of interest, too.

The suitability and manageability of the communication applications with the current input device and display type were of interest, i.e. how does the combination of different input devices, display type and layout effect on the performance with the device. This was measured with the performance times of each task and amount of errors during the task. In this way we got clearly comparable information between each demos: time and error number. The quality (severity) of the errors made by the test users were in focus, too. The possible reasons to them were noted by observing the test user.

The usability tests of the research project were summative evaluations, and made with PC demos, touch screen and a PC game which simulated driving a car. The tests involved four graphical (GUI) demos, which varied from a handset only to a many-button device with a 5 inch display. Each test user performed the specified tasks with total of two demos, and the order of the demos varied. The tasks had been selected to represent general communication related needs in car, and part of them were done while driving the simulator and part while stopped.

In the final paper I will describe the areas and goals of testing in more detail.

3. *Main findings and Design implications*

Due to the nature of the test arrangements there were both some demo-specific and general type of findings. In general, if a demo had too many buttons they were disliked, especially if they were totally unclear to the test users. The less buttons, the more positive comments the demo gained. Moreover, if the buttons were large, they

were considered good especially when driving. Additionally the small amount of buttons was considered a positive feature, and again this was valued when driving. The buttons, their labels or icons and their functionality should be self-explanatory. For example the abbreviation or icon should be clear and understandable to the user. Great care should be taken when designing the icons for an In-Car communication system.

There were driving errors with every demo during the tasks which were performed while driving. Additionally the more demanding the function, the more driving errors there were. Even if there were somewhat significant differences in the tones of the demos not many test users noticed any differences in them. The alert tones, such as phone ringing, incoming message etc. were noticed (and mentioned) most often.

The positive transfer from previous products was clearly noticeable. Familiar UI look and feel makes the In-Car communication system UI easier. For example, familiar red and green handset buttons from mobile phones helped with call handling tasks. However, small displays and texts as in handset displays cause some problems in car environment. This is not only with elderly drivers but younger drivers as well.

If there are shortcuts from other device to another, they must be really easy and visible, or they are of no use. For example a shortcut from radio to telephone and phonebook has to be simple and marked clearly.

In the final paper I will add more detailed results concerning the different demos, and more design implications.

4. Conclusions

In the future more attention has to be paid to the overall design of the In-Car communication systems. To achieve the ideal design the In-Car communication system solutions have to agree to the needs and objectives of individual users of the systems, i.e. drivers. The features of a such device have to be examined more closely: what features necessary in automobile environment and to what extent they are needed and preferred. When the features are examined the next step would be to decide which ones are suitable while driving, that is which of them stress the driver's memory load less, and how would these features be structured. The method for restricting unwanted features while driving should be considered, too.

It should be examined whether it is possible to let the current traffic conditions influence on the amount of available features, that is if the flexibility of the driver and passenger mode is possible to be increased. The features available while driving should be not only quick to learn, but easy to remember. The logical structure of the user interface has to be considered more closely, too, after the relevant features have been chosen. Moreover the speech recognition facility should be utilised in the In-Car communication systems.

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