Development and evaluation of an assistance application for texting while driving

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Abstract:

After conducting interviews (Mincheva) with drivers who compose/retrieve messages while driving have been established basic guidelines for designing an application, which will allow the drivers to reduce the amount of attention required for texting and the risk of accidents. In this project a prototype application was build to evaluate the design. The prototype was evaluated in laboratory conditions. The amount of distraction require for using the prototype while driving was compared with the amount of distraction require for using car's entertainment system and dashboard tools, and conventional method of composing and retriever messages.

Preface

The report was written during the spring 2015 by group is105f15as a master thesis on the 10-th semester of the Software Development program at the Aalborg University. The competence of this thesis is *Information Systems* and my task was to build the design ideas from my last project into prototype application. This application was build to be compared with other kind of secondary tasks while driving and aims to achieve legal amount of distraction while driving.

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Chapter 1

Introduction

Mobile devices have impacted in many areas of our lives. We often use mobile devices while we work, study, travel or for entertainment. We are getting mobile devices along any other task we perform.

One example of such multitasking is using a mobile phone to communicate while driving. Talking and text messaging while driving is forbidden by the law in Denmark and many other countries. It is allowed to use accessories that assist you trough the use of mobile devices - Hands-free. Such devices make legal the usage of mobile phone while driving. However these accessories are not designed yet to assist text messaging while driving.

There are tools and systems designed to be used while driving - car's dashboard tools and entertainment system. They are designed in a way that requires minimal amount of attention and they are legal to use.

The penalties in the law do not stop the users from text messaging while driving. A lot of research has been conducted to examine how distracting messaging can be, but little or no work has been done to design a different method of composing and retrieving messages. In this project I will try to develop an application that serves as an accessory for composing and retrieving messages. This application must use as little amount of attention as possible.

From the previous work (Mincheva) certain requirements have been gathered from interviews with users and basic design ideas have been established. In this project I will design a text messaging application and evaluate that design.

1.1 Research Question

The GSM (Global system for mobile communication) - systems provides the ability to be connected in real time, with everyone, any time, almost everywhere. The technology improves mobile communication - in every way from simple calls to sharing multimedia. People are able to call anyone at any time, access Internet services and etc. However this interferes with almost all other activities in our lives. People use this mobile communication, while they are working, traveling, relaxing and so on. Interacting with mobile devices requires attention, which in some situations may be valuable.

There are activities, where using mobile communication is prohibited. An example of such activity is texting (composing/retrieving) massages while driving. Both texting and driving require a great amount of attention on their own. Drivers must obey local traffic regulations, be aware of traffic conditions and respond to them adequately, in order to avoid accidents and drive safely. Texting on the other hand - is prohibited by traffic regulations in Denmark, because it requires significant amount of attention, which is problematic during driving that already requires a lot of attention. For example hands free accessories or a Bluetooth connection with car's entertainment system to act as hands free are developed to reduce the amount of attention required to make phone calls. Therefore such accessories, car's entertainment system and dashboard tools are allowed to be used while driving. However there is no such accessory or application that can reduce the amount of attention, while composing/retrieving messages while driving and therefore texting cannot be performed as a secondary activity.

Despite the traffic regulations, many people tend to merge these two activities, overlooking the safety issues and disregarding the regulations, thinking this is safe. This exposes them to risks, because texting requires too much attention, which compromises the safety on the road.

Technology provides the necessary tools to design proper texting utilities that can support texting as a secondary task. The design has to require much less attention, compared to current designs - and also a similar distraction level to other in car tools and systems.

The research question of this project will be:

"Is it possible to design an application for text messaging that is less distracting than existing text messaging systems and achieves lower or same level of distraction, as a car's entertainment system and dashboard tools? "

1.2 Overview

The next chapter presents what literature is related to the design and the experiment. It will discuss other evaluations similar to that in this project. In chapter *Requirements* are presented three major topics of the project. It describes what the current practices of composing an retrieving messages are, how users would like to text and what the most common messages are. These requirements are derived from previous work.

In chapter *Design* solutions are created in response to those three requirement guidelines. In the next chapter - *Build* - a prototype application is created which is eligible for evaluation of the design ideas.

Chapter *Evaluate* describes the aim of the evaluation, the conditions and the tasks of the evaluation and the experiment itself. In chapter *Results*, the results of the experiment are presented and they are analyzed according to statistical methods.

In chapter *Discussion* the experiment is compared to the related literature and in the final chapter -*Conclusion*- the answer to the research question is presented as well as the obstacles that couldn't been removed.

Chapter 2

Related Literature

In this chapter are presented some researches that have relation with the topic of this project. The result of those researches are presented here and discussed in later chapter.

2.1 Mobile phone use while driving: public opinions on restrictions

This paper (LAMBLE et al.) review two road user surveys on the use of mobile phones on the road. From 1998 to 1999 the proportion of the drivers that chose to use a mobile phone while driving rose from 56% to 68%. The data is collected during two separate periods. There were 1528 interviews in the first year (48.2% males between 15-82 years old) and 1521 interview in the next year (49.8% males between 15-79 years old).

The result shown that the young people generally use mobile phones more than older generations in day-to-day life. Figure 2.1 shows the distribution of the daily phone usage for each age category. It is clear that the a smaller proportion of the older drivers either do not use mobile phone while driving or do not have one in contrast to the younger driver. The drivers between 15-24 and 25-35 years used their phones more each day than the older drivers. In order to solve this problem the researchers have suggested a development of "Hands free" alike accessory for texting messages.

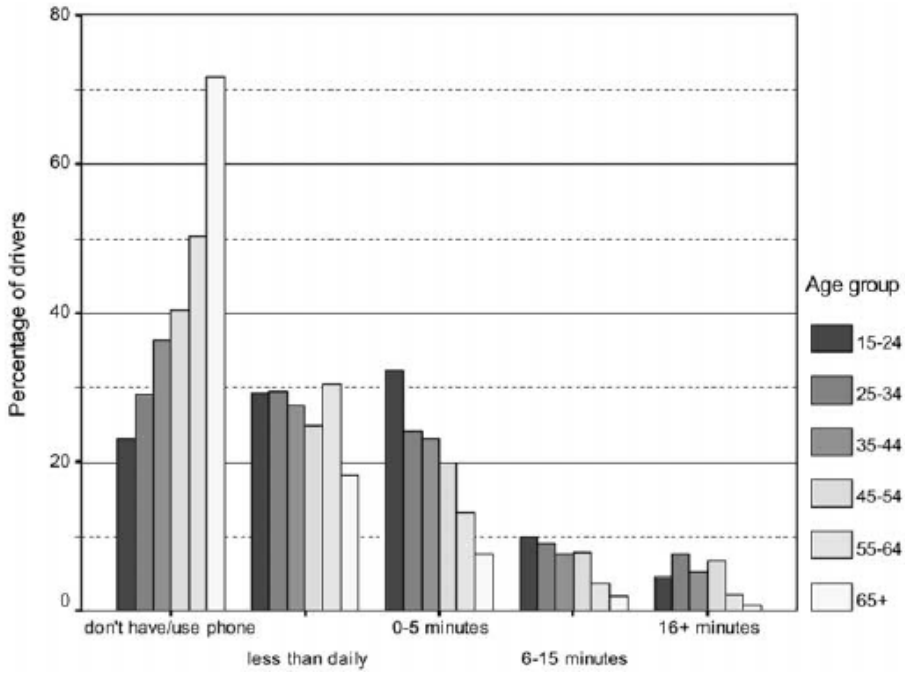

Figure 2.1: Daily phone usage while driving for each age group.

2.2 National phone survey on distracted driving attitude and behavior

This survey have included 6000 drivers. The majority of respondents (85%) reported driving almost every day, the other drive few days of the week. Eighteen drivers of them have been interviewed. For driver is considered a person who have been driving in the past year. The drivers were between the age of 18-34 and the sample was 49% male (51% female)(Tison et al.).

The participants were asked after how much time not looking to the road driving becomes dangerous. 68% think that driving is dangerous if they take eyes of the road for more than 2 seconds. One-third of the drivers between the age of 18-24 think that they can get eyes of the road for 3 to 10 seconds or more, before driving becomes dangerous. 26% chose less than second, 46% selected between 1 to 2 seconds, 19% selected between 3-4 seconds and 8% between 5 and 10 second (see figure 2.2).

This paper gives us an idea of how the drivers think while driving and how much time they are suitable to spend do not looking on the road. It will be also interesting to see of how much accidents people have according

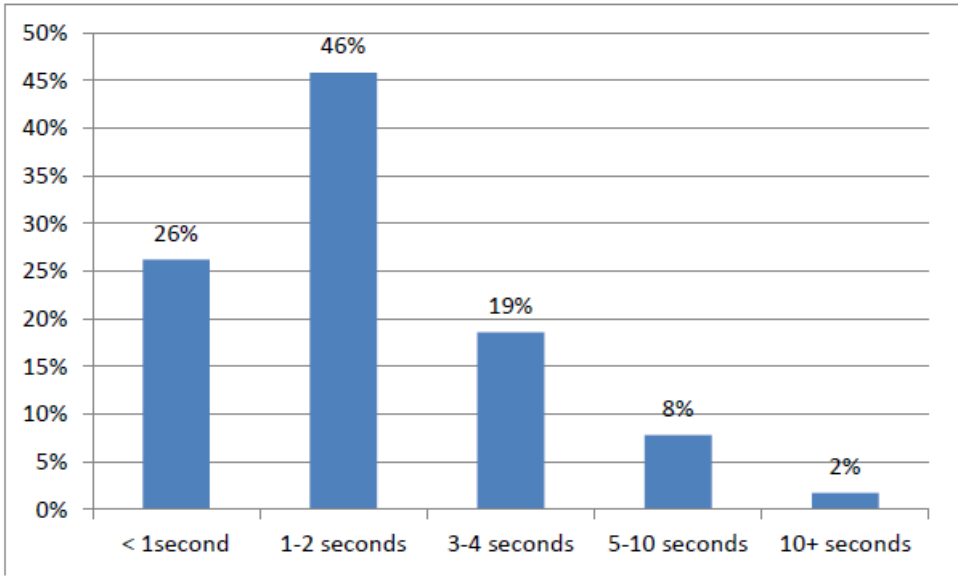

Figure 2.2: How Long Can a Driver Safely Keep His or Her Eyes off the Road

to how much time they feel safe to take eyes of the road. In this project I also compared three different types of interactions - entering text, using car's entertainment system and dashboard tools and retrieving messages.

2.3 Distraction Effects of Manual Number and Text Entry While Driving

This paper investigates the distraction potential of secondary tasks performed using car's dashboard tools and entertainment system and phones while driving. The experiment included one hundred participants on the age between 25-64 years, which had to perform secondary task on low-fidelity simulator. Each task was performed in 3 minutes drive and the measures included: lane position variability, car-following delay, target-detection accuracy and target-detection response time (Ranney et al.).

The experiment included:

- Radio tuning
- Destination entry by address
- Phone dialing

- Text messaging

The research showed hight level of distraction potential for text messaging while driving and lowest distraction potential to using car's entertainment system and dashboard tools. There is also a difference between drivers who used touch screen devices and devices with hand button interface and the drivers with touch screen performed slightly worse.

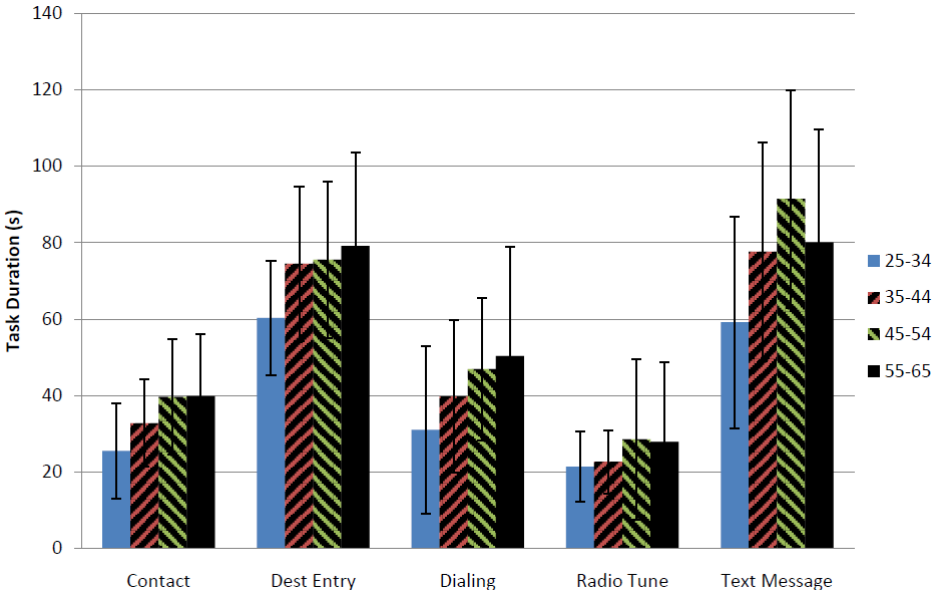

Figure 2.3: Task Duration of First Trial by Task and Age Group

On figure 2.3 is shown the impact of the text messaging, radio tune, dialing, destination entry and contact while driving. It is also divided between age groups. Text entering and destination entering have close results.

This paper gives an idea how distractive text messaging can be while driving. It also compares tasks performed on car's entertainment system and dashboard tools with text messaging and points out solid argument of why text messaging is prohibited with the differences between the amounts of attention required for both types of interactions.

In my project I also will compare those two types of interactions, but I also will pursue results similar or lower to the interaction which are legal, for my prototype.

2.4 The Effects of Text Messaging on Young Drivers

This research included 20 undergraduate students (12 male and 8 female), between 18 and 21 years of age. All of the participants where experienced with text messaging on Nokia cell phones. The experiment was conducted in driving simulator located at the Monash University. The participants had to performed text messaging by using text predictive software and also they ware instructed how to handle text predictions (Hosking et al.).

The research compared performing secondary tasks with not performing secondary tasks while driving and showed that there are greater than the normal levels of distraction while composing and retrieving messages. This study slow us that not only composing messages is treat for the attention of the driver, but the retrieving is also treat. This suggest that not only the composing method must be changed but also the method of retrieving messages has to be changed.

Event	Dependent Variable	Measure	Retrieving	Sending
All events	In-vehicle glances	Proportion	0.23 (164)	0.34 (378)
		Frequency	2.09 (49)	3.25 (123)
		Duration[1]	0.60 (154)	0.65 (282)
	Lane excursions	Frequency	1.75 (28)	1.65 (28)
Car-following task	Time headway[a]	Mean	1.86 (54)	2.17 (49)
		Variability	1.86 (152)	2.16 (99)
		Minimum	NS	1.22 (38)
	Lane position[b]	Variability	NS	0.09 (45)
Lane-changing task	Missed lanes[c]	Frequency	14 (140)	
	Speed	Mean	NS	NS
		Variability	NS	NS
Hazards	Braking time[c]	Mean	NS	
	Approach speed[c]	Mean	NS	
	Distance (min)[c]	Mean	NS	

Note. Positive numbers indicate a significant increase in the dependent variable. NS = no significant effect on the dependent variable. Numbers in parentheses show the percentage increase in the dependent variable.
[a]In seconds.
[b]In meters.
[c]Measured within the retrieving and sending periods.

Figure 2.4: Summary of Mean Difference between Text-Messaging and Baseline (No Text - Messaging) Conditions for Each Driving Performance Measure

Figure 2.4 shows how composing and retrieving messages impacts the driving performance compared to the base line condition.

2.5 Effects of phone type on driving and eye glance behavior while text-messaging

This study (Young et al.) present the impact of using touch screen keyboard versus numeric keypad for sending and receiving messages on simulated driving performance and eye glance behavior. Twenty-four participants between 25-50 years old were involved in this experiment with dual task performance. They send and receive text messages on either a touch screen phone or numeric keypad phone while driving on simulated freeway environment. All of the participants used their own mobile phones for the text messaging task in order to be familiar with the functionality of the phone and text messaging features. Half of the participant used touch screen keyboard and the other half use standard numeric keypad.

For the secondary task performance the authors use Two Mann-Whitney U test to present the results from reading and writing text tasks differed across the standard numeric keyboard and touch screen keyboard phone types.

	Read text	Write text
Keypad	18.7 (7.8)	28.5 (23.0)
Touch screen	16.5 (5.9)	21.1 (18.8)

Figure 2.5: Mean (SD) task completion time for the read only and write text tasks as a function of phone type.

As we can see in figure 2.5 the difference between numeric keypad and touch screen keyboard, which is not significant according task completion times. However, we can say that the touch screen keyboard shows slightly better result from the numeric keypad.

Chapter 3

Requirements

We need to develop a deeper understanding of what are the users' needs in a particular environment and how they operate in this environment (Harper et al.) .The standard HCI approaches are more focused on individuals' interactions than more extended study. We also need to be take in to account what social factors are into play, how users interact with those factors and what their values are .

The law against usage of mobile devices while driving cannot prevent drivers from composing/retrieving messages while driving. However, there are accessories that make sending and receiving calls possible while driving, but there is no accessory that makes texting possible while driving.

To find out how users operate in their environment we need to monitor that. In my last project I chose a design for composing/retrieving messages - composing with templates and retrieving by hearing the message. I had to gather understanding about how users compose and retrieve messages at the moment. How users would like to be able to compose and retrieve messages and what the most common messages are.

3.1 Current Practices

Most of the users ask for assistance from a passenger, however there are some constraints - users tend to do that only the messages that there are composing or retrieving are not about personal matters. Users also used the time that they have while traffic conditions are light for texting relaying on fact that it is safer then. Unexpected errors while composing messages is also a factor that consumes even more attention and leads to accidents. Users tend to spend less attention on this secondary task. During previous

work was also observed an accident during composing message while driving. The reason for this was the need of the user to correct a message and that drew too much attention.

3.2 Envision

Users imagine composing messages, by using speech recognition. However, this iteration requires a lot of recourses to work with, which will be hard to maintain. All solutions accommodating a database for speech recognition on mobile devices and an Internet connection for accessing such a database are hard to build due limited hardware capacity and an unstable Internet connection on the road. Users also most often envision the retrieving by hearing the message and the access to a grouped set of templates under specific icon. Receiving messages at an inappropriate time that disturbs is also something they wish to have control over. It is also prefer to have the ability to automatically reject a call and answer with minimal amount of interaction. However it is not preferred that messages are completely automated.

3.3 Template

Composing messages by using a template all exists in nowadays messaging application:

- IOS "Messages" default application
- Android Messaging

From (Mincheva) we know that users do not use them, because they are located in a difficult to find location of the application. In some default applications it is not even possible to alter the templates and they are available to use only when rejecting call. The templates are also not accurate according to the situation or they are not in the native language. We also found that the standard templates have to be modified very little, to be accurate according to the situation. For example users may need to enter a specific amount of time if he is composing a message related to a delay, arrival or other time related subjects or enter a specific location if it is related to the subject of the message. These little adjustments have been called variables. The templates have been categorized according to the different social arrears - family, work, friends and others.

3.4 Summary

After conducting the interviews the following requirements have been established:

- Users tend to ask for assistance from other passengers for composing and retrieving messages. However this is not suitable for private matters. Users must spend a minimal amount of attention.
- Users envision hearing as a interaction for retrieving messages and voice recognition as interaction for messages.
- Templates must be easy to find and alter. Users must be able to make small adjustments before sending a template to make it more accurate. Also they must be categorized according to different social groups.

Chapter 4

Design

To create a product, we have to know what are the goals which it have to achieve, what is the environment in which it will be used, what are the habits of the futures users and what are their expectations (Harper et al.). We already have those guidelines from the previews chapter now is time to envision how the application will achieve it's goal.

4.1 Current Practices

Here is envisioned how the application will handles the current practices and habits of the users. We already know how the users retrieve messages white the assistance of a passenger. Therefore, they should we able to retrieve the message the same way - the message must be read. However the application should handle the reading way of retrieving. This can we achieved in two ways: by automatically read the incoming message by the application or the user invokes reading on the message. We also must consider that the traffic environment must be laud and the application may read the message in laud moment and the user will not hear the message. Therefore it is better for user to invoke reading by him self (see figure 4.1). This way the user will be able to hear the message when he wants and as many times as he wants.

However the current practice of composing message - manually - must be replaces by using templates while composing with minimal amount of interactions and time spent.

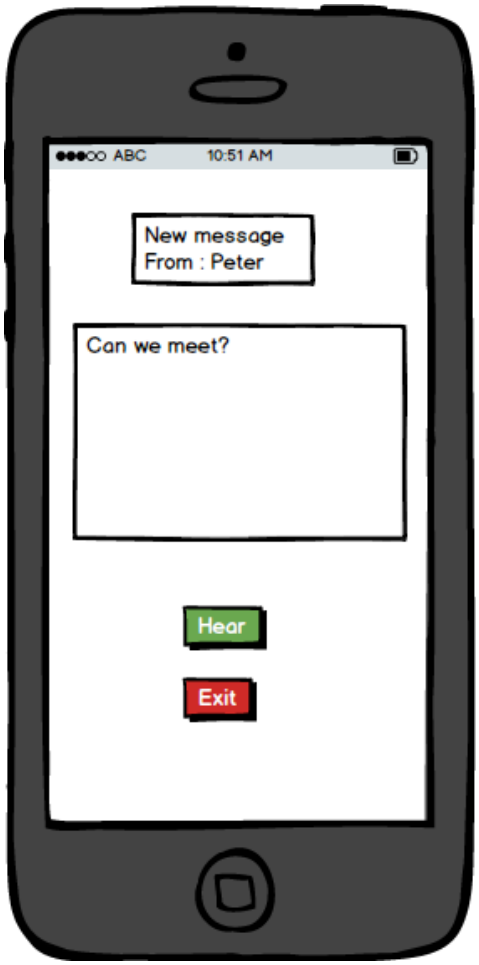

Figure 4.1: Retrieving Message

4.2 Envision

Here it is described how the composing of messages can be engaged. When the user is busy and he cannot retrieve a call (in situations such as driving), he must be able to quickly respond to the call by sending template message.

4.2.1 Quick Answer

The user must be able to send quickly respond on a phone call, by using single interaction - interaction equal of the interaction of rejecting a call. The respond however, will not be simply rejecting a call, but also sending a

template message answer.

This quick answer must contain a template thats universal for any kind of situations. However the user may not like the default universal template defined by the design. Therefore he must be able to alter this template.

The simplest way to mimic the interaction of rejecting a call is by placing quick answer button in position relatively close to the answer/reject buttons. This button will automatically reject the incoming call and send answer message to the calling person containing predefined template (see figure 4.2).

Figure 4.2: Quick Message

4.2.2 Answer with Template

In case the quick answer template, is not appropriate and the user want to be more specific, he must be able to choose specific template from predefined list of templates. In this case te user must be able to choose another button, that will lead him to his list of templates (see figure 4.2 "Template" button). The amount of iteration must be low and must be way lower than manually typing a massage - from two to four interaction.

4.3 Template

From the previous design we know that the template must be grouped by three groups: family, friends and work, and one extra group of other occasions. However defining those groups in sub menus will involve extra interactions which will not be necessary if the list of template is not so long. Therefore the messages must be color coded according to different groups.

The user must also be able to define own templates. This may lead growing list of templates which at some point must be heavy to scroll. When that happen the application must change the view of the template - divide them into sub menus.

The most commonly sent messages must float ot the top of the list in both variations of the list with templates. See figure 4.3.

The templates may also contain simple variable such as time, location or other information, that will make the templates more adequate to different occasions.

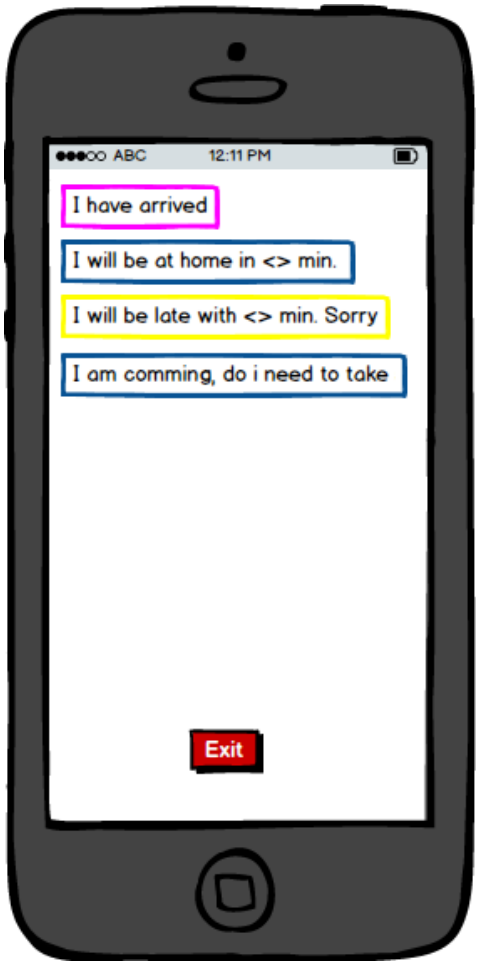

Figure 4.3: List of Templates

Chapter 5

Build

In this chapter I will describe what parts of the prototype are build, what are its views and functionality that are relevant to the evaluation. These parts are essential in order the suggested design to be evaluated. Some parts as the ability to adjust the application settings are not build in the prototype, other are faked for the sake of the evaluation and the reasons are described in last chapter 9. However not all that is envisioned in the previous chapter is build, because not every part of the design is relevant to the research question. Therefore, the prototype that is build doesn't fully reflects the envisioned design, but it is enough to evaluate the design ideas and pursue answer of the research question.

According to (Lazar et al.), there are several types of prototypes. However in this project I will mention two of this types, because they are most close to my prototype.

- Throw away prototype – This prototype helps to make a good starting point and easy to represent the users needs and scenarios. It is helpful to materialize out first vision and gather early feedback from the users.
- High-fidelity prototype – hi-fi prototype is a similar in look and feel to the final product, with lots of details and functionality. This type of prototype, are developed in environments which will be used to simulate the interactive effects of the system.

In this case the message composing/retrieving application that will be developed in this project can be considered something between high-fidelity prototype and throw away prototype. This prototype will be built on Java and XML on Android Studio. The application will runnable on Android platforms.

5.1 Quick answer

When the user is receiving a call he must be able to reject it and send an answer message to the person who called. This message will contain a template which can be customized from the user. The user will do that by clicking "Quick Message" button under the "Answer" button. When this button is pressed the call will be rejected and the application will send an answer message. See figure 5.1.

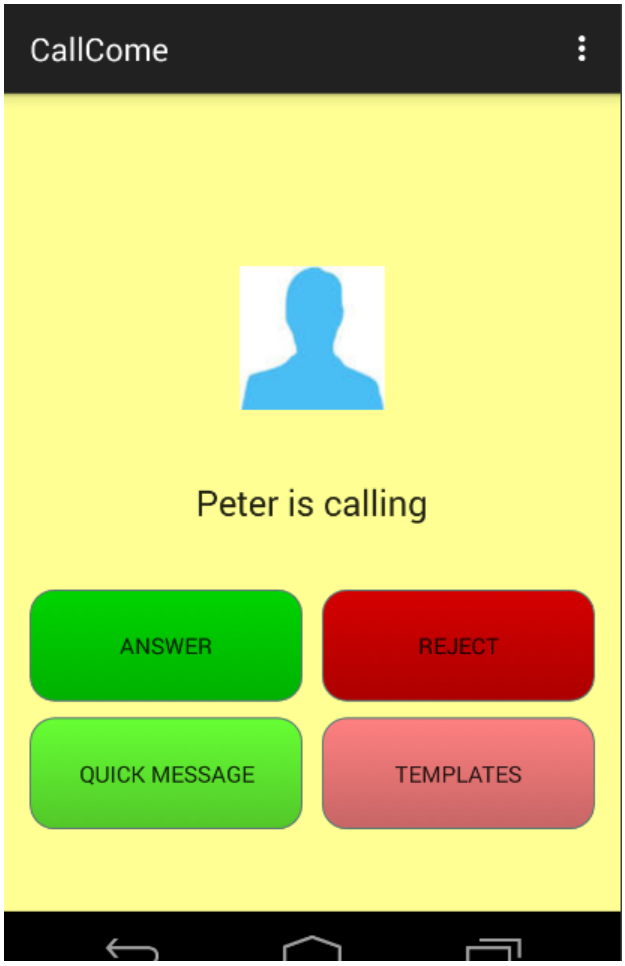

Figure 5.1: Quick Answer

5.2 Answer with template

When the user is receiving a call he must also be able to answer with more occasional message. He will be able to do so, by clicking the button "Templates". This button open a window from which the user will be able to choose from the color coded templates. When a template is chosen the user will be presented to the form of the template, adjust it's variables if it is needed and then send the message. See figure 5.2.

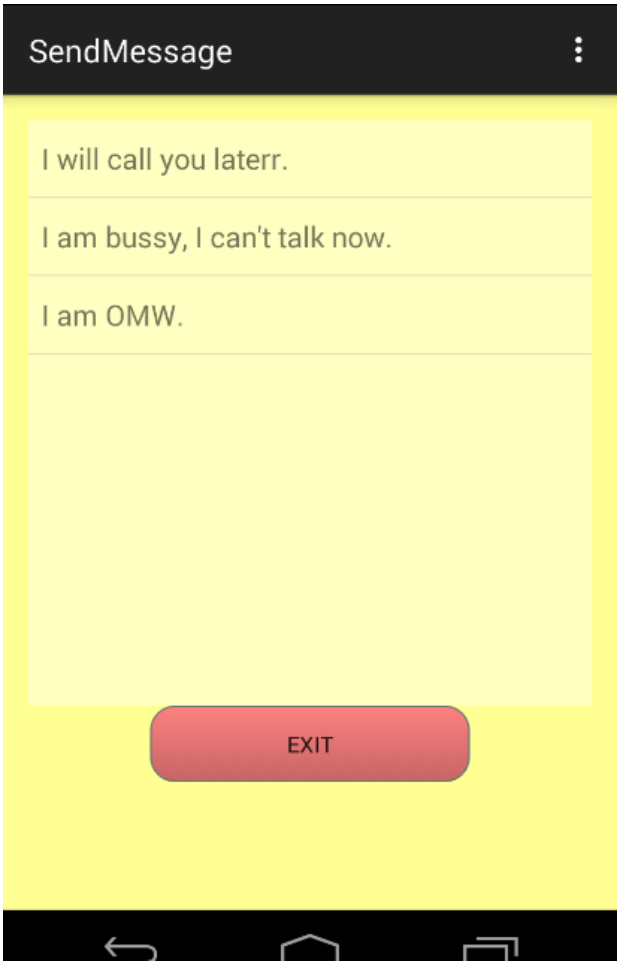

Figure 5.2: Answer with template

5.3 Hear the message

When the user is receiving a message he must be able to hear it. Therefore, when he receives a message and open it, he will be able to hear it by clicking the "Hear" button. However, it may be loud and that may be impossible, therefore he will be also presented to the text form of the message. It case the traffic conditions are not too heavy and the noise pases in a moment the user will be able to press the "Hear" button as much times as he needs. See figure 5.3.

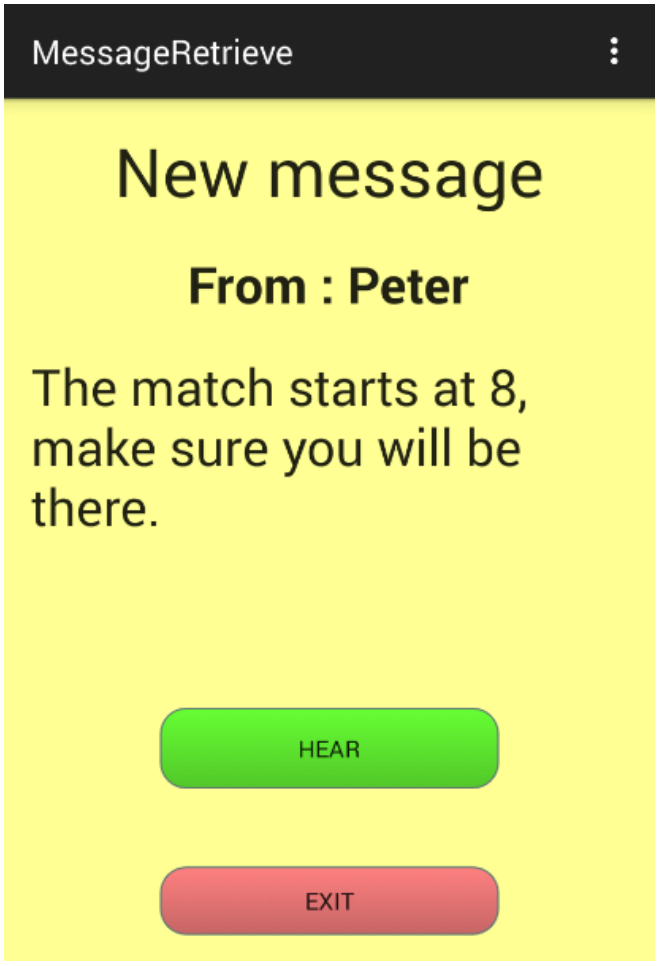

Figure 5.3: Message retrieve

5.4 Formal Parts

When the user starts the application he will be presented to the main menu. From there he can compose a messages by clicking the "Compose" button. He will be presented to the list with the templates from which he can choose a template, modify it's variables and send it.

He also will be able to view and edit the templates that he has by clicking the "Templates" button. Then he will be presented to the color coded list of templates, where he can add, remove or modify templates. The user we also be able to modify "Quick Message", by clicking the button "Edit Quick Message". There he will be able to edit the template that will be send as a "Quick Answer" to the person who is calling. See figure 5.4.

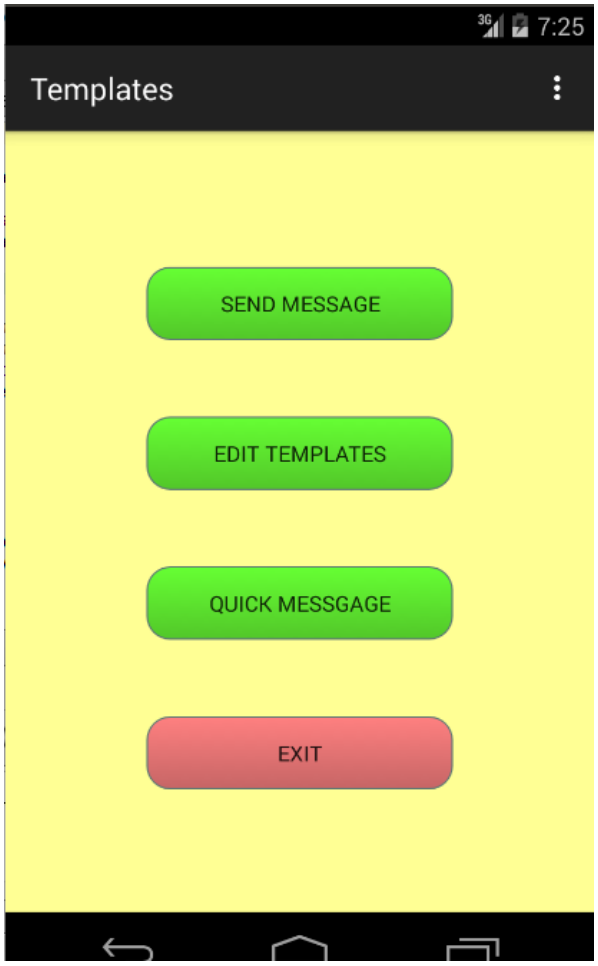

Figure 5.4: Main Menu

Chapter 6

Evaluate

This application can be evaluated by two ways.

- Field experiment
- Lab experiment

In the first experiment we need to use mobile device while driving. This however, will be illegal and expensive to conduct. On the other side it will be hard to simulate real life environment and there will be no random events while driving as if we use real environment. In the other case, the experiment can be conducted in safer conditions and it will require less resources. Also the lack of random events could interfere with the results. In simulated environment the traffic condition will be much more stable and the results will not be effected by other peoples' mistakes (Lazar et al.).

There are three types of experiment according to (Lazar et al.)

- True experiment – The experiment involves multiple conditions and the participants are randomly assigned to each condition.
- Quasi – experiment – The experiment involved multiple conditions or measures, but participant are not randomly assigned.
- Non – experiment - If there is only one observation group and only one measure involved.

In my case, the design of application will be compared with the car's dashboard tools and entertainment system and conventional texting method. To be more precise the amount of attention required, to interact with the

application will be compared with the amount of attention required to interact with the car's entertainment system and dashboard tools. Therefore, there will be three conditions and true experiment

The primary task for the users is to drive, because the purpose of the application is to assist in composing/retrieving messages while driving. While driving is also allowed to interact with the car's entertainment system and dashboard tools, therefore those two secondary tasks will be compared and the purpose of the experiment will be able to prove that there are equivalent according to amount of attention required.

6.1 Hypothesis

Each experiment has basic statement, which must be validated. Such statement is called "hypothesis". There must be at least one hypothesis and one alternative hypothesis and only one of them remains true and the end of the experiment (Lazar et al.).

The basic hypothesis is in the core of experimental design. The core hypothesis, will focus on the amount of attention required in the interaction with the application. In this case the null hypothesis is

"H0: The mobile application requites more attention to interact with, than car's entertainment and dashboard tools."

There are two alternatives of the H0: the application requites same amount of attention to interact with, or less attention. Therefore the two alternatives will be:

Ha: The mobile application requires same amount of attention, than the car's entertainment and dashboard tools.

Hb: The mobile application requires less amount of attention, than the car's entertainment and dashboard tools.

Also the application will be compared with conventional texting method. Therefore there will be two other hypotheses.

H1: The mobile application requires relatively same or more attention than conventional texting method.

H2: The mobile application requires less attention than conventional texting method.

If H0 remains valid at the end of the experiment, the application will need greater improvement, to achieve its purpose. In the other two alternatives, we can say that the application is useful. Comparing the application with conventional texting method will show what is the gap between, the amount of attention requited for text messaging with conventional method and the amount of attention required for texting with the application.

6.2 Variables

In each experiment, there are aspects of the product which are evaluated. Those aspects are called "variables". There are two different types of variables (Lazar et al.).

- Independent variables – different design features used for the same purpose
- Dependent variables – different user characteristics

In this case we will compare the amount of attention required to interact with two different types of design features. The independent variable will be the tasks performed with different interaction features. These variables will be:

- Answer a call by choosing a template
- Answer a call by sending quick template
- Retrieve message by hearing it.

There are also three corresponding variables with the car's entertainment system and dashboard tools:

- Play disk
- Adjust the temperature
- Adjust the air stream

The dependent variables are related with amount of attention required while performing the tasks and will measure:

- Accidents exposure - This variable represents the amount of time spent not looking at the traffic conditions while performing the tasks.
- Distraction - This variable represents how many times the users look out of the road while performing the tasks.

6.3 Experimental Design

Each experiment has one or more groups of participants. The experimental design refers to that are there assigned different groups for different conditions. The design can be: within group and between group. In this experiment is chosen within group design for reasons mentioned below.

- Within group design – one group of participants are assign to the different conditions. In this design the performance of the same group of participants is compared in the different conditions. It will be much easier to conduct the experiment with only one group. The problem with this design is that fatigue or learning effect can occur. However, because driving is the main task the drivers can remember the road if they have to pass the same way for the conditions. To avoid this, different routes with the same traffic load and traffic conditions must be designed for the both experiment conditions. Because of that and different secondary tasks no fatigue is expected to occur.
- Between group design – each group is exposed to only one condition, which means that we need larger sample size. This design has also larger impact on individual differences. In this alternative we can avoid fatigue and learning effect at the cost of recruiting more participants. This will be less efficient than designing two routes. Therefore this design is not appropriate for this experiment.

6.3.1 Condition 0

To compare the amount of attention required for interacting with the application and the amount of attention required for interacting with the car's entertainment system and dashboard tools, it will be designed equivalent experiment condition, with the same amount of tasks and the same amount of interactions. This means, three tasks of interacting with the car's entertainment system and dashboard tools with equivalent with previous condition's tasks' interaction load for each task. The users will be introduced to mock up

of the car's entertainment system and dashboard tools so they get familiar with it.

Interacting with the application – (composing/retrieving messages) is irrelevant to the control of the car and the car's signalizations. Therefore the tasks of the second condition will also be design to not interfere with car's control or signalization.

The participants have to perform three tasks:

- The user will have to turn on the entertainment system, switch to "play disk", choose specific song and adjust the volume. Total amount of four interactions.
- The user will have to adjust the temperature of the heating system. Total amount of one interaction.
- The user will have to redirect the air stream of the heating system. Total amount of one interaction.

6.3.2 Condition I

The mobile device will be mounted on the "dashboard". The users will be introduced with the functionality of the application and prepared for the tasks, in order to get familiar, as they would be if they use the application occasionally.

The participants have to perform three tasks:

- The user will answer a call by choosing a template – click "Send Template" button, chose a template, change variable if it is need and send. Total four interactions.
- The user will answer a call by sending quick template – click "Quick Answer" button, which automatically will send a template message to the person who calls. Total of one interaction.
- The user will retrieve message by hearing the message – the user will click "hear" button and the system will read aloud the message. Total of one interaction.

6.3.3 Condition II

In this condition we will investigate what is the difference the amount of attention required for using the application and the conventional method for texting. The user will have to achieve the same results as in *Condition I* and this will be the goal of the tasks, with regards to the number of interactions that the users spent to achieve the goal.

The tasks while be the similar to the tasks in *Condition I*:

- Answer a call with long text message
- Answer a call with short text message
- Read message

The amount of attention to answer with message while using conventional method will be compared with the amount of attention used to answer with template. Read message will be compared with hear message.

"Route – The route in all conditions will have the same amount of traffic signalizations and load as the route in the first condition. However, it will have different trajectory. This is to avoid learning effect and causing the participant to spend more attention on the secondary tasks at the second condition experiment."

6.4 Setting

In this section is described how the evaluation was conducted and in what circumstances. As begging is describe the environment in which the evaluation was setup.

For reasons mentioned above the evaluation had to be conducted in laboratory. The laboratory was set up in home environment. For a screen on which the driving world is presented was used a TV 32".

6.5 Participants

Lazar et al. suggested small group of participants with proper knowledge to the subject. Therefore were recruited 5 participants (3 male and 2 female). The users were between the age of 25 - 30 years old, they all had driving

license, experience and they are texting often. The users were allowed to practice on driving before the trails. They were also introduced to the mock-up of the tools that they are about to use and how to handle the application. This way they will be able to get comfortable with the "car" and the application, as they would be in real life. The users were asked to keep speed limit of 50 km/h. After they get comfortable with the environment they started to perform the tasks.

6.6 Material

For driving experience simulation was used a console racing video game (Grand Tourismo), set on free run mode. For controller was used steering wheel with semi-automatic gear box and pedals for acceleration and brakes. The settings of the game ware set to simulation[1]. For a vehicle was chosen everyday city car with small engine - Renault Clio 1.5 cc. This way it will be easier for the user to handle it. To simulate the car's dashboard tools and entertainment system was used mock-up of the tools that will be used (see figure 6.1).

On figure 6.1 is presented the mock-up which is build by using office materials and another console to mimic the interaction of changing CDs. The console is switched on with no peripherals attached to it and the button for ejecting the disk is functional to serve for the evaluation tasks.

6.7 Procedure

The mock-up and the android device were placed respectively to the driving seat as in real car. The application was installed on Android device and it was placed relatively closed to the mock-ups of the car's entertainment system and dashboard tools. For the Condition II they had to use their own mobile phone in order to be more used with it. The users performed there tasks on the same track in order to be familiar with the road as they would be in the real live, but however they performed the tasks on different parts of the track.

In order users to not get used to specific part of the equipment (car's tools, the application and their own phone) the tasks were ordered by using Latin squares method. This method is used to reduce the error effect.

[1]That means the driving experience will be as real as possible and there is no driving assistance by the game itself (breaks, steering assistance and etc.).

Figure 6.1: Mock-up

The users had to perform the tasks in specific order, in order the user to not perform 3 tasks of the same condition in a row and get used to perform on specific feature. They performed first a task of the ground condition, then a task from *condition I* and then task from *condition II* until all the tasks are finished. The order of tasks is presented in table **??**. The columns C_0, C_I, C_{II} represents the conditions. The letters T_{*1}, T_{*2}, T_{*3} represents the number of the tasks. See figure 6.2.

6.8 Data collection

To record the evaluation was used video camera, which keeps track of the screen, the user sight and what he is interacting with (See picture 6.3).

The camera with records the evaluation is positioned on the left of the participants and caches the screen, the mock-up, the users hands and part of his face and sees where the user is watching (see figure 6.3). On the video records from the camera it can be counted how many times the users move their eyes away from the screen to perform secondary task and on the video it can be measured for how long the users have been looking away from the road (see picture 6.4).

Tasks / Participants	C_0	C_I	C_{II}	C_0	C_I	C_{II}	C_0	C_I	C_{II}
P_1	T_{01}	T_{I2}	T_{II3}	T_{02}	T_{I3}	T_{II1}	T_{03}	T_{I1}	T_{II2}
P_2	T_{02}	T_{I3}	T_{II1}	T_{03}	T_{I1}	T_{II2}	T_{01}	T_{I2}	T_{II3}
P_3	T_{03}	T_{I1}	T_{II2}	T_{01}	T_{I2}	T_{II3}	T_{02}	T_{I3}	T_{II1}
P_4	T_{01}	T_{I2}	T_{II3}	T_{02}	T_{I3}	T_{II1}	T_{03}	T_{I1}	T_{II2}
P_5	T_{02}	T_{I3}	T_{II1}	T_{03}	T_{I1}	T_{II2}	T_{01}	T_{I2}	T_{II3}

Table 6.1: Order of tasks per user

Figure 6.2: Experimental setup

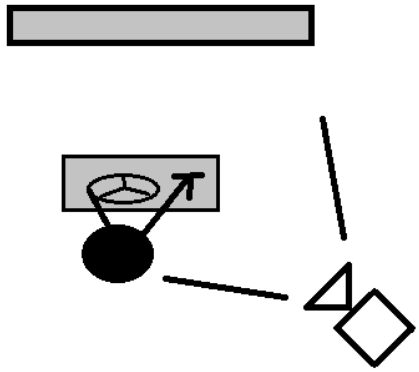

Figure 6.3: Video Setup

Figure 6.4: Screen shot from the videos

Chapter 7

Results

In this chapter the results are presented and analyze as suggested in (Lazar et al.). For analyzing and presenting the results One-way ANOVA method is used. The results will be covered according to each condition and they will be analyzed by the method mentioned above.

7.1 Condition 0

This condition is the base to which the other two conditions will be compared. For a base is the situation which happens most often and is legal. Driving and using the car's dashboard tools and entertainment system is the condition with distraction measures, which are the aim of the project. The results are presented in a table 7.1[1].

[1]The time that the users looked away from the road is not precise, but is relatively accurate and measured in the same manner for all participants.

Measures / Participants	Looks T_0 in times	Time T_0 in sec.	Looks T_I in times	Time T_I in sec.	Looks T_{II} in times	Time T_{II} in sec.
P_1	10	4,90	4	3,30	2	1,80
P_2	6	3,84	2	0,96	2	1,21
P_3	6	4,56	4	3.00	2	2,71
P_4	10	7,29	4	3,55	2	4,30
P_5	6	5,05	3	3.00	3	1,87

Table 7.1: Results for Ground condition

Measures / Participants	Looks T_0 in times	Time T_0 in sec.	Looks T_I in times	Time T_I in sec.	Looks T_{II} in times	Time T_{II} in sec.
P_1	3	4,35	1	2,20	1	0.99
P_2	5	2,57	2	0,99	1	0.80
P_3	5	3,72	1	1,20	1	1,10
P_4	2	4,17	2	1,66	1	1,13
P_5	4	5,05	1	0,96	1	0,88

Table 7.2: Results for using the application

The columns of the table represent the measures that have been taken.

- Look - this variable represents how many times the user looked away from the road.
- Time - this variable represents how much time users have spent, looking away from the road.

There are measures for each task of the condition and they are represented by the roman numbers.

7.2 Condition I

This condition is the one that the users use the application for composing/retrieving messages. This is the condition which aims to achieve the results similar or better than the ground condition, in order to prove the design valuable. The results from the tasks are presented in table 7.2.

7.3 Condition II

Here are represented the results for the condition in which the users used conventional methods of composing/retrieving messages. The results will be used for comparison with using car's dashboard tools and entertainment system (Ground condition) and conventional method of composing/retrieving messages. The results are presented in a table 7.3

Measures / Participants	Looks T_0 in times	Time T_0 in sec.	Looks T_I in times	Time T_I in sec.	Looks T_{II} in times	Time T_{II} in sec.
P1	18	8,96	4	2,84	3	2,57
P2	14	15,30	11	8,97	4	4,92
P3	16	12,89	7	7,04	3	4,50
P4	17	15,60	6	7,11	4	5,87
P5	29	19,34	20	18	12	8,30

Table 7.3: Results for conventional method for retrieving/composing messages

7.4 Analysis

The results were analyzed with IBM SPSS Statistics software. The trails of each subject are compared according to each condition - how much time looking away from the road it took for the user to perform the tasks ("Looks"), how many times the user looked away from the road ("Times[1]"). The data has been prepared according to (Lazar et al.) - a table with each case and the results for each case were prepared. The data was analyzed using *Repeated measures* tool, and within-subject variables were set to be measured - comparison between the "Times" and the "Looks" of the first, second, and third tasks in all conditions (repeated measures).

7.4.1 Comparison between C0 and CI

The most important result for this experiment is the comparison between the performance of the users while they use the prototype application and the ground condition - using car's dashboard tools and entertainment tools. The results of that comparison will provide the required information to formulate an answer of the research question, which will be the subject of discussion in later chapters.

In figure 7.1 we can see that there is a significant difference between the taken measures for conditions *C0* and *CI* ($p < 0.01$). Considering the results from the tables 7.1 and 7.2 it can be said that the users achieved better results using the application than using the car's dashboard tools and entertainment system. The results also vary for each participant - some participants achieved better results than others in general for all the tasks and the conditions. However, there is a difference in the performance of the

[1]How many times the user moved his sight on the secondary tasks.

users between both conditions - the users showed less distraction (less *Looks* and *Times*) per tasks for the condition in which they use the application.

Tests of Between-Subjects Effects

Transformed Variable:Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Looks	313.633	1	313.633	818.174	.000
	Times	230.242	1	230.242	78.845	.001
Error	Looks	1.533	4	.383		
	Times	11.681	4	2.920		

Figure 7.1: Two way ANOVA test for C0 and CI.

7.4.2 Comparision between CI and CII

The result from that comparison shows how the prototype stands in matter of performance comparing to the conventional methods of composing and retrieving messages. It will also show what is the impact on the way the users composing and retrieving messages. However, this comparison is not relevant to the research question, but also it will be subject to later chapters.

In figure 7.2 we can see that there is a significant difference in the measures of the users in various conditions *CI* and *CII* ($p < 0.01$). Considering the results of tables 7.2 and 7.3 it can be said, that the users performed their tasks with much less distraction using the application than using the conventional methods of composing retrieving messages.

Tests of Between-Subjects Effects

Transformed Variable:Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Looks	1320.033	1	1320.033	33.320	.004
	Times	1008.968	1	1008.968	48.282	.002
Error	Looks	158.467	4	39.617		
	Times	83.590	4	20.897		

Figure 7.2: Two way ANOVA testfo for CI and CII.

7.5 Summary

In this chapter have presented the result from the evaluation. In table 7.1 we have results which point relatively how much distraction is allowed by the law for secondary task. Those results are compared with the results from table 7.2 by Two-way ANOVA test and the test have pointed a significant difference in the measures. It is clear that the application achieves less or same amount of attention while is performed on it. The amount of attention also varies per user, however in general the users perform better using the application.

The application was also compared with conventional method of composing and retrieving messages. Two-way ANOVA test was also conducted on the results from the application and the conventional method. The test shows a significant difference, which is not surprising due the amount of interactions. The results from 7.3 show the amount of distraction required for users using their own mobile devices. The users had to perform more interactions while composing, because they had to input each letter of the message, which requires them more time. The retrieving also grabs more attention in the conventional method, while the substitute of this interaction in the application (hearing) achieved better results.

Chapter 8

Discussion

In this chapter are compared the results this project with the results from the related literature in chapter 2.

The results from (LAMBLE et al.) present a significantly larger proportion of the users in 1999, which used a phone in their vehicle 67,7%, than the 1998 sample, 55,8%. Over the two sample periods is shown the decrease in the proportion of drivers that to not own or use a phone (-11.7%). Time spend on the phone while driving was significantly higher in the 1999 sample than the 1998 sample. The younger people generally use mobile phones more than older people in everyday life. The youngest drivers between 15-34 years old use their phones more each day than the older drivers. All 1,521 interviewees in the 1999 sample were asked for their opinion on regulations for mobile phone use while driving. They responded to three opinions:

- There should be no restrictions on phone use while driving (25.2%)
- Hand-held phone should be banned while driving (48.5%)
- All types of phones should be banned while driving (26.5%)

From the result of this paper (LAMBLE et al.) in the interview data is can be seen that the youngest age drivers between 25 and 34 had the hight level of phone usage while driving and corresponding the highest level of experiencing dangerous or risky situations on the road while using their phone. This is expected since these drivers have the lowest amount of driving experience.

From this paper we can see that the usage of mobile phone while driving, significantly increase during the period from 1998 to 1999. Also from the

figure 2.1 we can say that the youngest drivers are the generation who have hight usage of mobile phone. In order to prove the result of this project, I also used younger generation of participants - between 25-30 years old, with proper knowledge to the subject.

From the results of (Tison et al.) we know that the drivers are wiling to spend considerable time not looking to the road, especially the young drivers. From the results of this project we know that the users are spending most time not looking the road while they are composing and retrieving messages manually. One of the aims of this project was to reduce that time. In figure 2.2 the authors of the paper present the perception of safety of the participants - how long a drivers safely keep his or her yeas off the road:

- 26% - 1 second
- 46% - 1-2 seconds
- 19% - 3-4 seconds
- 8% - 5-10 seconds
- 2% - 10+ seconds

The interviews were asked how many seconds they thought a driver could take his/her yeas of the road before driving becomes dangerous. The main reason reported for sending a text message or e-mail while driving is *how important the message or e-mails is*. The other reasons is to *who i am messaging*, *message is personal/social*, *message is work-related* and *need directions/information* . Sending text messages or e-mailing while driving, while less frequent that talking on a cell phone while driving was still quite high. 66% of the interviews said they continue to drive while texting, although sex differences were minimal.

In this project participated young drivers who accordingly to (Tison et al.) are wiling to spend from 3 to 10 second or more before driving becomes dangerous. The time presented for the first condition in which the user use the car's entertainment system and dashboard tools is between 3,84 - 7,29 for the most difficult part of this condition. Users in this project also using the application have spent from 2,57 to 5,05 in total from most difficult part of this condition - composing message. The last condition in which the used have to send and receive message manually only 1 of the participant shown less than 10 second interaction with the mobile phone.

From the results of (Ranney et al.) we know that text messaging requires significantly larger amount of attention comparing with the car's entertainment system. The text messaging was associated with the highest level of distraction potential, ten-digit phone dialing was the second most distracting task and radio tuning had the lower level. The following specific manual and text entry were used in the experiment:

- Radio tuning
- Destination entry by address
- Phone dialing
- Text-messaging

In this project also have been observe similar results . C0Task1 - the users had to change a disk and choose a song, this task was compared to CIITask1, and points similar results as in (Ranney et al.). However, if we compared CITask1 and apply the results to table 2.3 the results from the application probably will stand with lower bars then the other condition from the experiment(Ranney et al.).

(Hosking et al.) have found that retrieving messages also is serious sours of distraction. The amount of time that drivers spend not looking at the road when text messaging was up to 400% greater than recorded in baseline condition. It can be say that the participants spend a significantly greater proportion of time looking inside the vehicle when text messaging during both the retrieving and sending.

In my prototype application alternative method of retrieving messages have been suggested and evaluated. In CITask3 the users had to retrieve message by hearing it. The users spend one eye glance and from 0,80 sec. to 1,13 sec. in total looking away from the road. In CIITask3 the users had to retrieve a message by reading it and they spend from 3 to 12 eye glances and from 2,57 sec. to 8,30 sec. It can be said that hearing message could reduce seriously the distraction from retrieving messages pointed by (Hosking et al.).

In the last paper (Young et al.) the authors investigate what is the different between using a standard mobile phone and touch screen keypad while send and retrieve messages while driving. Paired comparisons conducted for each phone type revealed that, when drivers were writing text messages, mean speed was significantly higher that it was when reading text or when

not text messaging for both numeric keypad phones and touch screen keyboard phones. However the increase in mean speed was greater for those drivers using a numeric keypad phone.

In my project I use touch screen keyboard instead of standard numeric keyboard for the application. For the *condition II* all of the participants use their own phone to be familiar with it and to be more easy for them. Only one of the participant use standard numeric keyboard and the other four used touch screen keyboard. This participant who use a standard numeric phone present highest level of distraction. He needed to look away from the road around 29 times and need 19,34 second to send the message.

Chapter 9

Conclusion

9.1 Research question

This chapter is about how the goal of the project has been achieved, what had to be done differently, what the obstacles were, that this experiment met and what more can b done. But first we have to remind what the goal of the project wast and it is to answer the research question:

"Is it possible to design an application for text messaging that is less distracting than existing text messaging systems and achieves lower or same level of distraction, as a car's entertainment system and dashboard tools? ".

Now it is time to get an answer to this question. Results show that users devote less attention while using the prototype application for composing and retrieving messages than using conventional methods. This means that this alternative way serves that purpose. However, it is more important whether the suggested method of composing/retrieving messages can fit the legal norms of distraction. In other words the application must achieve similar or less amount of distraction than the car's entertainment system and dashboard tools.

For this purpose the prototype application was compared with car's entertainment system and dashboard tools. The results have shown that users spend significantly less amount of attention by using the prototype application than some of the allowed in car equipment during driving, for example to be more specific the heating system and the entertainment system. Therefore the car's entertainment system and dashboard tools have been taken for legal and their usage for legal secondary tasks while driving. To compare

the interaction with the tools mentioned above simple tasks that require the same amount of interaction (touches) as to compose, send and retrieve message with the application, were performed on mock-up. The results show that the application can achieved similar or lower amount of attention.

9.2 Limitations

In this section, it is discussed what could be done differently in this project.The most important point of the recommendations were presented, however there were some obstacles, which couldn't be removed and had to be solved in other ways.

The number of participants had to be higher than what was used in the experiment. This way the results would be much more convincing. Another obstacle was that the users had to represent different social groups - young and old drivers, business people, students and etc. However, that would require much more participants to be recruited, which was a problem for the experiment. Therefore, the group was relatively small and contained participants a close social group (students, newly graduated young drivers). The point of the experiment was to investigate the differences in the amount of attention required for using the prototype application, car's entertainment system and dashboard tools, and the conventional methods of composing/retrieving messages.

The prototype application wasn't built to its full extend. Some of the functionality couldn't be acquired because of the limitations of the building tools. The application couldn't take control over phone and call states, because permission could not be granted to modify and monitor those states in Android 2.2+. This restriction was made by Google in order to prevent the build of harmful software. Therefore, the application's reaction to events as incoming call or message have been faked and manually invoked during the evaluation.

The measures that have been taken, are not sharp but relatively accurate. This is because they have been taken manually while reviewing the records of the evaluation. This is due to the lack of an eye-tracking system that could serve this purpose.

The simulated conditions couldn't contain the perfect scenario that the evaluation must have - different routes for each tasks and etc. Also, the built simulator was not sophisticated enough to bring real life driving experience, but it was close enough to serve the purpose of the experiment. Measures such as deviation from the lane, change of speed and others weren't recorded,

because it was hard for the users to handle the simulation at the first place. Therefore, they were asked just to keep speed limit and follow the road without crashes.

The prototype application doesn't contain graphical features with great design - beautiful colors, shades, shapes and etc. The reason for that is the aim of the design - the interface must be simple enough, comfortable to use, fast to learn and with no enormous and complicated to understand functionality.

9.3 Future work

In order for the suggested method for composing and retrieving messages to have a more valid statement for requesting legitimize from the law it needs to provide evidence for that. Therefore the application must be developed to its full extend with the design suggested by this project. This means that the application must be able to take control of phone states and also have adjustable functionality as suggested in (Mincheva) - be able to restrict incoming messages in different occasions and etc. This design must also be evaluated perhaps with similar methods as in this project and then improve in the future (graphically and functionality) according the results. After such improvements and a more realistic evaluation - the future application could be tested in a real car on specifically designed track for the future evaluation and participants from different social groups. This way the future evaluation could provide solid evidence for requesting a place in the legal boundaries and perhaps share the faith of accessories such as "Handsfree". It also better if we take more deep measures with eye glance detection tools.

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