

EXPLORING HARDWARE USABILITY ON MOBILE PHONES

A mobile phone concept for an expanded demographic, including users with high demands on usability

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Preface

This is a Master's Thesis in Mechanical Engineering with Industrial Design at Lund's Institute of Technology. The thesis was conducted in collaboration with Sony Ericsson in Lund.

This project has been very interesting, fun and challenging. A lot of new insights have been reached, and a lot of experience has been gained in many fields including usability testing, interviews and rapid prototyping. This thesis has expanded our way of looking at product design and the design process, and we are very satisfied with the results.

We would like to thank everyone that's been involved in this project including all test participants, for putting up with hours of testing and answering questionnaires.

We especially want to thank Mattias Wallergård, our mentor at LTH, and Andreas Espinoza and Sally White, Senior Usability Analysts at Sony Ericsson for helping us develop this thesis and providing feedback and assistance throughout this project.

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Lund, March 15, 2010

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Abstract

This is a Master's Thesis in Mechanical Engineering with Industrial Design at Lund's Institute of Technology. The thesis is conducted in collaboration with Sony Ericsson in Lund.

Title: Exploring hardware usability on mobile phones - *A mobile phone concept for an expanded demographic, including users with high demands on usability*

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The purpose of this thesis was to investigate hardware usability issues on modern mobile phones, in order to form design guidelines and eventually a concept design proposal focusing on high usability. The project had a *Universal Design* focus, and the goal was to design a concept that fits as many users as possible.

Initially a market analysis was performed in order to find out what phones focusing on usability are available on the marketplace. It was clear that most of these phones were cheap versions of high-end phones, or lacked important functionality like quality displays, camera or MMS and often lacked appealing aesthetics and style. These phones are suitable for senior users with low demands on functionality. There is a gap between these phones and high-end phones, and no phones were available for users wanting a functional, aesthetically appealing, quality mobile phone with modern features, however still easy to use.

A large number of phones, of different format, style and price were borrowed from Sony Ericsson. These were reviewed in order to establish different problem areas like size, clarity, grip etc. Also, expertise from industrial designers and cognition researchers was brought in to establish what possible problems users can have with the phones.

The next step was to test the phones on users, and usability test sessions were held with users of different age. These sessions confirmed or denied the issues found earlier, but also brought light on new problems and issues.

In order to concretize the findings, a set of guidelines was established. These were based on the initial reviews and the usability tests, and operated as a function analysis in the project.

Using the guidelines as a foundation, several design ideas were discussed in order to solve the usability issues. Eventually, three design concepts were developed. These concepts were evaluated both according to the guidelines, but also through a concept test, similar to the usability tests.

At last, a final design concept was developed and presented through computer visualization (3D renderings) and a physical design prototype.

Keywords: *Usability, mobile phones, concept development, universal design, functionality*

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1 Background

This thesis' topic concerns the usability on modern mobile phones and how mobile phones are being used by different groups of users.

The usability of modern mobile phones is often questionable, and it is not always clear how the phones are supposed to be used. Especially for older users, or users not used to mobile phones, this can create problems. This chapter presents the thesis' background.

1.1 DIFFICULTIES AND CHALLENGES

Depending on age, situation, surrounding conditions and the individual, there are a number of challenges and difficulties that may occur when using mobile phones today.

It is common knowledge that age brings deterioration in eye-sight, known as presbyopia. The lens of the eye stiffens, making it harder to focus on nearby objects. It has a negative impact on performing both work and everyday tasks, as stated in recent research by Philip Morgan, University of Manchester [1].

These aging effects appear already at the age of forty. By the age of fifty almost everyone require some form of correction (glasses or contact lenses). Besides the loss of ability to focus, the amount of light needed increases. For instance, a 60-year-old requires twice the amount of light as a 40-year-old in order to experience or perceive the same luminous contrast [2].

Studies show that 60% of users over forty find it difficult to use modern mobile phones [1]. In particular reading and writing messages have been proven difficult.

Fine motor skills, or dexterity, may decline with age. This will make it harder for some to operate small devices such as mobile phones, both in terms of pushing buttons and holding the phone in a comfortable way. In combination with a decline in eye-sight this can cause serious difficulties in operating these devices for older users.

As well as the above physical challenges, many users face problem with understanding and learning new technology [3]. Today's seniors have not faced new technology such as computers and mobile phones early in their lives, and may therefore have difficulties using mobile phones to the full extent. Many of today's phones are advanced and it's hard to form a mental model of its operation. Too much technology will cause a barrier that the users have to overcome. Lack of experience cause a lack of confidence in using technology, and they may have a negative attitude before even trying.

All these factors form a challenge for developers of mobile phones. Some companies have tried but still have a long way to go.

1.2 CURRENT MOBILE PHONE MARKETPLACE

Today's mobile phone market is extremely tough. Brands are launching new models constantly, increasing performance and adding functions. However, this technology development has a downside. The phones are often aimed at young and advanced users, and the usability is often compromised.

Almost all mobile phone producers offer low-end phones for users with low demands on features, focusing on basic functions such as calling and messaging. However, these phones give the impression of not being as thoroughly developed as the mid- or high-end models, regarding design and user needs. The models offered are often stripped down versions of more expensive models, or older high-end models repackaged with a new name and styling (much like in the automotive industry where e.g. Skoda models often are cheaper versions of Volkswagen models). These models are popular and re-occurring on top sales lists. They are affordable and contain the basic functions wanted by the target group, but often fail on usability factors (e.g. screen and button size).

Some product lines (see figure 1.1, 1.2) have been introduced in the last few years focusing on usability. Doro has launched a number of phones [4] in the “PhoneEasy” series designed by the design company Ergonomidesign. Their line of phones has received awards for their user friendly approach. However, they are marketed as care-products aimed at seniors and users with functional disorders. They have an interesting concept, but the products give the impression of being an aid, and not a mass-market product.

Nokia has reached some success with their *classic* [5] line of phones, although not focusing on usability, but more on a clean and classic design. Some of the models are being marketed as being “user friendly”, but it’s not the main selling point. Also, Emporia Care [6] has reached some success with their “Life Plus” phone, with a large resemblance to Doro’s approach. Binatone is a new player on the market, offering phones with focus on usability [7].



Figure 1.1 Example of phones marketed as user friendly



Figure 1.2 Example of phones marketed as user friendly

There is a gap in the marketplace, for phones being intuitive, well designed and functional yet easy to use. Even though demands on usability increase, this doesn't necessarily entail a decrease in demands on functionality, design, image and aesthetics. These users are often forced to settle with a product that will only partially fulfill their needs.



Figure 1.3 Opening on the marketplace

1.3 PURPOSE

The purpose of this thesis was to investigate hardware usability issues on modern mobile phones, in order to form design guidelines and a concept design proposal focusing on high usability. The project had a *Universal Design* focus, and the goal was to design a concept that fits as many users as possible.

1.4 TARGET DEMOGRAPHIC

The mindset of this thesis was that usability and simplicity does not have to interfere with aesthetics or functionality. A phone with high usability can be useful both for users with physical and/or cognitive limitations as well as for common users that want a simple, easy-to-use mobile phone without compromising on style. Therefore, instead of thinking in terms of target demographics, the term *Universal Design* (i.e. "design for all") was used, where designing for the extremes makes the product easy to use for all users. The principles of Universal Design are established by The Center of Universal Design [8] and are described in section 2.2.

1.5 LIMITATIONS

The project spanned over 20 weeks, and therefore its extent had to be limited.

- On mobile phones, hardware and software interaction are often closely connected. However, the project's main focus will be on *hardware usability*, i.e. the industrial design of the physical phone.
- A large part of the project consisted of the usability testing. In order to make this process possible, the extent of the testing couldn't be too large. The equipment provided by LTH and Sony Ericsson was used. The tested users were those who were available at the time for the research, e.g. friends, acquaintances and colleagues (not connected to the project or human factors).
- The design concept should not be a fantasy project but rather something feasible without advanced technology development.
- The design process had an *industrial design* character, rather than being a mechanical engineering project. Engineering factors were taken under consideration but not developed in detail.

1.5 SHORT INTRODUCTION TO SONY ERICSSON

Sony Ericsson is a joint venture owned equally by Sony Corporation and Telefonaktiebolaget LM Ericsson and was established in October 2001 [9]. The company's vision is to be the leading brand in *communication entertainment*. The company's main selling points are design and user experience.

A large part of the company's product development is located in Lund, Sweden and during this thesis, Sony Ericsson assisted with support, advice and resources for product development, mainly from the Sony Ericsson Experience Lab (SEEL).

2 Theoretical framework

Different theories were employed during the project, including usability testing, Universal Design, design methodology and different design principles. The chosen principles, including the mindsets of Donald Norman and Dieter Rams, are suitable for the project's design approach.

2.1 USABILITY

Usability is a term that describes how well a product, software and/or hardware, is designed in terms of usage and interaction between user and product. Usability can be defined as:

"The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." – ISO 9241-11.

Usability is a broad concept and in order to properly investigate usability issues a more concrete description is needed. Usability is often divided into smaller sub-terms [10]:

- *Relevance - is how well a system serves the users' needs.*
- *Efficiency - states how efficiently the users can carry out their tasks using the system.*
- *Attitude - is the users' subjective feelings towards the system.*
- *Learnability - is how easy the system is to learn initially and how well the users remember the skills over time*

Depending on the product and situation, these sub-terms are of different weight, but all four are important in order to define a well-designed product.

2.2 UNIVERSAL DESIGN

Universal Design [8] is a new approach (or philosophy) to designing and developing new products. Its focus lies on making products that can be used by everyone while simultaneously maintaining functionality and aesthetic values.

The following seven principles constitute the main guidelines of Universal Design.

Principle one: Equitable Use

The design should be appealing to all users by making allowances for use by different people with different abilities and physical attributes. It shall provide equal means of use whenever possible or provide an equivalent alternative. By doing this, segregation among users can be avoided.

Principle two: Flexibility in Use

The design should be flexible in order to accommodate different methods of using the product. The differences in accuracy, precision and speed among different users must be taken into consideration.

Principle three: Simple and Intuitive Use

The user's experience, knowledge, language skills and concentration level shall not affect the user's ability to understand the device. This can be done by minimizing or eliminating unnecessary complexity and by being consistent with user expectations and intuition.

By arranging information in relation to its importance and by providing proper feedback during use, it's possible to assist or facilitate the user's intuition.

It is also important to accommodate a wide range of literacy and language skills.

Principle four: Perceptible Information

It is necessary to communicate important information to the user. This has to be possible in different surroundings with different surrounding conditions and take different user's sensory abilities into account.

This can be enabled by using different modes (pictorial, verbal, tactile) for the presentation of information and by facilitating compatibility and interface possibilities with external devices.

Principle five: Tolerance for Error

Hazards and errors and their consequences can be minimized by arranging elements (most used, most accessible, etc.) and by providing proper warning. For the same reason, the design or product should incorporate fail safe features and make it possible to redeem any errors afterwards.

Principle six: Low Physical Effort

Usage shall be efficient and comfortable. The user shall be allowed to remain in a neutral body position as much as possible. Operating the product shall be done by using appropriate force and using a minimum of repetitive actions.

Principle seven: Size and Space for Approach and Use

Appropriate size and space shall be provided to accommodate different user's body size, posture, and mobility. Both seated and standing users need a clear line of sight to important elements and to comfortably reach all components. The design also has to take variations in hand and grip size into account and provide adequate space for the use of assistive devices or personal assistance.

2.3 USABILITY TESTING

Usability testing is used to evaluate a product or concept by testing it on users. The goal is to identify problems and challenges that occur during use. The intent is to ensure that the product is easy to learn and to use, satisfying to use and provides functionality valued by the target demographic. Usability testing is beneficial in many ways, reducing service costs and minimizing risks, and of course adding competitive value to the final product. However, testing is always an artificial solution; testing in a lab is a simulation of a possible user scenario. It is also hard for the participants to fully represent the target demographic. Despite this, usability testing is an important indicator of problems and challenges.

Jeffrey Rubin [11] presents three different types of tests; exploratory, assessment and validation tests. The exploratory test is conducted early in a product development cycle, and is used to examine and explore preliminary design concepts. The concept design can be a mockup or a product simulation that represents its basic layout and functions.

The assessment test takes place a little bit longer into the development cycle, and should be executed with a working prototype in order to examine and evaluate how effectively the concept has been implemented.

The validation test is performed in order to certify the product's usability, and takes place much closer to the release of the product. The participants are given tasks to perform with very little or no interaction with a test monitor.

Rubin presents "Six stages of conducting a test" using the same methodology for all of the three types of test.

The first step is to develop the test plan. The test plan addresses the "how, when, where, who, why, and what" of the usability test. It serves as a communication tool among the test monitors and the development team. It also describes what resources are needed to perform the testing. The test plan should contain several sections, including purpose (the reason for performing the test), problem statement (describes the issues and questions that need to be resolved), user profile (describing the end users of the product), method/test design (providing an overview of how the test will be performed), task list (describing the tasks that the participants should perform during the test), test environment and equipment, test monitor role and evaluation measures (describing what data to be collected).

Step two is to select and acquire participants. The user profile or user characterization of the target demographic should be established in the early stages of the product development process. How to acquire people from the target population effectively depends on constraints of time, money, resources etc. The user profile should contain information about age, skills, education, experience etc. The number of participants in a test depends on several aspects, such as the duration of the test and if the results need to be statistically valid. However, four or five participants are enough to expose the majority of usability problems in the shortest amount of time.

The third step is to prepare the test materials. These are used to communicate with the participants, collect data etc. The materials can include questionnaires, data loggers, task scenarios etc. An orientation script can be used to describe what will happen during the test session. It's important to make the participants feel at ease. The tone of the script should be professional but friendly.

The data collected during the test can be put into two major categories; performance data (objective measures of behavior) and preference data (subjective data, feelings or opinions). Data can be logged automatically (keyloggers), manually (by observers using data collection forms) or by the participant (self-reporting).

The fourth step is the actual conducting of the test. The test should have been taken by the developers to make sure everything is in order, the equipment should be checked before the test (video cameras etc.) and on the day of the test the monitors should prepare themselves mentally in order for the test to be conducted correctly. Allowing the participants to think aloud while conducting the test is a simple technique to capture what the participant is thinking of while working. It's important for the monitor to be sure of when to assist and when to let the participant struggle. The participants should never be blamed for anything that goes wrong, "mistakes are always the fault of the product".

The fifth step is the debriefing with the participants. This session is the last opportunity to understand the errors and/or difficulties that occurred during the conduction of the test. By observing the test, the problems with usability are exposed, but it is not until the debriefing full understanding of why the problems occurred can be reached. The debriefing session can be performed by analyzing post-test questionnaires and interviewing the participants, exposing both

high-level issues and more specific issues. The main focus is on understanding problems and difficulties rather than problem solving.

The last step of the usability testing is to transform the data into findings and recommendations. Rubin's method suggests a preliminary analysis to find the "hot spots", the worst problems, for the designers to work on immediately. A final report with more details on the findings should be presented later. Performance data (mean time for completing each task etc.) and preference data (such as grouping similar answers into categories) will be summarized along with other measures. This data will be analyzed to identify all the user errors and difficulties, and then used to establish a final report with recommendations for the development team.

2.4 DESIGN METHODOLOGY

Basic design methodology [12] is taught at The School of Industrial Design at LTH. The design methodology includes:

- Formulating a brief and establishing the desired results.
- Function analysis
- Gather inspiration (mood/image boards)
- Research
- Idea generation
- Evaluation of ideas in relation to the function analysis
- Concept development

This method offers a flexible workflow and is suitable for industrial design projects.

2.5 EXPERT EVALUATION

Relevant expertise can be consulted in a design project, in order to gain additional knowledge, new insights and different perspectives.

2.6 DESIGN PRINCIPLES

2.6.1 Gestalt Laws

The Gestalt Laws, or "*prägnanz*", originate from Gestalt psychology and deals with how the mind visually recognizes and organizes smaller elements into figures and patterns. These laws can be used in design in order to aid communication between user and product [13].

- *Law of Closure* — The mind may experience elements it does not perceive through sensation, in order to complete a regular figure (that is, to increase regularity).
- *Law of Similarity* — The mind groups similar elements into collective entities or totalities. This similarity might depend on relationships of form, color, size, or brightness.
- *Law of Proximity* — Spatial or temporal proximity of elements may induce the mind to perceive a collective or totality.
- *Law of Symmetry (Figure ground relationships)*— Symmetrical images are perceived collectively, even in spite of distance.
- *Law of Continuity* — The mind continues visual, auditory, and kinetic patterns.
- *Law of Common Fate* — Elements with the same moving direction are perceived as a collective or unit.

2.6.2 Donald Norman

Donald Norman, a professor of cognitive science, has written numerous books, including *The Design of Everyday Things* [14], on usability and user centered design. In his books he connects what he sees as good and bad design to the underlying psychology and cognition.

User centered design, according to Norman, is about the needs of the user. He has established a series of guidelines (involving mapping, visibility, constraints etc.) to fulfill these needs [15].

1. **Visibility** – *The more visible functions are, the more likely users will be able to know what to do next. In contrast, when functions are “out of sight,” it makes them more difficult to find and know how to use.*
2. **Feedback** – *Feedback is about sending back information about what action has been done and what has been accomplished, allowing the person to continue with the activity. Various kinds of feedback are available for interaction design: audio, tactile, verbal, and combinations of these.*
3. **Constraints** – *The design concept of constraining refers to determining ways of restricting the kind of user interaction that can take place at a given moment. There are various ways this can be achieved.*
4. **Mapping** – *This refers to the relationship between controls and their effects in the world. Nearly all artifacts need some kind of mapping between controls and effects, whether it is a flashlight, car, power plant, or cockpit. An example of a good mapping between control and effect is the up and down arrows used to represent the up and down movement of the cursor, respectively, on a computer keyboard.*
5. **Consistency** – *This refers to designing interfaces to have similar operations and use similar elements for achieving similar tasks. In particular, a consistent interface is one that follows rules, such as using the same operation to select all objects. For example, a consistent operation is using the same input action to highlight any graphical object at the interface, such as always clicking the left mouse button. Inconsistent interfaces, on the other hand, allow exceptions to a rule.*
6. **Affordance** – *is a term used to refer to an attribute of an object that allows people to know how to use it. For example, a mouse button invites pushing by the way it is physically constrained in its plastic shell. At a very simple level, to afford means “to give a clue” (Norman, 1988). When the affordances of a physical object are perceptually obvious it is easy to know how to interact with it.*

2.6.3 Dieter Rams' Ten Commandments

Dieter Rams is one of the most influential industrial designers of the twentieth century. He started working with consumer electronics and products at Braun in the 1950s, and later on became chief of design, a position he held for over thirty years. Many of his designs are today considered icons and collector's items, and are often found at museums and exhibitions.

Rams' designs are often recognized by simplicity, functionality and minimalism (by today's measures). During his career, he formulated ten design guidelines [16], defining his view on "good design". They are often referred to as *Dieter Rams' Ten Commandments*. We considered Rams' mindset and principles to be very suitable when designing with usability in mind.

The Ten Commandments

- Good design is innovative
- Good design makes a product useful
- Good design is aesthetic
- Good design makes a product understandable
- Good design is unobtrusive
- Good design is honest
- Good design is long-lasting
- Good design is consequent to the last detail
- Good design is environmentally-friendly
- Good design is as little design as possible

3 Method

This chapter describes how the chosen theories and mindsets from chapter two are implemented in the project. Also, the workflow for the project is presented. The project's process begins with different test sessions, which are analyzed and used to form design guidelines and a design concept.

3.1 WORKFLOW

The workflow for this project is presented below:

1. Theory studies and background research
2. Initial testing
3. Expert evaluation
4. Pilot testing
5. Usability testing
6. Establishing Guidelines
7. Concept development (*including concept usability testing*)



Figure 3.1 Workflow

3.2 USABILITY TESTING

The usability testing was used to analyze the hardware usability of the mobile phones. Hardware usability includes factors such as grip and size, button design and layout as well as cognition and user experience.

The first usability tests performed were validation tests of existing mobile phones. The conducting of the test was performed with a number of different phones, with different attributes and physical format. By doing this, important data could be collected and used to establish an understanding of advantages and disadvantages with the different types of phones.

Smaller details of the phones were also studied. The size, shape, feel and placement of the buttons are some of the most important factors of mobile phone usability.

It was also important to establish an understanding of the synergy between aesthetics/style and usability/functions. It's important that the phone conveys an appropriate style and attitude towards the specific demographic. Therefore, the first impression of the phones was also tested, in order to understand what the users look for when choosing a new phone. It is important to combine an appealing style with usability, since when buying phones, usability cannot be tested extensively, and the decision to buy is often based on images and brief contact. Therefore, the first impression regarding looks are of large relevance.

The tests were conducted at the usability lab at IKDC, Lund Institute of Technology during October 2009. The participants covered most of the potential users, ranging from 25 to 65 years of age. The

number of participants depends on the length and extent of the test. For the shorter pilot test (see chapter 6) 10 participants were tested, and for the longer, more extensive usability test (chapter 7), 8 users were tested.

The tests consisted of a number of basic tasks like turning the phone on and typing a text message. Every task was monitored and notes of certain behaviors, as well as typing performance were taken. After and during the performing of the tasks, a number of questions were given to the testers (e.g. how easy/intuitive the task was, main problems etc.).

3.3 EXPERT EVALUATION

During the master thesis project, input and feedback was received from our mentor at Lunds Institute of Technology, Mattias Wallergård. In addition we had help from Andreas Espinoza and Sally White, senior usability analysts at Sony Ericsson.

Also, the opportunity to consult other staff at the Department of Design Sciences was used. Interviews with various experts at LTH were performed in order to get a broader perspective on the different usability and design issues.

3.4 FORMING GUIDELINES AND CONCEPT DEVELOPMENT

The information from the usability testing was analyzed and used to define the problems and challenges that occur during use of mobile phones. These findings were the basis for developing design guidelines. Based on these guidelines, a concept design was developed, visualizing the findings. During the design process further usability testing of concept prototypes was performed to enhance the concept.

This design process differed from the basic design methodology. The usability testing was a large part of the research, and the established guidelines worked as a function analysis. Also, the project objective was specified very clearly in the beginning of the process, and therefore, no brief was established.

In addition, the knowledge and skills acquired in the fields of semiotics, aesthetics, ergonomics and product innovation was applied during this project.

4 Initial testing

Upon receiving a number of mobile phones from Sony Ericsson (fig 4.1), some initial basic reviews were made in order to establish an understanding of difficulties and design problems.



Figure 4.1 Workflow

4.1 BASIC HARDWARE USABILITY REVIEW

4.1.1 Method

By studying the phones (16 different, non-smartphone Sony Ericsson flip, slide or stick phones, see 4.1.4) we've discussed and taken notes on first impressions regarding look & feel and perceived complexity, in order to establish an understanding of what issues were relevant in the upcoming usability testing and expert evaluation.

Specific terms for the different parts of the keyset and buttons are used in this review (and later on in this thesis). These terms are:



Figure 4.2 Button layout terminology

4.1.2 Usability impression

Usability impression is a term used by us, describing a user's first impression of a mobile phone from a usability perspective. This covers colors, design attributes, keyset layout and other features that make the phone seem easy or hard to use, i.e. how the user perceives the phone's usability.

When a user is choosing a phone in a store setting, only a brief look is offered (and sometimes a quick hands-on). Based on this brief look, the user forms an opinion about the phone's different qualities. However, this brief look does not always reflect the phone's usability in the long term.

A mobile phone with focus on usability has to convey an appropriate feel, and the *usability impression* should match the actual usability.



Figure 4.3 Phones discussed in this chapter

4.1.3 Look & feel

By just looking at a phone, ideas will arise on its usability: *"Does it look easy to use?"*. The initial observations show that the usability impression does not often coincide with the actual usability. For instance, the *Yari* is shiny and has no symbols, and radiates complexity, but is actually quite good in terms of usability – it's large, comfortable to hold and some of the main buttons are really large (in fact, the best navigation buttons of all the phones tested).

In opposite, the T707 conveys a quite user-friendly design. When opening the flip phone, the buttons are big and the button area is roomy. However, the navigation keys are inadequate with poor feedback (which may be due to this item being an early prototype), and poor symbols. The main navigation key does not convey the fact that it is a physical button (it more resembles a touchwheel iPod style), neither do the answer/reject or soft keys.

These are two reversed examples of the importance of the usability impression. For an uninformed consumer introduced to these products for the first time, the T707 will probably look like a better choice than the Yari. Your first, short impression will decide what phone you'll use for a long time.

Therefore, it is very important to communicate the correct level of usability with the design of the phone.

4.1.4 Format

Three types of phones were tested: *Flip phones* (that unfolds upwards), *slide phones* (the screen and the upper keyset is slided upwards to reveal the numpad) and ordinary "*stick phones*". The main issues for each format are presented below;

Flip phones (figure 4.4): Often demands a two-hand grip to open it. The proportions between width and thickness are often a bit "off", since the phone has to be quite thin when folded. Also, the distance between the screen and the soft keys is too long. The hinge creates a depth dislocation, creating an extended mapping problem. The space for the navigation buttons is often poorly managed.



Figure 4.4 Flip phone

The fact that the screen is not folded up 180 degrees, but forms an angle between the two parts (keypad & screen) makes it more comfortable to look at the screen while typing on the keypad.

Another asset of the format is that the screen can be large which enables the possibility to use large numbers and letters on the screen, as well as icons and symbols.

Another asset is that no "lock keypad"-feature is needed since no buttons can be reached when the phone is folded. The "lock keypad"-feature can be circumstantial for some users not used to mobile phones.

Slide phones (figure 4.5): The slide phones can be quite top-heavy when "un-slided", and when using the lower keys (7 8 9 and * 0 #) the phone tends to wobble in your hand, since the grip is very loose and the center of gravity is quite highly placed. The most prominent example of this problem occurs on the Aino phone, due to its large screen making the phone both heavy and long.

When holding an expensive phone in your hand, you don't want to compromise your grip in order to reach the lower buttons with your thumb.



Figure 4.5 Slide phone (closed and opened)

On most slide phones, only the numpad is hidden and the navigation keys are visible when the phone is closed. Since the numpad is placed underneath (depth wise) the navigation keys, you have to lift your thumb when pressing the navigation keys. On a stick phone where all keys are on the same level, you can just slide your thumb around over the keypad.

Another issue is the actual sliding mechanism. The maneuver is not always intuitive, and the visual guides for the function are often questionable.

The assets of the format, is that it enables a lot of space to place buttons and a larger screen, while still being compact when closed. Also, the keypad unlocks when sliding the phone up, eliminating the problems with unlocking the keys "manually".

In opposite to the flip phones, the proportions on the two parts can be distributed better. The screen-part can be thin, making the lower part (which is the main gripping area) thicker, thus offering a more stable grip.

Stick phones (figure 4.6): The main disadvantage of the stick phone format is the total space for placing screen and buttons. The flip and slide phones offer multiple surfaces for distribution of features, while the stick format forces all elements to share the same space. With the demand of a slim, neat phone design, this causes a problem to fit both screen and usable keys. Most of the stick phones are compromises, either with a large screen and small buttons, or bigger buttons but with a smaller screen. Today's trend with large displays (for watching video etc.) forces the buttons to be small and squeezed together and creates issues with the usability.

Another issue is the key-lock. There is no mechanical limitation in using the keys (as on the flip/slide formats), preventing the users from accidentally pressing the buttons. Therefore, you are limited to a non-intuitive software solution where you have to perform a button combination or hold down a certain button for a period of time. This is an artificial solution that has to be learned.



Figure 4.6 Stick phone

The most prominent asset of this format is that all features are instantly available. There is no need for a mechanical operation to start using the phone. Since all features are presented on the front side of the phone, you instantly get at grip of the mode of operation. This is also the format that most resembles a traditional plug-in phone – making it easy for new users to understand what it is. However, putting all features available on the front side can cause a cluttered impression which affects the usability impression.

4.1.5 The importance of the on/off-button

Of the 16 Sony Ericsson phones tested, we noticed that the on/off-button was placed or designed differently on almost all phones (figure 4.7). We feel that this is a problem, since it's creating an illogical inconsistency among the phones. If you use a phone, and switch to a new one of the same brand, you'd expect the basic function of starting the phone to be the same on both models – This is regrettably not the case.



Figure 4.7 Variations of the on/off button

Some phones have the on/off-button placed on top of the phone – but it is often small and not very easy to find. Some had the “reject call”-button operating as an on/off-switch when being held down for a few seconds. This is not intuitive, and the symbol is often discrete and “hidden”, making it hard to find the on/off function. Multiple functions on one button can create confusion and accidental use. These ways of turning the phone on were most frequent on the slide and stick

phones – but with no consistency within the phone types. Most of the flip phones often had the on/off-button placed beneath the numpad, only being available when the phone is open.

4.1.6 Upper keyset (navigation keys etc)

These are the most used buttons on the phones. They are used for navigation through the menus, phonebook, to answer/reject calls etc. Our first feeling is that the upper keyset sometimes is a bit “over designed” – focusing more on a stylish design (and *Walkman*¹ functionality) rather than on the actual telephone operations. This creates a number of different problems;

- The rocker key (often designed as a circular four way key with a center button) is often quite small. The area for the key on the phone surface is often limited, but the button could in most cases be larger or have a different design to better match the space limitation.
- Another problem with the rocker key is the design of the circular button. It is often (sometimes due to lack of space) designed to be pushed down on the edge instead of the actual button. This creates a cognitive problem, “where should the button be pressed?”. There is often a lack of indicators of where to push and sometimes, you cannot tell if it actually is a button. Also, it is not very comfortable to push the edge of the button.
- The answer/reject call buttons are often small and not very prominent – especially in relation to the importance of the actual *phone* functionality. They are often squeezed in between two other keys, and on some phones it’s hard to press without touching the other nearby buttons. Some designs do not have a dedicated answer/reject button – instead relying on the software mapping. Why is this not standardized on all models, creating a consistency within the brand?
- In general, the total upper keyset (figure 4.8, often consisting of eleven different buttons on a small area – the four way navigation key with its center button, and three buttons on each side) is squeezed together, making it difficult to aim, feel and press a single button without interfering with the others, especially if your fingers are a bit thick.



Figure 4.8 Examples of typically small rocker and soft keys

- On the flip phones, the buttons are often quite flat – making it difficult to feel where to push. On the upside, the flip phones often had larger buttons (due to a larger keyset surface).

¹ Walkman is a trademark used for Sony’s and Sony Ericsson’s music and media players

4.1.7 Lower keyset (numpad)

The lower keyset consists of the ten number keys (1-9, 0) and two additional keys (*, #). A number of issues were discovered.

- **Size:** Of course, the size of the buttons is of large importance. It decides how easy a button is to see (symbols and numbers can be larger on a large button) but also how easy it is to press the button without interfering with other buttons.
- **Feel (a):** Some phones have a large, flat surface with poorly defined buttons. This creates a tactile problem – It can be hard to feel the position of the button, and to find the transition between the different buttons, or to the surrounding surfaces.
- **Feel (b):** The feedback of the buttons is of large importance. It has to be comfortable to press the buttons, and there should be no uncertainties regarding if a button actually has been pushed. The resistance should not be too high, but neither too low. Some of the phones had quite a “mushy” feel – with no distinct click or proper feedback.
- **Space:** Spacing, both between buttons in order to distinguish them, and around the keyset (edge space), is of large importance. Obviously, a lot of space between the buttons will make them easier to push. The space around the keypad however, is also very important. Especially, the space below the keyset has to be sufficient. When using the lower keys, your grip will be compromised, and if there’s little or no space beneath the keyset, it’s hard to retain a one hand grip. On slide phones, it’s important to have enough space above the lower keyset, so that the upper part of the phone (with display and upper keyset) does not interfere with your thumb movement.
- **Symbols:** Too many, small, squeezed in symbols on one single button can create a quite cluttered impression. Numbers and symbols have to be large and distinct, in order to make the buttons easy to read and find, but also to improve the usability impression.

4.1.8 Size and grip

In general, the size of the phone is of large importance regarding usability. It affects both the layout of the features and the ability to grip the phone. As mentioned above, the different formats offer different form factors. The flip phones are in general quite thin when opened, making them uncomfortable to hold. The relation between width and thickness has to be considered in order to make the fingers fit well around the shape.

In general, the slide phones had quite a good form factor – especially on those models that had a thin upper part and a thicker lower part (e.g. Yari, W705). A thinner, lighter upper part also adds to the center of gravity being placed lower, making it easier to retain a stable grip when using the lower keys. However, larger phones like the Aino can be top heavy, as mentioned earlier, due to a large, heavy upper part. This causes a shift in the center of gravity and places it outside of the hand. See illustration below (figure 4.9).

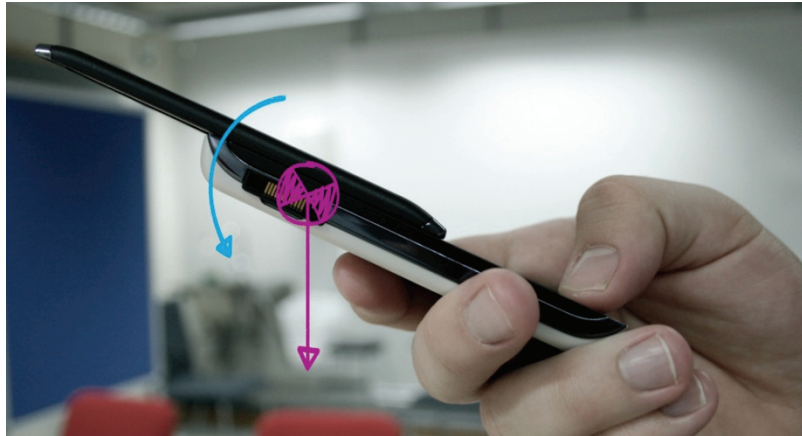


Figure 4.9 Grip of Aino

Also, the choice of material is important regarding the grip. Some newer models have a rubbery, matte finish on the back, making the phone both comfortable and easier to hold. Some design elements, such as a brushed aluminum surface, looks quite rugged but can be slippery instead – causing a conflict between perception and actual properties.

There is a large variation in form of hand- and finger size, dexterity etc. among the users. It is important that the phone accommodates to the user – e.g. being designed for the extreme cases in order to fit all.

A well designed phone in terms of grip and size contributes to the user experience in a positive way. The phone will feel comfortable and focus can be drawn towards the more important factors, such as the phone's actual functionality.

4.1.9 Other keys and features

Additional buttons, features and design elements will affect the ability to grip the phone in a comfortable way. Too many additional features placed on the side of the phone will, except from contributing to a cluttered impression, make the phone uninviting, and establish a risk of pressing buttons accidentally. Some models also have design features such as protruding lines or an oversized lens cover, obstructing a decent grip. These details will also affect the usability impression, making it look more complex than it is.

On some models, the cable connector (which is quite large and not very smooth) is placed where you want to put your fingers, adding to the above discussed problematic.

4.2 CONCLUSION OF INITIAL REVIEW

The tested phones had different qualities and problem areas. Although their general look is quite alike, there are big, unjustified differences in the designs. We felt that the issues discussed above were of relevance for the usability testing. Although, we couldn't know then, what the target users would experience as problems and what not. This preliminary, objective analysis results helped us form plans and task lists for the usability testing.

The issues discussed are of different relevance. Some of the issues affect the usability directly, e.g. button design and layout. Other issues are more important from a comfort point of view, like

placement of camera or charger connector. These “minor” problems can be important from a loyalty point of view when the user is buying a new phone.



Figure 4.10 Overview of the phones tested

5 Expert evaluations

After performing the initial review of the Sony Ericsson mobile phones, we found specific difficulties and problem areas within the phones' usability, as presented previously. In this step of the analysis, the purpose was to extract knowledge and insight from experts in various research areas, in order to gain additional knowledge about the problem areas, and also to validate or discard our initial findings. After this step was conducted and analyzed, the knowledge gained was used when establishing the task list and purpose of the usability testing.



Figure 5.1 Workflow

5.1 METHOD

The evaluation was conducted as an interview and recorded in the usability lab at the Ingvar Kamrad Design Center (IKDC) at LTH to be analyzed afterwards. We set up some general discussion points related to our initial findings, with small modifications between the two different experts.

We chose two experts at IKDC, with different areas of research, but both still connected to the subject of usability in different ways, in order to cover different angles of the problems.

The evaluation began with the expert being introduced to three different phones (stick, slide, flip – C901, W705, W508) with different formats and styles. The expert was asked to express his initial thoughts and first impression when exploring the look and feel of the three phones.

5.2 ARNE SVENSK

5.2.1 Who is Arne Svensk?

Arne Svensk has been a researcher at Certec at IKDC since 1993, after getting his master's degree in electrical engineering. He has extensive experience in working with people with functional and cognitive disabilities, being involved in developing different technical aid solutions.

What we wanted from Svensk was feedback on the mobile phones' usability in terms of understanding, learnability and cognition.

Svensk has limited personal experience with mobile phones. He uses his phone approximately 2-3 times a week.

5.2.2 Svensk's evaluation

Formats and first impression

Svensk's first reaction was that the stick phone was the one with most "phone affordance", all the features were clearly visible on the front and he immediately recognized it as a telephone.

The sleek flip phone with Walkman features on the front was the model that was hardest to approach due to the fact that it lacks obvious phone elements (buttons, screen etc.) when closed. Also, the Walkman functionality is dominating the appearance of the phone when closed, making it hard to identify it as a telephone instead of a media device. Svensk stated that he initially had "no strategy what so ever" on how to approach the device and its phone functionality. Due to his limited experience with mobile phones (e.g. he has never used a flip phone) he did not initially know how to open the phone and reach its functions; he had to guess on how to open it. However, when opened, he could identify the device as a mobile phone when all elements became visible.

When approaching the slide phone, he could identify it as a phone due to its visible screen and navigation keys, as well as the red and green keys for denying and accepting a call. However, he clearly stated that it wasn't as apparent as the stick phone. The main difficulty was to open the phone in order to reveal the alphanumeric keys. Svensk did not know how to approach the mechanism; he wasn't aware of its slide functionality. He tried to bend it open and press different buttons without success. When finally managing to open the slide phone, he was very surprised. He explained that he did not get any clues from the design (index pointing out the functionality) on how to open the phone. The gap between the two parts of the phone gave him some clues, but *dragging* the front upwards was "the least imaginable direction" according to Svensk.

We also showed Svensk the Yari slide phone. Due to its sleek shiny front surface and its design elements concealing the slide mechanism, he suspected a touch screen and could not identify it as a slide phone despite having explored the W705.

Summarizing the results of Svensk's impressions of the different formats, we can conclude that the design and form factors of the phones can make it hard to identify the phone functionality when approaching the phone for the first time. This will affect the usability impression, and when the main functions are hidden, it's very important from a usability standpoint to point out where they can be found (by unfolding or unsliding the phone). This can be done with different design elements, e.g. semiotics.

Turning the phone ON and OFF

The next step was to investigate the on/off-function on the phones. The first attempt was with the flip phone (W508). Svensk initially tried to start it with the center select key, claiming that it was "large and obvious" placed neutrally in the middle of the phone. On the W508, the center-select is very prominent. To start the phone is the first and most important function when approaching the phone for the first time – therefore, Svensk connected this function to the most prominent key – center select.

When exploring the phone, Svensk eventually found the small symbol on the red "reject call" key. Svensk was somewhat upset with this, claiming that the red "reject call" key is a *negative* button, used for rejecting a call. To start the phone with this key creates a cognitive problem. Also, putting the important on/off-functionality as a secondary feature on a button used for something else, can create a problem in learning how to operate the phone.

All three phones had the same method for turning it on and off. Especially on the W705 the symbol was difficult to find (figure 5.2). This is both due to its placement and design, but also due to Svensk's cataract (clouding of the eye's lens due to age). Cataract makes it difficult to handle reflections such as the ones occurring in the shiny detailing on the W705.



Figure 5.2 Example of discrete on/off symbol

Some Sony Ericsson phones have a dedicated on/off-button, often placed on top of the phone. We showed one of these models to Svensk, but he could not find the button – it blended in too well with the design elements on the phone – being almost camouflaged. We had to give Svensk hints on where to look for the button in order for him to be able to find it. Svensk was not pleased with the design and placement of the button, but pointed out that a dedicated start button is important due to its essential function.

Discussing the keyset

We let Svensk use the phone for some small tasks, in order for him to get familiar with the keys. When browsing through the grid menu (which he found very intuitive and elegant), some errors in mapping occurred. Svensk connected the “back” function in the software to the red reject call key, instead of the intended soft key above. When browsing the grid menu, the soft key and the red key has the same result when pressed; they take you back to the main screen. Therefore, Svensk connected the red key to the on screen mapping (intended for the soft key). Svensk's mental model didn't match the actual system, but since his actions worked, he was misled to believe that his model was correct.

To learn a system based on actions is quite easy, but when the system does not work the way you thought, confusion and frustrations will occur. It will be harder to learn the correct system later on. Therefore, it's important to be clear with the mapping and layout of the soft keys and red/green keys.

A problem of a more physical nature is the rocker key design. On many models (e.g. W705), the rocker key is circular with no clear indications of direction. Svensk discussed this issue, asking himself; what happens if I press the button diagonally (e.g. 5 o'clock, 10 o'clock etc.)? There are no indications on the W705 telling you that it's not intended to be pressed in another direction than up, down, left, right.

Another problem brought up by Svensk, especially prominent on the C901 ("Greenheart") but occurring on a lot of models, is that when using the rocker key and the red/green keys, it's difficult to avoid touching and/or pressing the surrounding soft keys and other keys. When putting your thumb on the rocker key you might touch other keys, making it uncomfortable to use. This can cause a fear of pressing surrounding buttons by mistake.

Many models suffer from poor contrast in button design. The C901 is especially troubled by this. Not only are the buttons visually alike (form & color) but also have the same texture and tactility. These factors make it hard to distinguish the buttons from each other, and to read them in general.

Svensk thought that the key lock feature wasn't very intuitive. Although there is a small key symbol on the [*]-button, it is not very clear, and the combination of [*] plus [-] (right soft key) is not logical. Svensk discussed some kind of symmetrical double command in order to lock or unlock the phone, referring to stoves.

5.3 ANDERS WARELL

5.3.1 Who is Anders Warell?

Anders Warell, PhD Engineering & Industrial Design and MSc Mechanical Engineering, is a senior researcher at IKDC. His area of expertise is design methodology and product semiotics with a special interest in consumer products.

What we wanted from Warell was feedback on the mobile phones' look and feel. With his knowledge in semiotics and aesthetics, we hoped to gain some understanding of what the different phone types and styles communicate, i.e. usability impression.

Anders Warell considers himself to be an average mobile phone user, and currently uses a Sony Ericsson W302.

5.3.2 Warell's evaluation

Design impressions

Warell initially stated that the stick is the most traditional one, a conventional phone with all features (screen, buttons) instantly visible. The slide and flip phones are more secret, hiding their functionality and enable more possibilities for aesthetical expression. On the downside, it's hard to decide what to show when closed and what not to, i.e. "how should we interact with the user?".

Discussing style, the flip is according to Warell's own preferences the most attractive one, due to its simplicity and purity. The stick lays all the features out for you directly, while the slide is somewhat in between regarding complexity. "It tries to be more of a phone than the flip". However, the slide's (W705) gold and shiny detailing makes it a bit "kitsch" and pretentious.

The *visual complexity* of the phone will greatly affect the overall expression of the telephone. The flip phone with its pureness tells the user that it's not that hard to handle. Although, with the functions hidden when closed, the design must lead the user into the next step of interaction (unfolding the phone).

The stick phone, with all features available directly, is very clear in communicating its purpose. The downside of this is that it expresses a high level of visual complexity, with the front side being filled to the brim with features.

It is important to find out what we want to convey in the telephone concept design. What should be accentuated when designing “for all”? The level of visual complexity and the up- and downsides of hiding or showing off the elements must be determined in order to reach a design that is good both in terms of usability and style.

Universal Design and target demographic

The flip format has some advantages regarding Universal Design. Warell states that the larger space available for buttons and screens, as well as the format’s balance and grip are very suitable when designing a phone for our intended demographic (although not optimized on this model, W508).

Based on his large experience in industrial design, Warell states that it’s hard to find general preferences within the “mature user” demographic. By looking at their homes and their choice of other consumer products, a lot of different styles will be found. Factors such as background and identity influences what types of products you like or dislike. Your choice of phone depends on who you are, who you want to be and what you want to express. Therefore, there are a lot of factors that needs to be taken into consideration when designing “for all”; the design should be neither extreme nor boring.

Materials

Warell discussed how the selected materials affect the expressions in the three different phones.

The slide phone (W705) with an aluminum front side being cold, technically advanced and quite hard in its expression, although the gold detailing is adding a “kitsch” factor to the expression. However, the back side of the W705 is black with a rubber like surface, enabling a good grip. The back side is soft and a bit organic, creating a different expression on the back side, compared to the steel cold front side.

The stick phone also uses a technically advanced expression in its use of metal-style plastic, trying to convey a high tech material feeling.

The flip phone is also plastic, but with a more modest expression. It does not try to be something it’s not, e.g. faking a metal finish. The material is plainer, making the phone more approachable. With plastic being a “non-pro” material, the expectations on the phone’s complexity will be lowered. Using materials wisely, the usability impression can be affected in a positive way.

Buttons and functionality

Regarding the on/off-method, Warell quite easily finds the on/off-symbol on the red key, being an experienced Sony Ericsson user. However, he questions the placement of the function and buttons with dual functionality. He also finds the symbols to be small and somewhat “hidden” (especially on the W705).

Just like Svensk, Warell claims that this method is something that has to be learned. It can cause problems for users with lack of experience, or experience from other consumer electronic products with different on/off-maneuvers.

The action of turning the phone on (on/off-button) should be visible and obvious when the phone’s turned off. However you don’t want accidental use of the on/off-function. This depends on the chosen design strategy: minimizing the number of buttons (which can have positive effects on

usability) or having designated buttons for the important functions (which creates clarity, but eventually also a cluttered impression).

Discussing the navigation keys, Warell initially talks about the mapping to the screen. The mapping demands some kind of understanding of the system, which not all users have. However, when learned, it's not that difficult to handle. The distance between the screen and the soft keys can be problematic, especially on the flip phone where the hinge demands a certain amount of space.

Also, Warell noted that the button closest to the screen should correspond to the action described, although this is not the case with the center select button (in those cases when it has a corresponding screen action). The center select key is surrounded by the rocker key, and the up-direction on the rocker is the button closest to the screen, and the mapping can create a minor mapping issue.

Warell discussed other methods of interaction and navigation, e.g. suggesting research on a touchscreen-keypad combination or iPod style touchwheel etc.

Just like Svensk stated, Warell thinks that the buttons on the stick phone (C901) blends in to the surrounding materials; they are not well defined in form of texture and materiality. Also, they are visually alike. The slide phone (W705) offers more distinguished buttons, both visually and tactility-wise. Also, the navigation key set follows the screen when the phone is unslided, avoiding the distance problem with mapping that occurs on the flip phone.

The flip phone (W508) has another issue. Between the red/green keys and the buttons below, there is a divider in form of a ridge. This is not a bad thing. However, the soft keys above are almost identical with the ridge in their appearance, creating a cognitive problem; *"Is it a button or not?"*.

Style vs. usability

Again discussing the matter of expression and style, Warell brings up Doro's line of phones for seniors and users with functional disabilities. They have launched a series of phones attempting to focus on usability and users with special needs. These phones are equipped with somewhat exaggerated design features such as oversized buttons. Their image shouts out "aid product", and it's interesting to discuss if the users in need of a phone like this want to be labeled as a person in need of aid. Doro's line of phones, even though they are good for some users, holds a too strong image of being aid products in order to reach a broader market. Also, their phones are not that thoroughly developed and even though their usability impression is good, the actual functionality of the phones can be questioned. Large buttons doesn't necessarily mean high usability.

In opposite, Apple is considered a trendy company, with an image focusing on sleek design and user experience. They are often quite good in terms of usability, and the products seem to show empathy with the user. They have managed to handle this, without being labeled as an "inclusive design" company, maintaining their image.

It's important to give the user a positive experience; everything should work smoothly without forcing the user to study the manual or thinking too much about how stuff works. Details, materials and their transitions etc. has to be well thought-out in order to reach a pleasant experience.

Finally, Warell states that explicit regards to some specific problems (sight, dexterity) combined with good design principles in general, should be “enough” to develop a concept that fulfills the purpose of this project.

5.4 CONCLUSION

There are a lot of factors that has to be taken into consideration when designing a mobile phone for our intended purpose. Both Svensk and Warell gave a lot of interesting feedback on the mobile phones. As well as confirming a lot of our suspicions from the initial review, they gave us new issues to keep in mind when setting up the usability test, and when designing the concept.

Some main points that emerged from these interviews were extracted:

- Functions and functionality should be clear and not hidden
If a function is not instantly apparent – the design should communicate how to access it
- Its important to be consistent in the overall design
Design elements and guidelines should not be mistaken for buttons or other interactive elements.
- Be attentive when establishing inter-button-relationships
Create proper spacing and differentiation between buttons
- Be mindful of contrast when designing the different buttons
Color, texture, elevation and shape, as well as the background, must be taken into consideration
- Find a middle ground between style and functionality/usability
The design must convey a usability look and feel, without being exaggerated or labeling the user. It has to maintain a descent style.

6 Pilot test

Before conducting the usability tests, a smaller pilot test was performed. This test was used to learn how to properly prepare and perform a usability test and interpret the findings. However, we exploited this opportunity to collect some initial data and user opinions on selected phones. Parts of the test were performed at the Sony Ericsson Experience Lab, where we also had the opportunity to observe and learn from Sony Ericsson's tests, and get pointers and input from experienced human factors analysts.



Figure 6.1 Workflow

6.1 THE PARTICIPANTS

The participants for this test were chosen randomly, i.e. “Hallway testing” [10]. The users were in the age span of 20-30, representing a cross section of a somewhat younger user group. Ten users were tested.

6.2 METHOD

6.2.1 What to test

In this test, the following aspects were investigated:

- Navigation keys – *Button layout and placement, spacing between buttons, feedback and size.*
- Style and format – *What do users feel about the different formats? What do the different styles communicate? How do different design elements affect the overall impression?*
- Size and grip – *Which phone is more comfortable to hold and use, and why? Materials?*
- Alphanumeric keyset – *Performance, layout, feedback, symbol contrast and clarity. Which phone is faster to type on and why?*

Some of the data was collected through traditional usability testing, i.e. letting the user face tasks and scenarios. More soft data, such as opinions and impressions was collected through questionnaires and interviews (performed simultaneously with the testing). We were mainly interested in user opinion regarding style, format and the usability impression.

6.2.2 Chosen tasks

These are the tasks that were presented to the user:

First impressions

We presented a phone to the user and asked him/her to talk freely about his or her first impressions regarding style, format and the level of simplicity/complexity.

Performance tasks

These tasks were given to the user in order:

1. The user was instructed add a given contact to the contacts list.
2. The user was instructed to type a certain message (SMS), while being clocked.

“Hej! Hur mår du idag? Vad ska du göra i eftermiddag?”

Evaluation

The user was asked to talk about their user experience. How did they like the phone after actually using it for some simple tasks? These findings can be compared with the initial impressions, in order to establish an understanding for the usability impression and actual usability.

6.2.3 The chosen phones

We chose three phones to be tested, the C901, W705 and W508 (figure 6.1). These three phones are different both in terms of format (stick, slide, flip) and in terms of style and aesthetic values.



Figure 6.2 Pilot test phones

6.2.4 Assumptions

Before testing the phones, we made some basic assumptions regarding their usability. The assumptions were used to test our thoughts against the users' opinions.

C901

We thought that: The tight spacing between the keys on the upper keyset, combined with the poor definition and transition between the keys would create a poor user experience.

The look and style of the phone would cause the users to perceive it as older and dated.

The typing performance would be quite fast, due to the layout of the alphanumeric keys and how they are placed close together

The shape of the phone, mainly the rounded backside, would make it comfortable to hold. However, the glossy, metal-like plastic material would give the phone a slippery feel, which could undermine the grip.

W705

The round shape of the back, combined with the softer rubbery material, would make the phone both comfortable to hold and provide a good grip.

The symbols and numbers on the alphanumeric keys would be clear and easy to read. This would be due both to the size and contrast to the background color, as well as the matte finish on the material.

The buttons and separation between buttons, on the upper keyset would be perceived as more defined. This due to the buttons having more distinct edges and make better use of elevation.

Users would experience the difference in height and the ledge between the alphanumeric keys and the upper keyset as cumbersome when typing.

The typing performance would be slower than on the C901.

W508

The phone would feel too thin when unfolded. This could cause the grip to feel awkward.

Initially, it would be considered functional and easy to use due to its large buttons placed spaciouly on a large surface.

The soft keys would be hard to see and hard to use due to their design and placement.

The alphanumeric and upper keys would feel flat and undefined, making it hard to orient your fingers without using visual guidance.

The typing performance would be slower than on the C901.

6.3 FINDINGS

These findings were based on user comments made before (usability impression) and after (actual usability) using the phones.

6.3.1 Stick – C901

First impressions

- Basic - *The general impression was that this phone was plain in both design and functionality. A very basic, typical phone.*
- Unattractive look – *Almost all users found the phone to be unattractive with little or no appealing design features.*
- Outdated – *The look was considered by most to be dated with an old and boring feel to it.*
- Chrome splines – *One thing that stood out among the design features was the chrome splines mixed in with the alphanumeric keys. They were considered to be both out of place and interfering with the overall visual impression.*
- Buttons – *The cluttered layout of the buttons made them hard to distinguish. Also, the monochrome design with low contrast of the keys caused some of the symbols to be hard to read.*

User evaluation

- Grip – *The shape was fairly good, although the material finish made it somewhat slippery.*
- Navigation keys – *The tight, compact layout of the upper keyset made the keys uncomfortable to use due to the risk of accidentally pushing the wrong button or several buttons at once. It was generally difficult to sense which button (especially the soft keys) your finger was pointing at. This also affected the user experience negatively.*
- Feedback – *Most users considered the buttons to be mushy and needed to be pressed down harder than desired. Poor tactility in general.*
- Typing – *Some comments were made, by avid users with a lot of texting experience, regarding the size and layout of alphanumeric keys; The tight spacing and smaller buttons made it more comfortable and made it easier to write fast, enabling a good 'flow'.*

6.3.2 Slide – W705

First impressions

- Clean and modern – *Most users thought the phone to be stylish and qualitative. The aluminum look and a well chosen material mix gave it a sense of value. Unisex, modern and somewhat technical were other attributes mentioned.*
- Grip – *The rubberlike material was commented by many users; it provides a nice tactile feel and comfortable grip. Also, the matte finish on the back, in combination with the stylish front, was liked by most users. The shape and weight of the phone was appreciated, it sits well in your hand.*
- Navigation keys – *Most users found these keys to appear somewhat more complex and "high tech", making them a bit more difficult to approach.*
- Slide format – *The main functionality is presented instantly (navigation keys etc.), with a quick and easy access to the alphanumeric keyset when needed.*
- Buttons – *Most users were neutral to the alphanumeric keyset. No comments were made on the buttons being placed to tight (compare with C901 above). The matte and plain layout made them feel durable.*

User evaluation

- Format – *Well appreciated by most users. The size of the phone was considered to be just right.*
- Slide ledge and distance - *The ledge between the lower and upper part of the unslided phone caused some minor frustration; when typing, sometimes your thumb has to leave the alphanumeric keys to access the upper keyset. With the ledge and difference in height, you can't just slide your thumb upwards, you have to lift it. Many users commented on this. Also, the distance between the top of the alphanumeric keyset and the ledge could be problematic if you have large fingers.*
- Buttons – *The slightly matte finish of the alphanumeric keys created a comfortable tactile feel. The elevation of each key made it quite easy to distinguish, despite a quite plain and non-separated layout. However, some comments were made on the keys, claiming they were a bit too small.*
- Feedback – *Considered by most users to be good, with a nice feel and click.*

6.3.3 Flip – W508

First impressions

- Simplicity and style – *There was quite a wide range regarding views on the simplicity of this phone. Some commented on how the walkman focused front (when closed) made it look odd and somewhat confusing, from a phone perspective. However, the relatively clean surfaces give the phone a sense of simplicity. Some users commented that the materials gave it a cheap and plastic look. However, some users found it modern and quite good looking.*
- Buttons – *Many had the initial impression that the phone would be easy and pleasant to use due to its larger buttons, and the spacing between.*
- Flip format – *Too access the functions of the phone it has to be opened. You can't open it comfortably with only one hand, which could cause problems when you only have one hand available. Because of its size and awkward proportions, some users felt that it would be uncomfortable to use and handle the phone.*

User evaluation

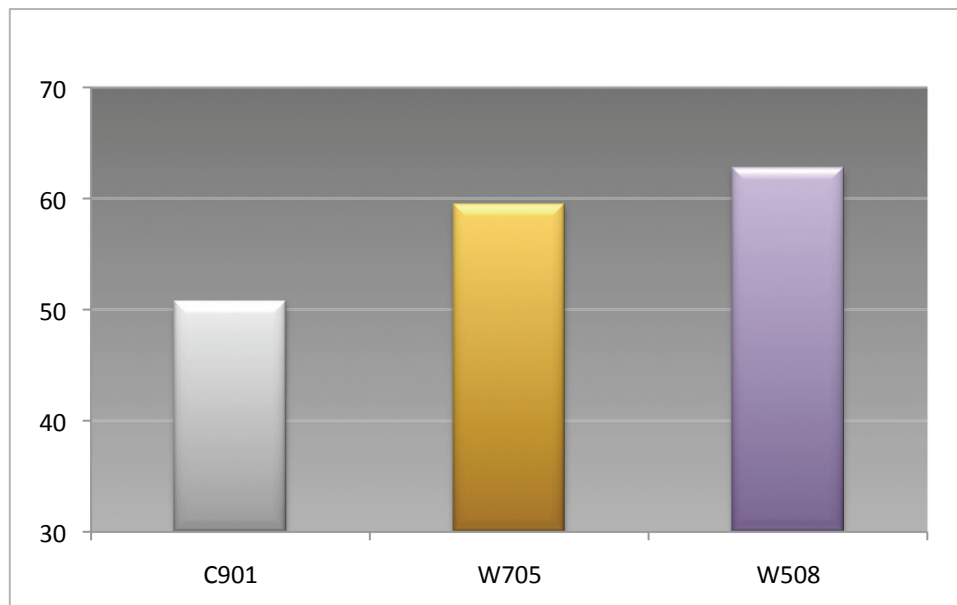
- Soft keys – *The soft keys were perceived as design elements rather than keys. Some noted that, in addition, their placement made them feel separated from the rest of the upper keyset, causing them to be difficult to find and use.*
- Size and grip – *Because of the large button area and the vertical distances the typing was somewhat slow. The users had to put more effort into moving their thumb around and didn't feel like they had a good flow when typing. The phone felt somewhat difficult to handle due its disproportionate design (thickness vs. width).*
- Buttons – *Many found that the entire area where the buttons are placed in general, and the buttons in specific, felt cheap and of poor quality. The buttons are not elevated and are hard to distinguish. The tactile feel is poor, and the feedback is questionable. The clear plastic material on the buttons made them reflect light, making them difficult to read.*

6.4 TYPING PERFORMANCE

The data from the typing test has been compiled into a chart below. The chart shows the average typing time, in seconds, for the three phones. The C901 had a clear advantage over the other two phones, being 9 seconds faster than the W705 and 12 seconds faster than the W508.

Of the ten users tested, eight were clocked correctly, and therefore the data is based on eight users instead of ten.

Table 6.1 Total time for all phones



6.4.1 Analysis of typing performance

The C901, although it suffers from a lot of usability issues, is the quickest phone to type with. The buttons are placed tight together, and the thumb can easily access all the buttons, including the upper keyset, without being forced to change grip. The buttons are quite difficult to distinguish horizontally, but the vertical separation is good, due to the separating details between the rows and the convex shape of the buttons.

The other two phones had worse typing performance, but due to different factors. The downside of the W705 slide phone is the sharp edge and elevation of the navigation buttons, disturbing the typing flow and adding time to the end result. However, the alphanumeric keyset itself is similar to the C901. The W508 flip suffers from its size. The buttons are scattered, demanding a large thumb movement to reach all the buttons. Reaching between the navigation keys and the lower alphanumeric keys is uncomfortable, unless you alter your grip, which will disturb the typing flow even more.

6.5 CONCLUSION

Most of the findings regarding actual usability were consistent with the assumptions and our initial review made before these tests. This confirmation was important as it allowed us to move forward with an expanded test on the same matters.

However, we learned some new patterns of use and the severity of some of the usability issues. Most notably were the different issues with the W705 and W508 which caused them to be slower when typing, and how the user reacted to this. The distance between the buttons on the W508 flip actually made it quite strenuous to use.

We received some valuable opinions and comments regarding style and looks. These were important since this project also had a focus on the usability impression and maintaining aesthetical values, according to the Universal Design principles. We investigated the different formats further, collecting opinions on other phones, and compared them regarding looks and how they communicate functionality and sense of simplicity/usability.

This was the first usability testing we've conducted. The test time was kept down, and instead we tried to perform as many tests as possible in a short time. These were performed simultaneously with Sony Ericsson's tests, which we could observe and learn from. The main objective was to learn how to set up a test session (questions, tasks, data to be collected), and to get a feel for how to act as a test monitor. Also, when analyzing our material, we learned what was important and what wasn't.

We also learned how to present a task, with clear introduction and explanation of what we want the users to do, and then let them perform the task or questionnaire while we're observing without interrupting. This was not performed very well with our first tests, since we didn't know how to react on different user behavior. Also, we learned the importance and timing of follow up questions, in order to extract the gist of the problem.

Also, strategies were developed on how to formulate the questions in order not to be leading, or affect the user to answer in a certain way.

A lot of experience was gained, and useful hints and tips from Sony Ericsson made us more confident and comfortable when performing tests.

7 Usability Testing

Using the experience from the pilot test, a proper, more extensive test was performed. This chapter presents the method of testing and the results from this more extensive usability test. The test consisted of questionnaires and a typing performance test.



Figure 7.1 Workflow

7.1 METHOD

The purpose of this usability testing was to reveal the needs and preferences for users of different age and experience. These tests were used to establish an understanding of which usability issues are relevant, how important they are and how they differ with age and experience. Also, opinions regarding looks and styles were collected. This data was used as a basis for the aesthetical values of the design concept.

The testing was performed at the Usability Lab at IKDC.

The testing focused on a number of general usability issues that has been found during the research. Quantitative and qualitative data was gathered during the test in order to obtain a basis for design decisions. This test was used to clarify issues regarding grip, size and the center of gravity, as well as typing performance and button design. Also, the different formats, as well as materials and aesthetical values was examined.

7.1.1 Test participants

The participants chosen for this test were men and women of ages between 20 and 65, with different experience of mobile phones, in order to obtain the Universal Design perspective (in the pilot test, random users were tested). By doing this, both general usability issues and age specific matters was revealed. Eight users were tested.

7.1.2 The chosen phones

We chose three phones to be tested, the C902, W595 and Z770i. Just like in the pilot test, these three phones are different in terms of format (stick, slide, flip) and in terms of style and aesthetic values. New phones were chosen for this test in order to find more usability issues. With this test, we gathered further information regarding style and format from different demographics.



Figure 7.2 Usability test phones

7.2.3 Assumptions

Just as with the pilot test, some basic assumptions regarding the different phones' usability were made. The assumptions were used to test our thoughts against the users' opinions.

The **C902** is a standard stick phone. It is quite wide and the buttons are not very distinctive, and provides poor feedback which can cause problems when typing. The relatively high weight of the phone can be quite tiresome.

The **W595** is a slide phone with quite small buttons. The alphanumeric keys are distinctive and clear, although the navigation keys are a bit cluttered. It is quite small, which can be troublesome for users with large hands.

The **Z770i** is a flip phone with large buttons. However, the buttons are not very distinctive and can create problems. Also, the format causes some inherent issues, like the thin profile of the phone when unfolded. Its navigation keys are quite cluttered and can be problematic.

7.3 TASK LIST

The test was divided into three parts. Initially, the user had a quick hands-on with the phone, creating a first impression equal to what may be achieved when browsing phones in a store or warehouse. They were asked to respond to a series of general statements regarding the phones' simplicity and style, by filling out a questionnaire and thinking aloud while doing so

The next step of the test was to enable the participant to handle and explore the phone. This enabled us to collect quantitative data in form of typing performance, but it also helped form a user opinion on the phone. This was used when evaluating the phone in the final part of the test.

The final questionnaire enabled the user to evaluate their experience with a number of statements similar to the first step. This questionnaire was more specific and let the user express their opinion on certain usability factors such as button feedback, mapping etc.

Both the initial and the final questionnaire let the users rate the statements on a seven-point scale, where the extremes are "agree completely" (seven points) and "do not agree at all" (one point).

7.3.1 Questionnaire part 1

1. The phone appears simple – *Simple in terms of usage*
2. The phone is attractive
3. The size of the phone is good – *Proportions and physical dimensions*
4. I like it!

7.3.2 Exploring task

Initially, the user was asked to browse the menu system and change a number of different settings (e.g. background image, ringtone volume etc.) in order to get a feel for the navigation keys (including the rocker key and soft keys etc.).

7.3.3 Typing task

The next step of the exploring task was the text message challenge. The user was asked to open a new text message, and was challenged to type the word "Fantastiskt" (fantastic) five times, while being clocked. This task was repeated three times in order for the user to acclimatize to the phone and the word. This word was chosen because it is easy to spell and remember, and it makes use of a majority of the alphanumeric keys.

7.3.4 Questionnaire part 2

1. The phone was simple to use
2. The phone's size felt good
3. The phone was comfortable to use – *Regarding grip, materials, how well it sits in the hand*
4. Finding the right buttons was easy
5. It was easy to see and read the buttons' symbols and letters
6. The buttons had a good click – *Feedback*
7. The navigation keys are well designed and explains their function well
8. It's easy to connect the buttons to the on-screen actions – *When to use which button?*

7.4 RESULTS: QUESTIONNAIRE PART 1

7.4.1 User rating

The phones were rated between 1 and 7 points (a higher score is better). The column charts below shows each phone's mean value in each category.

Table 7.1 Simplicity

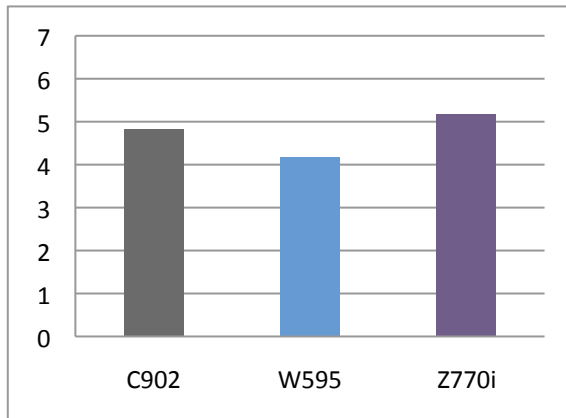


Table 7.2 Attractiveness

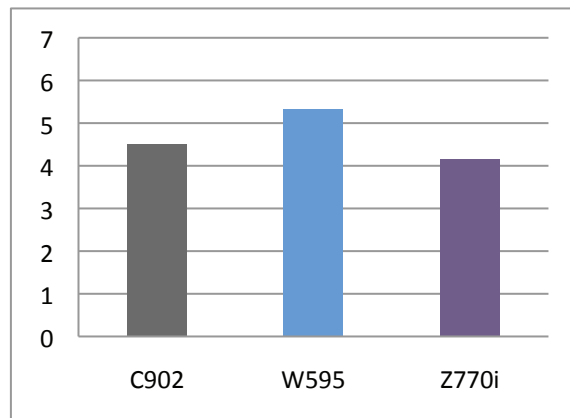


Table 7.3 Size

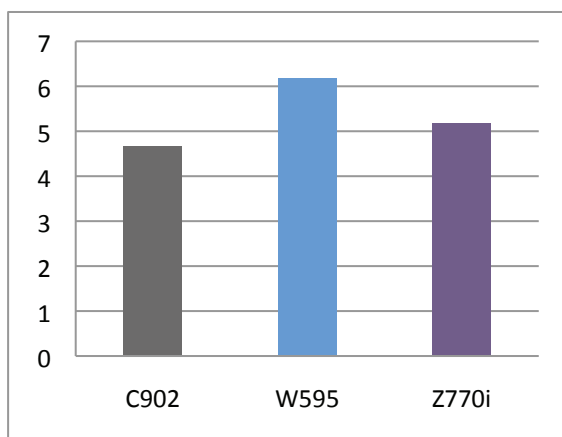
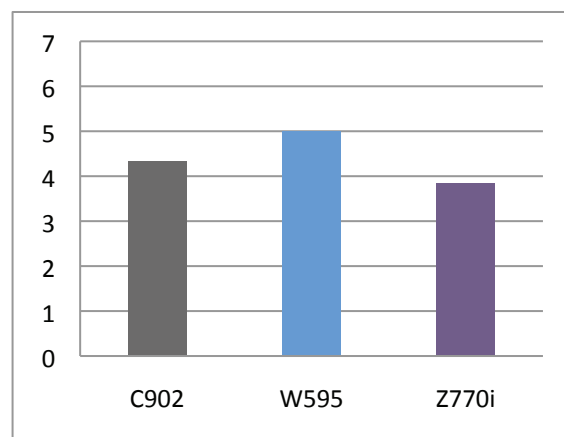


Table 7.4 Likeability



Using these charts, we could easily tell which phone was the best within each category. Regarding simplicity, the Z770i flip phone was the winner, while the W595 slide was regarded as the most complex of the three phones. However, the W595 was the clear winner regarding attractiveness, size and was the most liked in general. The Z770i was considered to be the least attractive phone, as well as the least likeable. The C902 scored worst regarding size.

7.4.2 User opinion (Part 1)

The user opinion collected during the questionnaire is presented below.

1. Simplicity – “The phone appears simple”

C902: Because of its familiar format, many users found this phone to be quite straight-forward and approachable. In general, it appears to be quite basic and well structured, largely due to the strict layout of the key set. However, the buttons and design features were considered to be packed together too tightly. Most users found it to be the most exclusive looking phone of the three. Its weight made it feel solid and of high quality, but also somewhat technical and advanced.

W595: Most users felt that the navigation keys were too small and oddly designed, making it appear a bit complicated (as shown above table 7.1). The buttons are small and interfere with each other, making it hard to distinguish buttons and causing uncertainty on where to push. Its rounded corners and edge, combined with the choice of material and playful color made it feel kind and accessible. The slide format added to this by hiding many of the keys when closed.

Z770i: This phone scored highest on the simplicity ratings, mainly due to its format. The format enables the buttons to be relatively large and placed spaciouly (*We’ve noticed that this characteristic is the single largest factor when initially judging simplicity*). When folded together, unintended use is avoided since the features are hidden. There are some usability issues, mainly regarding the navigation keys. The layout and snake-like design features creates an odd grouping of the buttons, causing confusion with the users. Some users found it cheap looking, with its plastic detailing (*this also adds to its simplicity ratings*). The inside (unfolded) was considered more appealing than the outside. Quote: “It’s not exactly Dieter Rams”.

Conclusion: *The Z770i is considered to be the simplest phone at a first glance, mainly because of the large buttons and the generous spacing, enabled by the format. The format also hides the features, creating a secure feel. The W595 was considered least simple, mostly due to ill designed navigation keys (the half circle design causes the buttons to interfere with each other). Also, the slide format on the W595 is relatively new which adds to its complexity. The C902 has a standard format and is considered familiar, but its compressed keyset lowered its score.*

2. Attractiveness – “The phone is attractive”

C902: The opinions on this phone varied from quite old fashioned and boring to rather attractive and elegant/luxurious. There were no visible patterns in form of age or gender on these opinions, although most users found it to be “okay” with no strong liking or disliking.

W595: Most users found this device to be differentiated and set apart from other phones on the market. This is due to the format and its shape (rounded ends), combined with its original metallic blue finish and chrome splines on the side. A majority of the users thought it was rather attractive and interesting, with its playful

appearance. Some users were doubtful on its design, claiming it is a bit “too much”. Quote: “Quite sexy”.

Z770i: Considered the least attractive. It has a non-consistent look between different parts of the phone. The in- and outside has different expressions, but there is also a difference between the upper and lower keys. All together, it has a non-coherent expression.

Conclusion: *While the C902s classic look was quite plain, the other two phones were more engaging. The W595 is a bit odd, but pulls it off. Although being a unique player, it has a quite clean and neat design. The Z770i also tries to stick out, but fails with a non-consistent and poorly executed design.*

3. Size and proportions – “The size of the phone is good”

C902: Almost all users commented on the size by claiming that it is too wide. The width causes the phone to feel clumsy, and its proportions are uncomfortable. Some users claimed it was a bit too heavy.

W595: Considered handy and sleek. It’s easy to carry, and suitable for a jeans pocket. It sits well in the hand, with a good shape and a well located center of gravity. The opinions were uniform and most users considered it comfortable to handle.

Z770i: Most users found it too thick when folded together. It doesn’t fit your pocket as well as the other two phones. When unfolded, it’s quite long (and too thin) which wasn’t appreciated by most users. The grip wasn’t considered to be very good, and comments were made on it being too light and top-heavy. However, it was considered manageable. “Okay” was a term used by many to describe its size.

Conclusion: *The size, proportions and shape of the W595 was considered very good. However, its slim design limits the possibilities to design the keyset. The C902 is manageable but a bit too wide. The same goes for the Z770i, being manageable but too thin and too light when held unfolded.*

4. Likeability – “I like it!”

C902: Only really liked by one user. The rest of the users were indifferent towards it, thinking it was okay but slightly boring.

W595: Quite well liked, getting relatively high user scores in general. The somewhat “unclean” front lowered the score slightly with some users. It seems to be universally appealing, getting high ratings from both younger and older users.

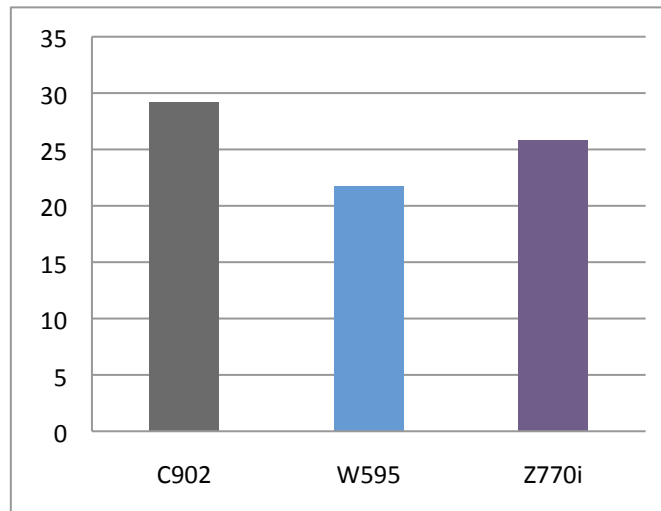
Z770i: This phone was highly disliked by the younger users, but seems to appeal to the mature users. This was largely due to its format; the phone is rather big when unfolded, making it possible to hold and handle it like a traditional telephone.

Conclusion: *Most users seem to favor the W595, both due to its looks and its format.*

7.5 TYPING PERFORMANCE RESULTS

The subjects performed each test three times, and the mean value of the users' best (lowest/quickest) times for each phone is presented in the table below.

Table 7.5 Typing performance results (seconds)



Testing six users is not enough for a statistically assured data. However, it provides a hint on which phones are easy to type with.

7.6 RESULTS: QUESTIONNAIRE PART 2

These are the results from the second questionnaire, taken after the user had explored the phone and typed with it.

Table 7.6 Simplicity

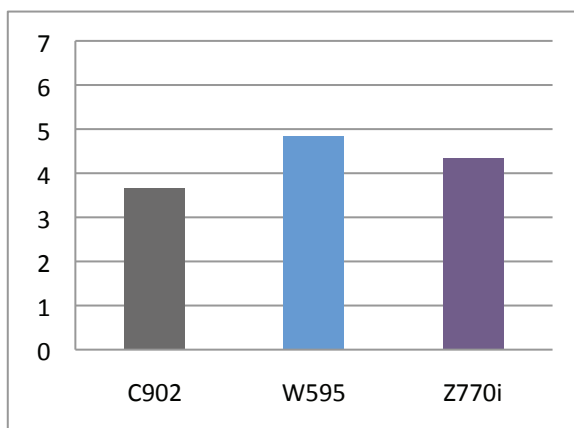


Table 7.7 Size

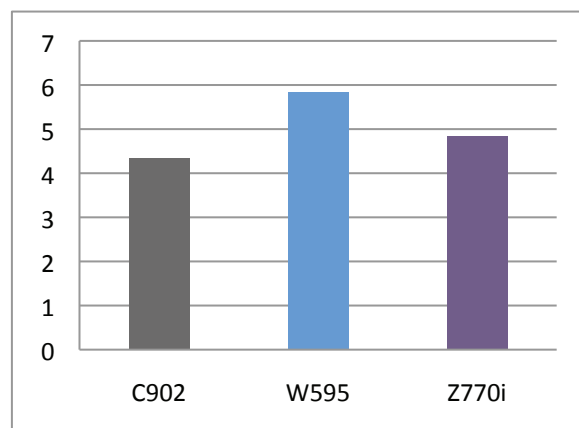


Table 7.8 Comfort

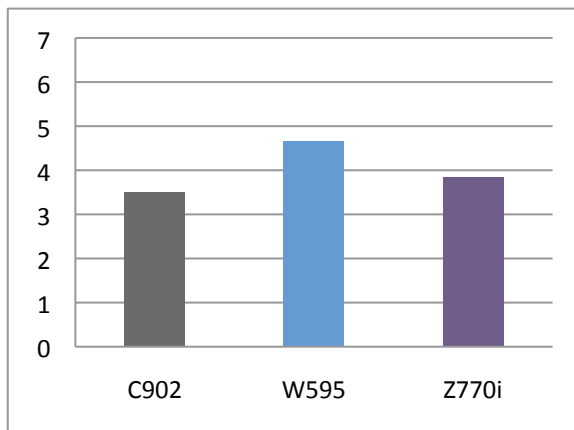


Table 7.9 Finding buttons

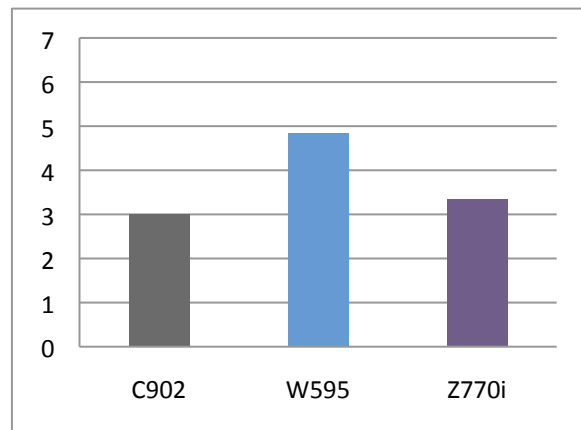


Table 7.10 Clarity

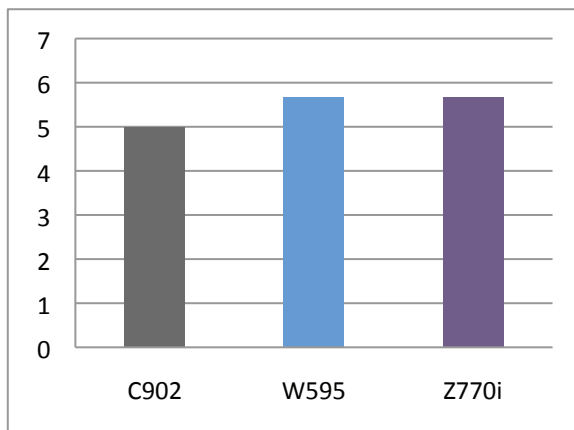


Table 7.11 Pushability

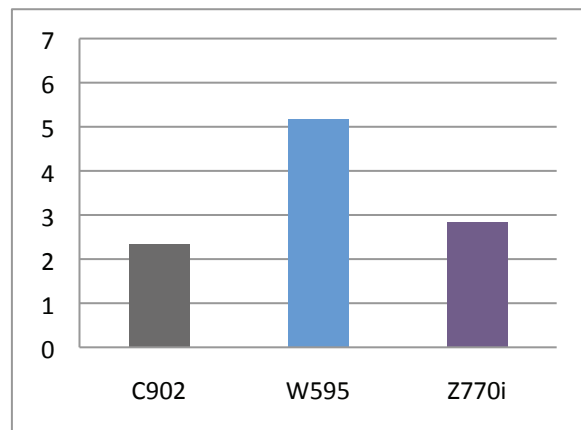


Table 7.12 Navigation keys

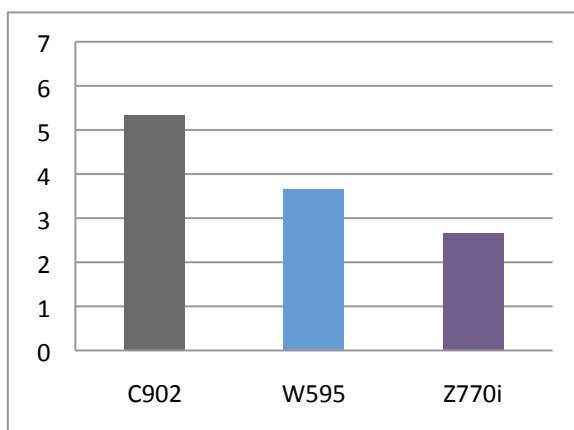
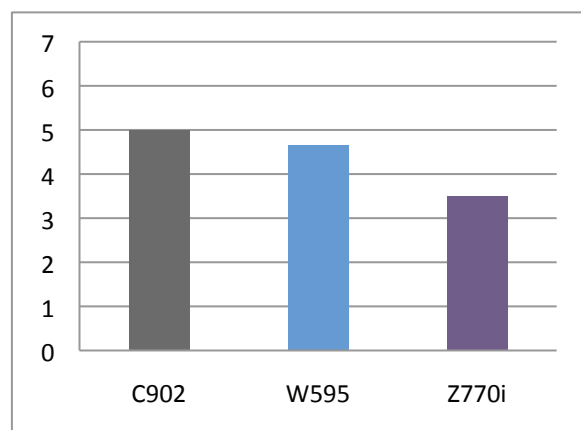


Table 7.13 Mapping



7.6.1 Commenting on the results

With the users having tested the phones, some pre-usage opinions were confirmed, while others were revised. The W595 was not considered simple before the test (had the lowest simplicity-score in the first questionnaire), but received the highest score after using it. Actually, it beats

both the C902 and the Z770i. The Z770i was thought to be simple, but after using it, most users changed their opinion and the phone scored much lower afterwards.

Regarding the physical attributes (size, comfort, button design & feedback) the W595 is the clear winner, although its navigation key design is questionable. The Z770i's good qualities include the clarity (of the buttons) and its size. In all other categories, it fails. The C902 scored well in mapping, navigation keys and clarity.

7.6.2 User opinion (Part 2)

1. Simplicity – *"The phone was simple to use"*

C902: A general user opinion was that the rocker key had good clarity, but being a bit too small with poor feedback and a mushy feel. Also, the users thought the buttons were packed too tightly, dragging the score down. In general, it was considered uncomfortable to use.

W595: This phone was considered good in general. The somewhat small buttons worked better than expected. The phone is easy to approach due to its keyset being divided on two surfaces, although this causes some problems when typing. The navigation key layout was considered cluttered, unclear and unstructured, lowering the score slightly.

Z770i: Many comments were made the navigation keys, regarding its unclear and odd design. It's not obvious how to use and where to push, since the buttons aren't very well distinguished. The grouping of the buttons was questioned, and in specific, the soft keys were considered poor in terms of placement and design. The typing flow was interrupted by the button spacing and distances. The large keyset area demands a large thumb (or finger) movement, considered tiresome by most users.

Conclusion: *Simplicity is often judged by button design, where large buttons appears more usable, but this isn't the case. Feedback and tactility are more important factors, creating a good flow and feel.*

2. Size and proportions – *"The size of the phone was good"*

C902: Considered too wide by most users. In general, also a bit large and a bit too heavy.

W595: The size was experienced as good by most users. Some comments were made on it being a bit too small for the hand when unslided, and therefore unstable.

Z770i: Its format leads to some problems. A majority of the users thought it was too thick when closed, and to thin when unfolded. Also, it was considered top-heavy, with its long appearance when opened. Many users approached this phone with two hands, in order to establish a decent grip.

3. Comfort – *"The phone was comfortable to use – weight and grip"*

C902: Considered, by most users, to be both too wide and too heavy. This caused the phone to sit awkwardly in one's hand. This combined with a somewhat slippery

material and an inconvenient keyset, made the phone generally uncomfortable to use. A few users liked the heavier feel and the sense of quality it brought.

W595: Widely considered to be well-balanced, with a good center of gravity. The weight was just right in relation to the phone's size. The material of the phone gave it a sense of security and was generally considered pleasant to touch and grip.

Z770i: All users commented on the grip and how the phone was uncomfortable to hold and use. Again, the large distances and the proportions make this phone awkward and bulky to operate. The weight (and weight distribution) feels strange, according to the users.

Conclusion: *This topic is very dependent on the format (size, weight distribution) of the phones. It also depends on chosen material and surfaces are managed.*

4. Buttons – *"Hitting the right buttons was easy"*

C902: The buttons are placed too tightly, and the feedback is poor. This caused the users to feel uncertain on which button they actually pressed. The sloping buttons made it hard for the users to know where to aim and push.

W595: The alphanumeric keys were appreciated. Even though they are quite small (same size as C902), their design (being distinguished, and relatively well separated) enables a good typing flow. The users claimed that they could navigate the keyset without being dependent on seeing it (i.e. the telephone has a pleasant tactility in its buttons). On the other hand, the navigation keys were harder to explore without looking, due to their odd and intertwined design (this also made the users to sometimes press several keys at once).

Z770i: The flat layout of the keyset made it almost impossible for the users to navigate by tactile feel (visual confirmation was required). This also made it difficult for the user to tell which button they had pressed.

Conclusion: *Well separated, elevated keys with a nice tactile feel are important in order to achieve a good typing flow, which in turn leads to a pleasant user experience.*

5. Buttons – *"It was easy to see and read the buttons' symbols and letters"*

C902: The monochrome white on black look was considered to be okay by most users. However, the reflections (caused by the glossy surface) and the sloping design of the keys caused some minor problems with visibility. Also, comments were made on the symbols being a bit too small.

W595: All keys were considered good, with clear and large symbols (in relation to the button size). The symbols on the navigation keys were somewhat less visible, especially the on/off symbol.

Z770i: The spacious design enables large and clear buttons, which was appreciated by most users, even though they were somewhat shiny (reflective).

6. Pushability – “The buttons had a good click”

C902: The keys on the C902 have a non-responsive feel and demand a harder push than desired. This highly affected the typing flow, and made the phone feel unpleasant. Quote: “*Feels horrible to type with*”.

W595: The buttons on this phone had a much better and more distinct click than the other two. The only negative comment was that the buttons were slightly stiff.

Z770i: The keys felt unresponsive with little or no feedback (they demand a quite high pressure in order to respond). The audible feedback is almost non-existent. Very disliked by the users. Quote: “*Miserable feedback*”.

7. Navigation keys – “The navigation keys are well designed and explains their function well”

C902: Considered to have the best navigations keys among the three phones. It has a good, easy-to-understand structure and makes good use of elevation. Most users found it easy to press the intended button. A downside was the monochrome color scheme which made the buttons feel a bit withdrawn.

W595: The main problem, as brought up earlier, was the intertwined layout of the buttons. This makes it hard to know which button you are aiming at, almost forces the user to guess.

Z770i: Many users said that the design and shape of the navigation keys were purely aesthetical with little focus on functionality. Even if the “cross” is easy to understand, everything around it is cluttered and messy. Some users thought the soft keys were design elements rather than buttons. Also, the button design forces the users to press on a surface instead of an actual button, which most felt was uncomfortable and odd. All in all considered unintuitive.

Conclusion: *The three phones have very different navigation key design, everyone with upsides and downsides. In general, the C902’s square rocker key and distinguished button design were the most appreciated. On the other two phones, the focus of the navigation keys is more on being a stylish design feature rather than a functional set of keys.*

A general issue is that the red key (reject call) takes you back to the main menu. This is not appreciated by all users and somewhat confusing, tricking the user and can create a false mental model (see expert review, chapter 5.2.2).

8. Mapping – “It’s easy to connect the buttons to the on-screen actions”

C902: The closeness between the screen and the buttons was appreciated by many users, creating an intuitive connection between the button and the on-screen selection. Some comments were made on the soft keys being placed “outside” the screen area.

W595: Slightly longer distance between the soft keys and the screen, combined with a non-obvious key design makes the mapping appear less evident than on the C902.

Z770i: The distance between the soft keys and the screen is very long, mainly due to the format of the phone. The users thought it was understandable, but not obvious. Some users were confused by the distance, and even thought the soft keys were intended for left/right navigation.

Conclusion: *The understanding of the mapping is very dependent on the distance between the keys and the screen. With longer distance, it becomes more important with an evident design explaining the mapping function.*

7.7 CONCLUSION

The testing clearly pointed out some important usability problems regarding button design and layout. The problems can be both physical (e.g. the buttons being indistinctive) as well as on a cognitive level (e.g. mapping issues and symbols).

When comparing the results from the first and second questionnaire, most users reviewed their opinion. Initially, the Z770i with large buttons gave an impression of being easy to use. However, after testing the phone, most users thought it was uncomfortable to use. One of the major misconceptions about usability and mobile phones is that large buttons are easy to use. This can be true, but not always. Large buttons increases clarity and is easier to spot, but they are often not very comfortable to use and provides a quite poor typing experience. One important finding was that users can handle smaller buttons than they initially thought.

8 Forming guidelines

These guidelines are based on the findings in the previous usability testing, as well as our own reviews and expert opinions. They are supposed to be used as a list of factors to keep in mind when designing a mobile phone, and also for evaluating different design concepts.



Figure 8.1 Workflow

8.1 GUIDELINES

8.1.1 Form and grip

The shape and dimensions/proportions, of the phone, should

- Allow a flexible grip, offering a comfortable grip for both left- and right-handed users, as well as the possibility to use both hands (*hand ergonomics*).
- Accommodate to different hand sizes and levels of dexterity.
- Allow the user to browse and reach a majority of the buttons and functions without compromising the grip.
- Not be too large (it should fit a normal pocket or case).

The weight and weight distribution, of the phone, should

- Allow the phone to sit comfortably in your hand (*center of gravity*).
- Be distributed in such a way that the phone feels qualitative and distinct, without causing the phone to be too heavy (to carry, to hold etc.).

The material choices of the phone should

- Improve the grip of the phone, making sure it doesn't slip out of your hand.
- Make the phone feel safe to handle, i.e. a non slippery feel.
- Make the phone feel nice and comfortable to use from a tactility point of view.

8.1.2 Button design

The keyset has to be designed to offer a good typing flow, with the ability to browse by tactility and still being sure of the location of the buttons. The buttons should fulfill a number of demands.

- Clear physical and visual separation with clear tactile contrasts (i.e. the ability to feel where the buttons are placed)
- Clear elevation of each button (i.e. the buttons must not be too flat)
- An appropriate size (this does not necessarily mean large buttons)
- Be well organized and clear, without arbitrary shapes and placement
- Clear visual contrasts, including symbols and color scheme
- The button's shape and affordance should conform with its function

8.1.3 Functionality

Regarding the phone's different functions and their visibility and clarity, these aspects has to be considered.

- The main functions should be clearly visible when first approaching the phone (with slide or flip format, it should be obvious on how to reach the hidden functions).
- Extra features such as media player, internet browser etc., should not steal attention from the main functions. It's not necessary to place physical buttons and design elements for these functions if they are easily accessible from the software interface.

8.1.4 Mapping & semiotics

How well buttons (and other elements, such as connectors, card slots etc.) explain their function is of large importance when using the phone.

- Buttons of equal function should look alike (*consistency*).
- The software functions mapped to soft keys and navigation keys should be as consistent as possible
- Avoid placing several functions on one button, unless it's absolutely necessary.
- Both the design and symbol of a button should match its function (*affordance*).
- Use the gestalt laws (*proximity, similarity, continuity...*) in order to arrange and organize functions.

- Symbols used on buttons should be of low complexity, in order to be visible despite their size.
- The symbol language should be easy to understand, using established icons, indexes and conventions.

8.1.5 Aesthetic qualities

The phone should have an appealing appearance and express usability. The design must not discourage use and repel the user, regardless of his/her experience. The user should feel secure about using the phone. The phone should be simple, non-obtrusive and universal in its design, without being boring. The following points must be considered and well thought out.

- The chosen colors and how they are combined, i.e. color scheme
- Shape and form
- Materials and material combinations
- The use of design elements and detailing

8.1.6 In general

All of the above guidelines have to be thought of not only individually, but as a unity in order to achieve consistency. A good design consists of a mixture of these interoperating factors.

9 Concept development

This chapter focuses on the “softer” parts of the design process, e.g. mood boards, sketches and eventually 3D models / renderings.



Figure 9.1 Workflow

9.1 METHOD

The steps used in the design process are presented below. They are based on Eckhardt's design methodology [12], but are adapted to fit this specific project.

- **Mood boards** – Used for inspiration and ideas. To look at other products (universal design, good design awards etc.) helped us to define the look and functionality of the concept phone.
- **Limitations & Specifications** – Based on the design guidelines, user needs etc., limitations and specifications were set up defining the phone's functionality.
- **Idea generation** – By discussing and visualizing ideas on separate functions as well as on the complete phone, we could decide on what to move forward with. Sketch models were used to realize shapes (and evaluate hand ergonomics).
- **Computer visualization** – Digital illustrations and 3D computer models/renderings were created for our concepts.
- **Rapid prototyping** – Physical models from the 3D models.
- **Evaluation and testing** – Usability testing and evaluation of the concepts
- **Final design ideas** – The findings from the concept testing were used when designing the final concept
- **Finalizing the concept** – Design Freeze. Models for rendering and physical prototyping.

9.2 INSPIRATION

Mood boards can represent target groups and users, design styles, similar products etc. Regarding our target group, it was hard to find specific preferences. The phone should be *Universal Design* and accessible for as many user as possible. Even within the limitation of users between 55 and 65 years of age, it was hard to find a universal style. Therefore, our mood boards focused on products with "good design", i.e. with high usability and user experience. Also, an image board representing Dieter Rams' work is included. Rams' designs are known for being simple and functional, yet aesthetically appealing.



Figure 9.2 Example of the work of Dieter Rams



mood board / **good design**

Figure 9.3 Inspiration



mood board / **good design**

Figure 9.4 Inspiration

9.3 LIMITATIONS AND SPECIFICATIONS

9.3.1 Format

The three main formats in today's marketplace (excluding touch- and smart-phones) are, as discussed earlier, stick-, slide- and flip phones. Based on the usability testing we decided to eliminate the flip format from our design process. The format's main advantage is that it allows both large buttons and a large display. However, the (inherent) downsides of the format are too many. The proportions (thickness, length) of the unfolded flip phone are awkward and do not support a decent grip. Also, mapping issues occur due to a large screen-to-keyset distance, as discussed earlier. The format is not very popular on the market, and we consider it to be out-dated.

The slide format has its advantages in form of size, spacing and hidden functionality which can improve the usability impression. The "standard" stick format offers a good usability impression due to its high phone affordance. Therefore, the slide and the stick format were used in our development.

9.3.2 Functionality

Regarding functionality, the phone should contain all the standard features of a modern phone. The need for an easy-to-use phone does not imply that it lacks functionality or quality. Many of today's phones marketed as having high usability (see background, section 1.2) are lacking functions and often include a low-quality display. With this project being aimed at a large range of users and using the Universal Design approach, we wanted to make the phone feel like a quality phone with all the functionality of a modern phone with increased usability and user experience.

9.3.3 Specifications

Before approaching the idea generation process, a set of specifications was developed (see figure 9.5 below). The specifications are based on a standard Sony Ericsson phone combined with the guidelines presented in the previous chapter, in order to extract the necessary needs and wants from this product

Layout and functions are presented in the illustration. Regarding the connectors at the bottom of the phone, the standardized USB interface was chosen. This is also more environmentally friendly in a larger sense, since it eliminates the need for brand-specific chargers. This connector is supplemented with a 3,5mm jack for headphones, loudspeakers and hands free-devices.

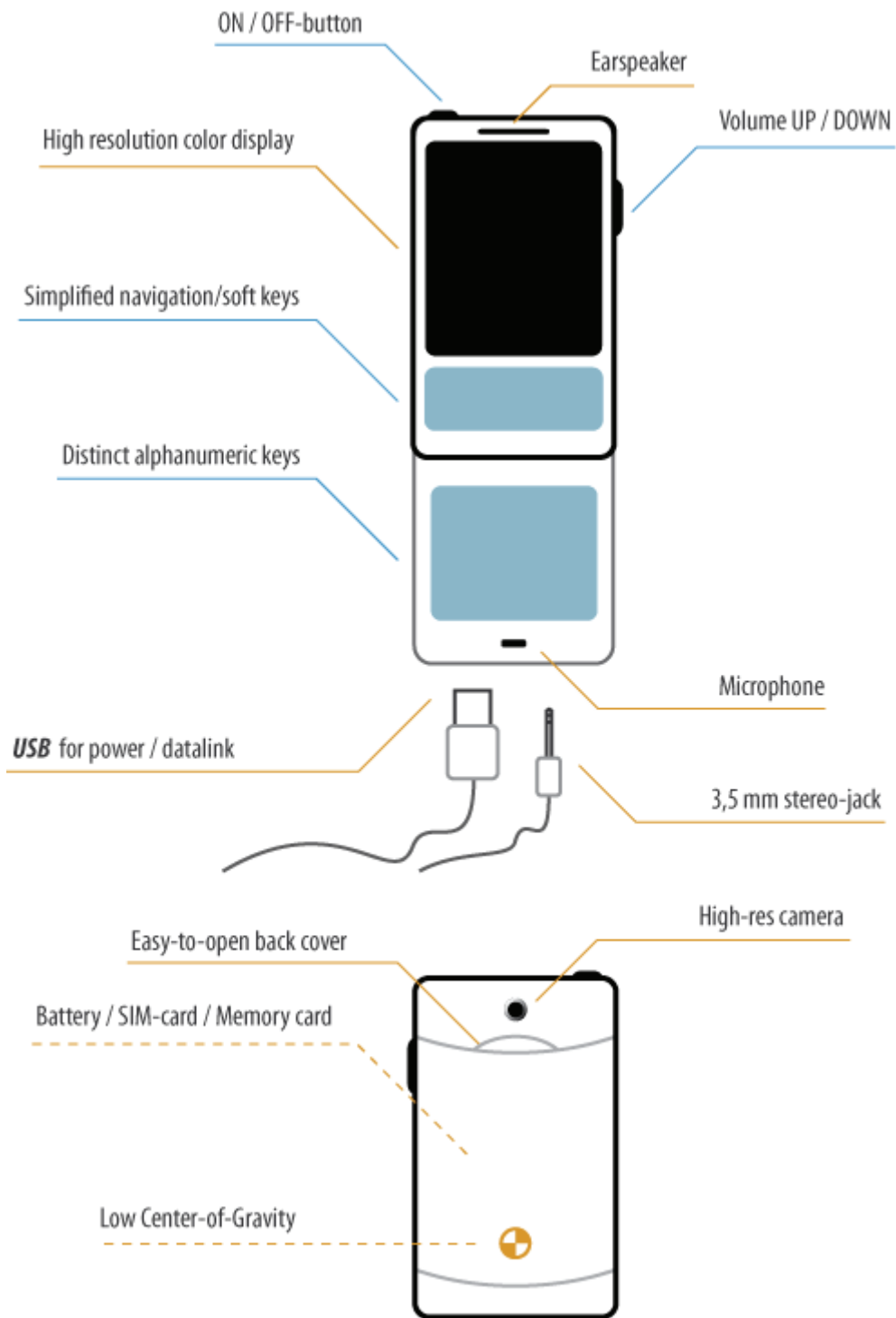


Figure 9.5 Specifications

9.4 IDEA GENERATION

In this first idea generation, ideas on all features on the phone were explored. Sketches on buttons, shapes and other design elements were developed, as well as simple models used to evaluate basic hand ergonomics.

9.4.1 Navigation keys

Initially, the navigation keys were explored. The usability testing showed that these often were cluttered and too tightly spaced, and therefore a solution was sought. The main navigation device, the rocker key, has to be larger and more distinct, and different solutions were discussed. As shown in figure 9.6, inspiration was brought in from gaming devices with more clear directions on the navigation device (i.e. a four-way cross or D-pad²).

A lot of effort was put on trying to make the navigation- and soft-keys simpler. The standard Sony Ericsson layout with eleven buttons is quite complex and cluttered. However, we decided to stick with the Sony Ericsson Graphical User Interface (SE GUI), in order to keep the concept more realistic. Therefore, some of the initial ideas, like the four-way cross, were discarded. With the SE GUI, three soft keys are required (center select, left and right soft key).

With this limitation, we still wanted to simplify the keyset. Initially, all non-needed buttons were discarded, i.e. the activity/internet-key. We also decided that no extra functions should be applied to existing buttons, e.g. putting a camera shortcut on the rocker key, purifying the keyset. As discussed earlier, the phone functionality should be dominating, and secondary features like camera or music player can still exist, but be accessible from the software.

² D-pad: Short for directional pad. Often used on game controllers.

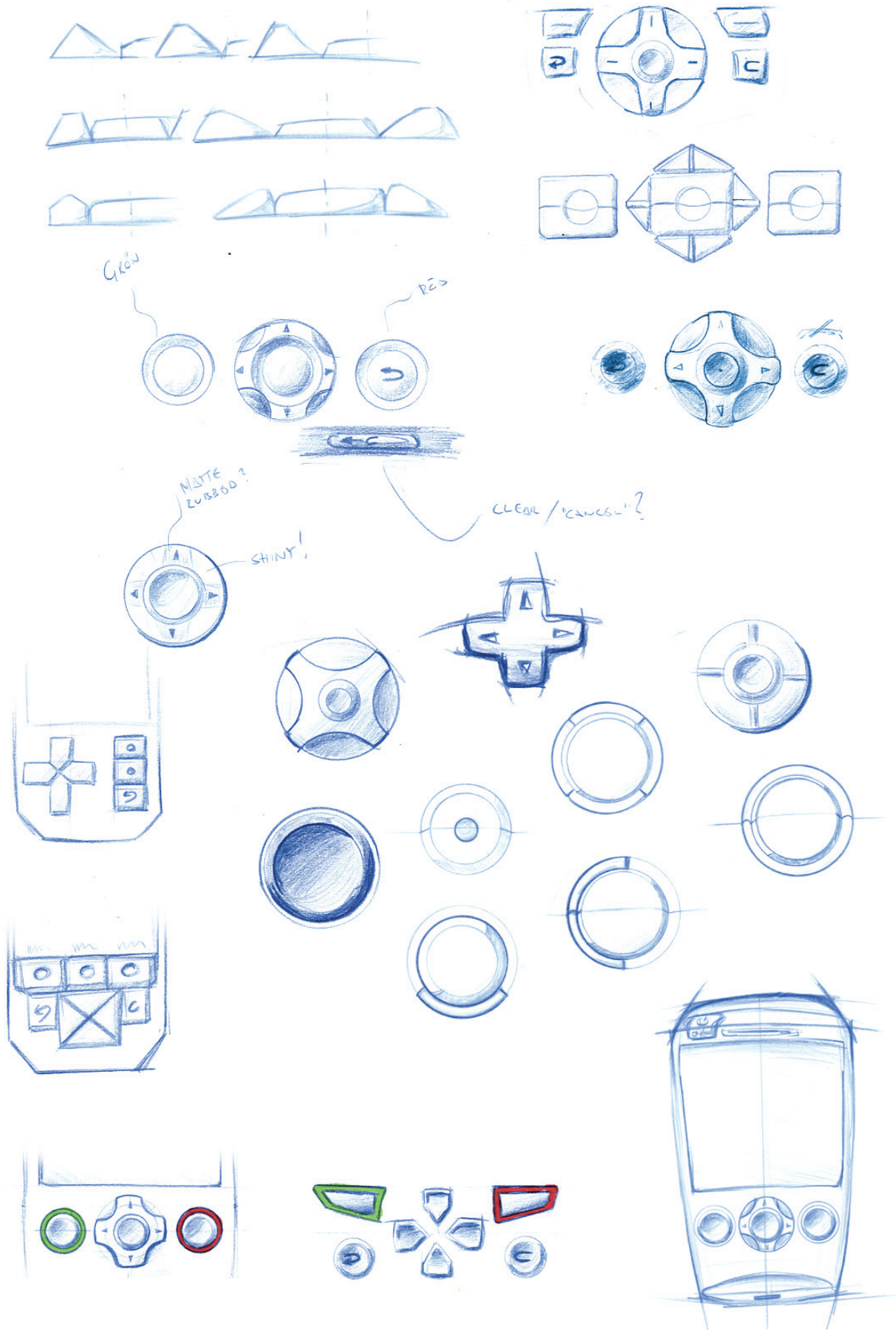


Figure 9.6 Sketches – Navigation keys and devices

A standard SE phone keypad often consists of two (three with the center select) soft keys, and two call keys (green and red key) used to accept or reject a call. The red key also often functions as on/off button. However, the soft keys and the call keys are almost never used at the same time. The call keys are redundant when not receiving a call, and the soft keys are not used when receiving a call. Therefore, we explored if it's possible to merge these buttons (from four to two). This idea collides with the idea of never putting two functions on one button, but with clever mapping and clear symbols, a decent compromise can be achieved. Our mindset is presented in figure 9.7 below.

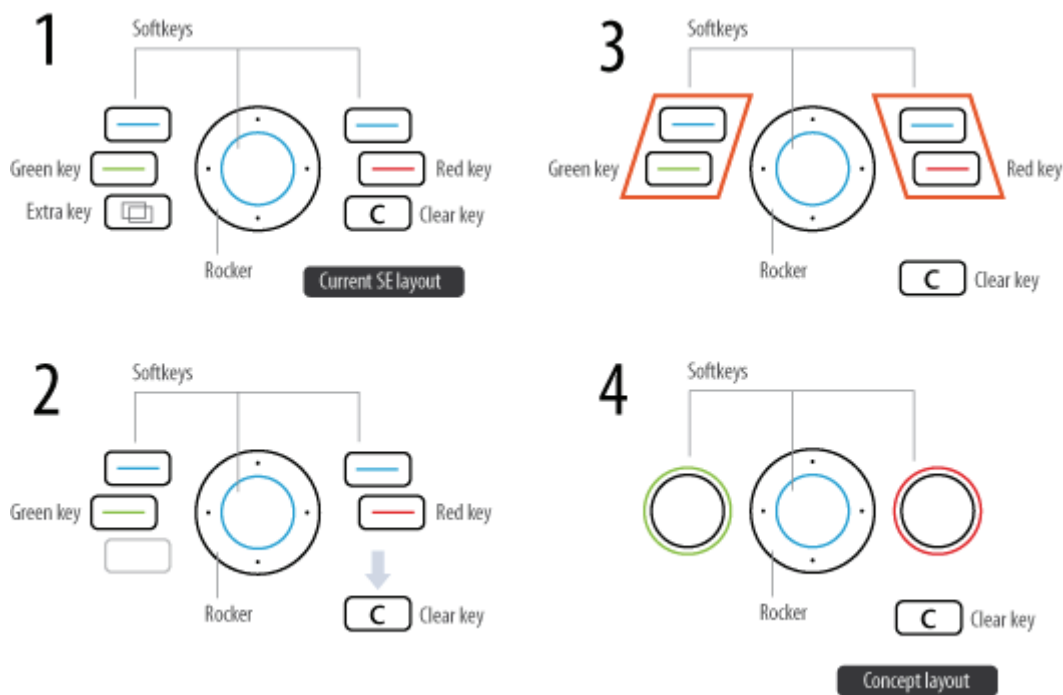


Figure 9.7 – Simplifying the navigation keys

As seen in the illustration, the clear key ("C") is separated from the rest of keys. This is due to the fact that the clear key's main function is to erase characters when typing, i.e. being a function more related to the alphanumeric keys than the navigation keys. This decision has support in the Gestalt laws, grouping keys together according to their functions.

When putting two functions together (soft keys and call keys), clear mapping is needed in order to make the product easy to use. We discussed a design that, when not using the telephone functionality, consists of three soft keys and a navigation rocker key. The soft keys are used for confirming actions, selecting menu objects, stepping backwards in the menu structure, etc. However, when the phone functionality is used, e.g. when dialing a number, receiving a call etc., the soft keys are physically lit up in green and red, to mark their change of functionality and explain their function. This feature, combined with clear on-screen mapping, is a good compromise between keeping the phone functionality and keeping the complexity level low (see figure 9.8).

The telephone symbols on the call keys were discarded, but the red and green colors are kept. This design was discussed with Arne Svensk. Svensk, with his experience in cognitive science, confirmed that the green and red colors are strong symbols of yes and no, but the abstract phone symbols are of less importance.



Figure 9.8 Interaction of accepting/declining calls and dialing

9.4.2 On/off, keylock and volume keys

Next, we discussed the other buttons placed on the phone. Just as with the navigation keys, redundant buttons on the sides were discarded. Walkman and camera buttons are not essential, and can therefore be excluded in order to achieve a cleaner look and feel. What is essential, however, is a dedicated on/off button and, by our judgment, volume keys. Also, an external keylock feature was discussed.

Different designs on these buttons are presented in figure 9.9.

The most common placement of the on/off button is on top of the phone (if not placed on the reject call key). This is an established standard used on many devices such as remote controls, digital cameras etc. We decided to place it on top and to improve its visibility and clarity. One thing we didn't want was to hide the on/off button. By using highlighted coloring and/or other visual guides, the user can easily find the on/off function.

Different keylock buttons and methods were also explored. The keylock feature can consist of a button (to be pressed or held down), a mechanical switch, or other combinations of keys. However, this function is dependent on the phone format (slide and flip phones does not necessarily need this function). Also, it's closely associated with the software, and therefore it's not thoroughly investigated in this thesis.

The volume keys are usually placed on either side of the phone, and often consist of two buttons (or a two-way rocker key) to increase or decrease the volume when talking. This functionality is quite essential, and therefore we decided to keep these buttons. Different styles and types of buttons were discussed, and were investigated further in the concept testing.

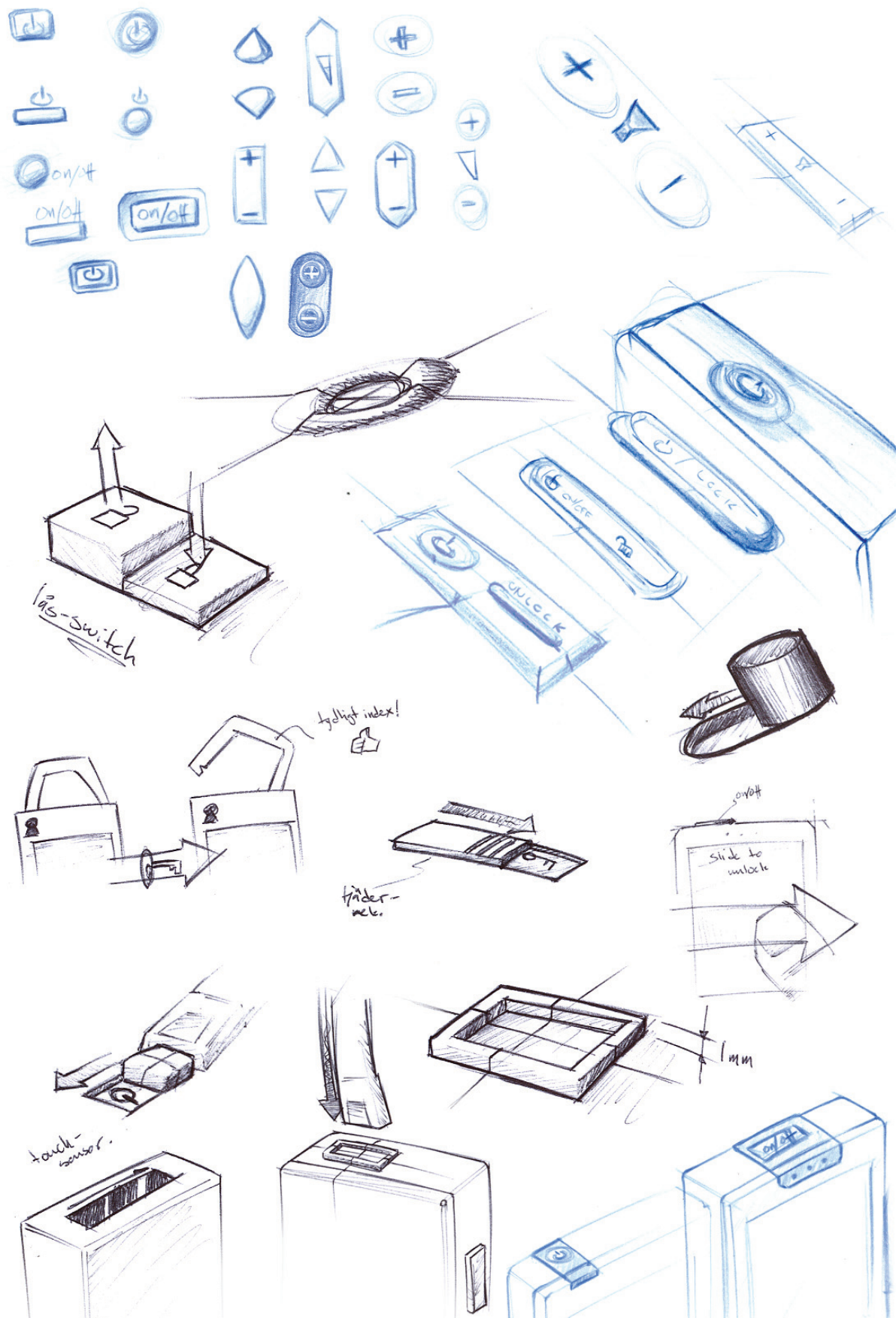


Figure 9.9 On/off, keylock, volume keys.

9.4.3 Shapes

Regarding the shape of the phone, we mainly wanted the phone to sit comfortably in the user's hand, without worrying over losing their grip (or face). Different ideas were put on paper and discussed. The main goal was to find a shape that is both comfortable and aesthetically appealing.

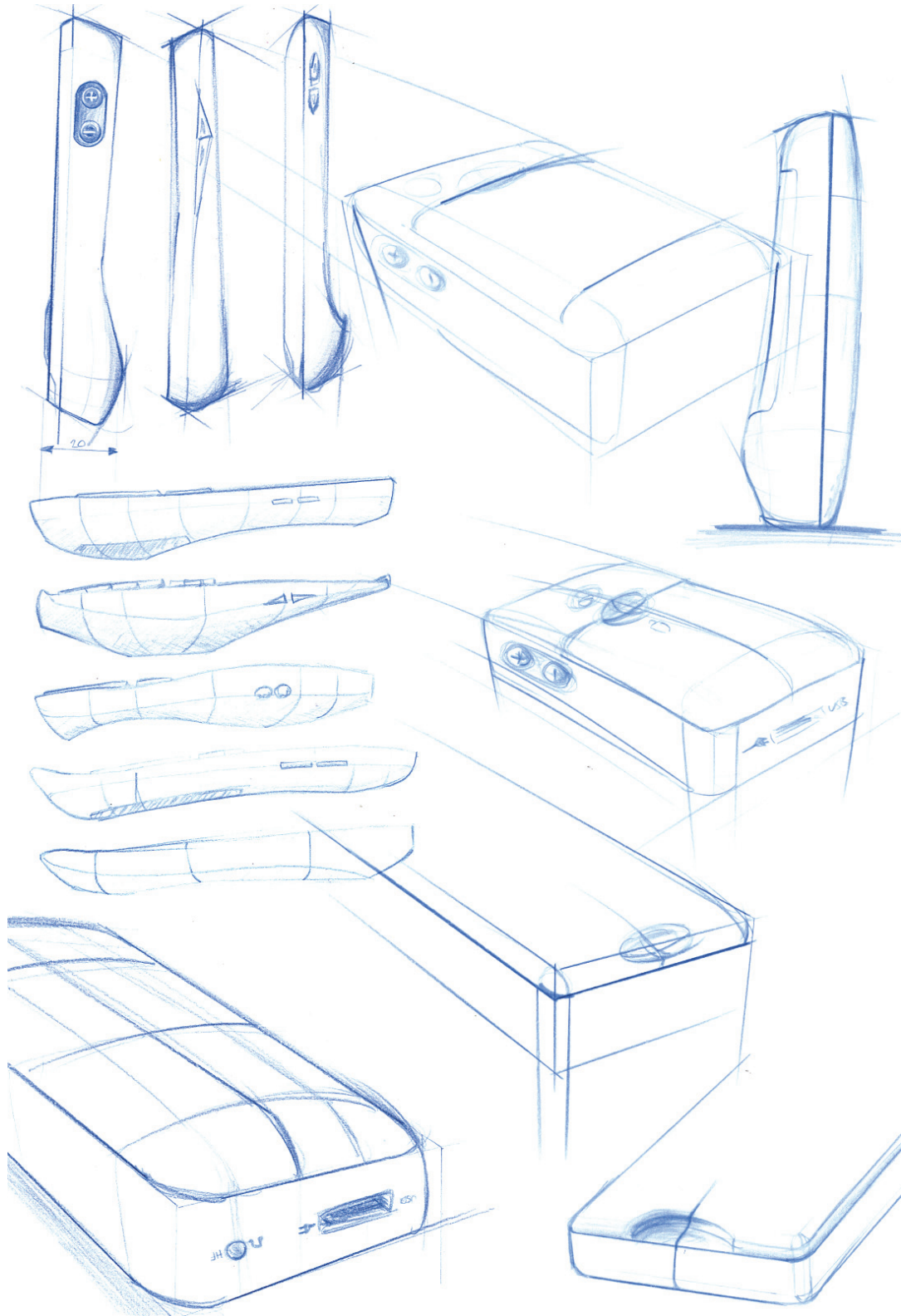


Figure 9.10 Sketches - shapes

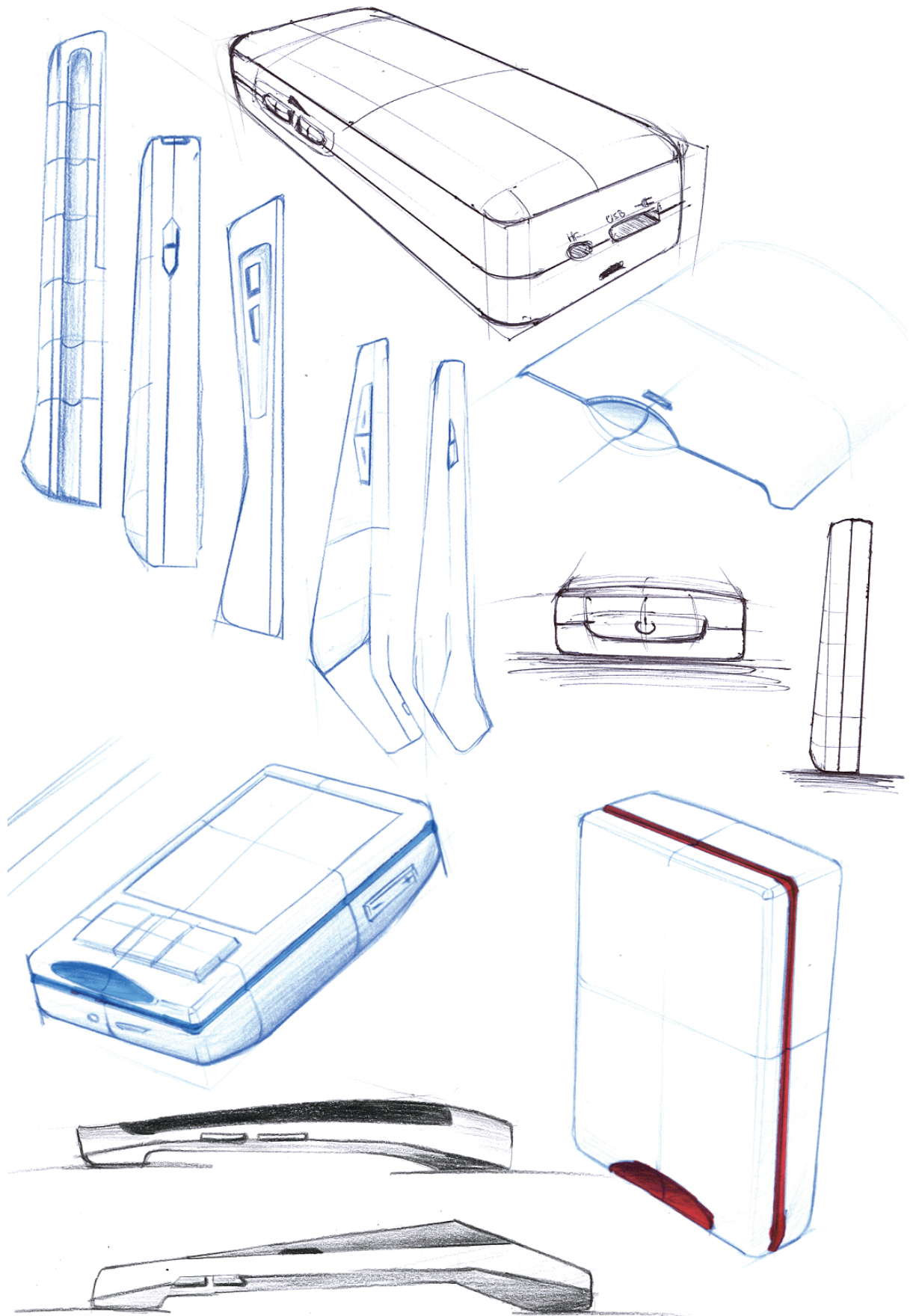


Figure 9.11 Sketches - shapes

In order to evaluate these different shapes, rough models made of plastic foam were developed (figure 9.12).



Figure 9.12 Rough models

With the actual shapes realized in physical models, we could evaluate them and decide on which shapes to move forward with (the weight was not representative).

9.4.4 Further sketching, possible concepts

With the above factors discussed and visualized, some rough concept sketches were made to illustrate complete telephone designs. Also, some additional ideas were discussed;

As different shapes were developed an idea of a concave surface fitting a thumb, placed below the navigation keys, was discussed. As noticed in the *expert review*, users with no experience of slide phones can find it difficult to understand how to open the phone. By placing an index, suggesting an action (upwards movement), the user can be lead to the correct usage. This index increases the slide *affordance* by making the action *visible* (Norman, see 2.6.2). Further clues on how to operate the slide mechanism can be given to the user by highlighting the fact that the phone consists of two main parts. This can be applied through a strong contrast color being visible on the side (where the two parts of the phone connect).

With the navigation keys having a new design, the clear key was separated from the soft keys and rocker key. Being placed to the right, below the right soft key, it is positioned as on most phones. However, as various concept designs were developed, new placements were discussed. Since the clear key is mainly used when typing digits or letters, its natural placement should be together with the alphanumeric keys. Further sketches and drawings visualizing these ideas are presented in figures 9.13, 9.14 and 9.15.

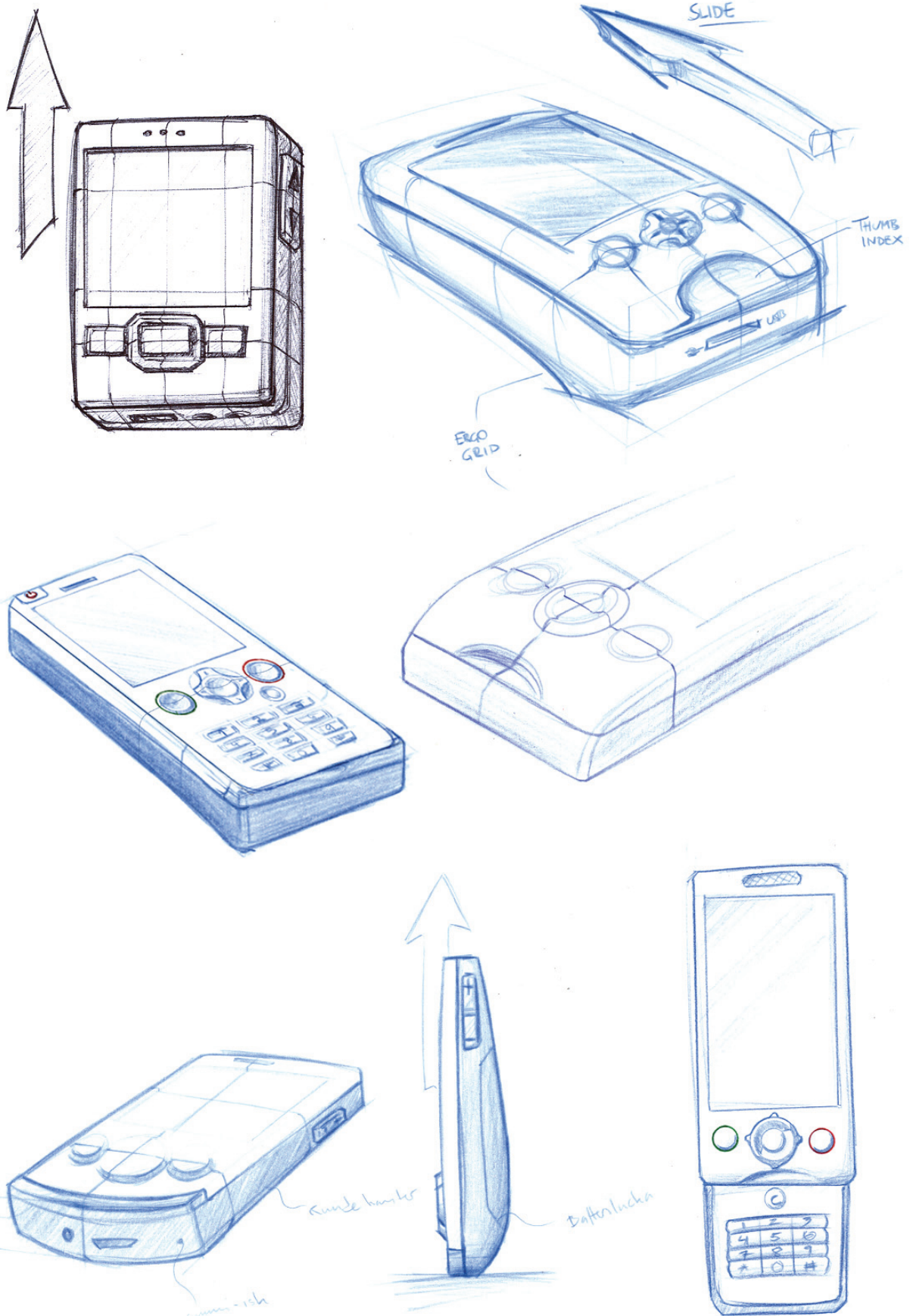


Figure 9.13 Design concepts

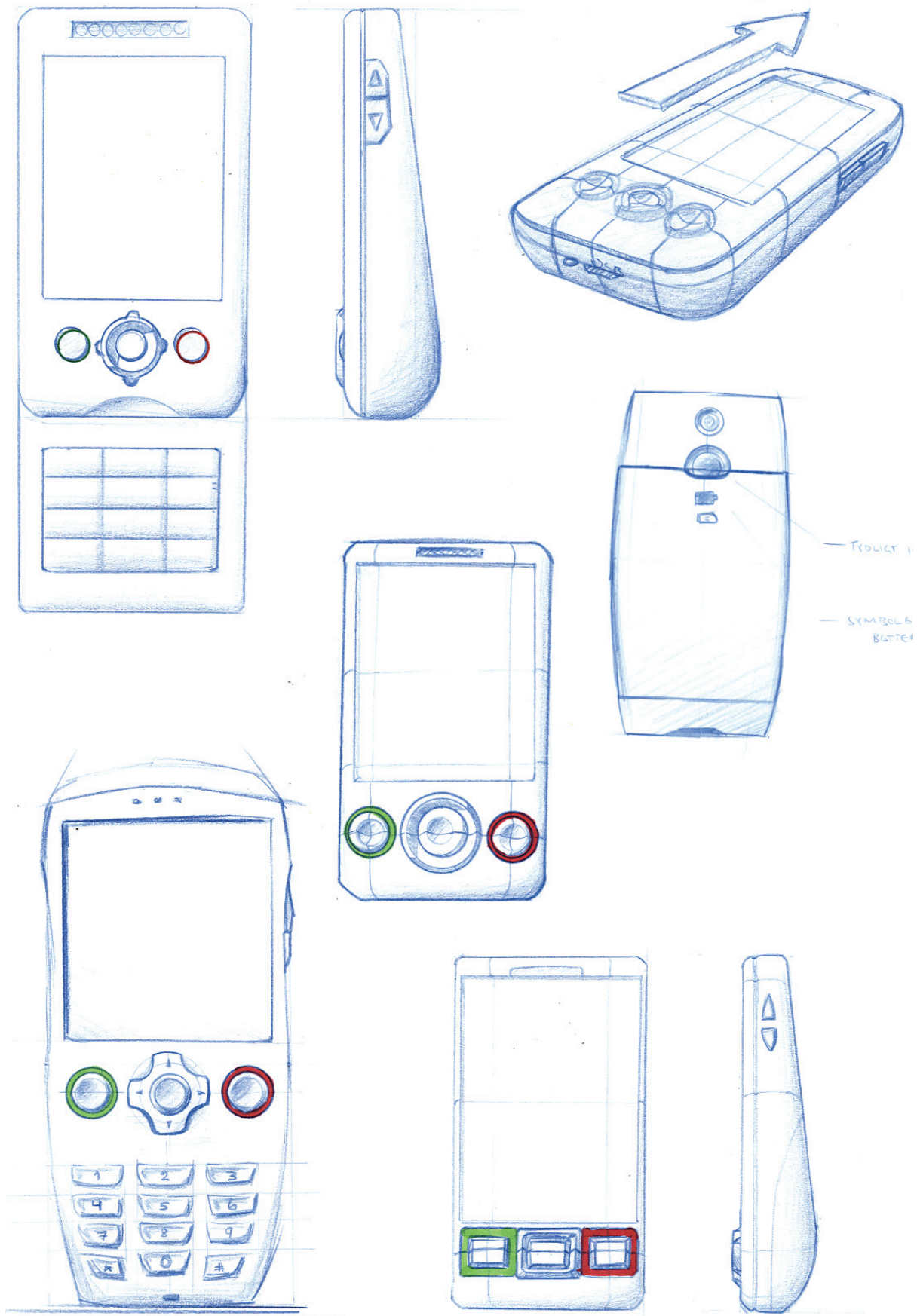


Figure 9.14 Design concepts

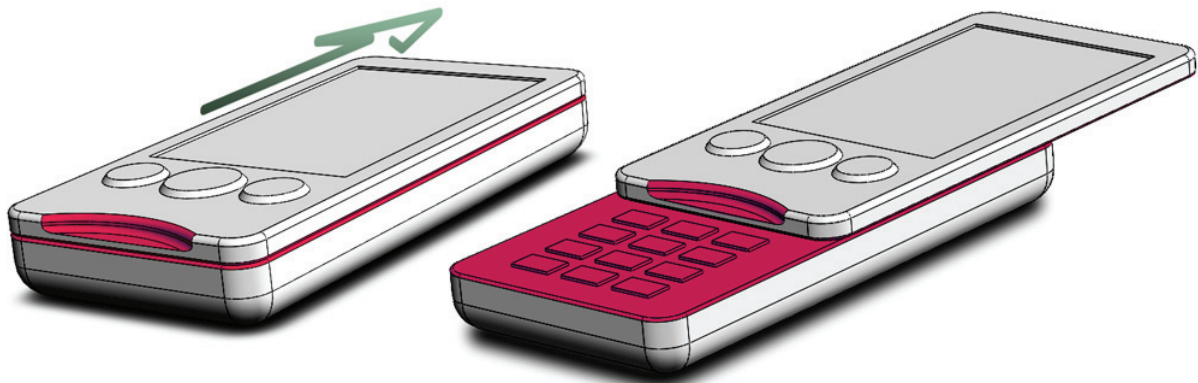


Figure 9.15 Visualization of thumb grip and semiotic guides

9.4.5 Concept elements

From the various ideas created, different concepts for evaluation were put together. In order to create these concepts, the main ideas and designs from the idea generation had to be concretized.

The main features to be tested in this step were the navigation device (i.e. rocker key), the alphanumeric keys and the volume keys as well as the shape of the phone's backside.

Navigation devices



Circular Rocker w. Center Select



Gamer Style Rocker w. Center Select



Square Rocker w. Center Select

Figure 9.16 Rocker keys

Three different rocker keys have been developed, as illustrated above. Two of them, the circular and the square rocker resemble rocker keys seen on various Sony Ericsson (and other brands) telephones. However, we've made them larger and more distinct, both regarding visibility and tactility. Also, a circular rocker with clear visible directions (inspired by gamepads) has been developed.

Alphanumeric keys



Figure 9.17 Alphanumeric keys

During the usability tests, two major problems were discovered with the existing alphanumeric keysets; they were either too small or too hard to sense (due to cluttered layouts and shapes). Flat buttons are aesthetically clean and offers a lot of space for printing numbers and letters on, while more bulging buttons are easier to sense. Both of these were tested, as well as possible combinations.

Volume keys



Figure 9.18 Volume keys

Three types of volume keys have been developed. All three sets (figure 9.18) are slightly larger than on most of today's phones, and the main factor to test was the positioning, and to investigate what shape was more appealing.

Shapes

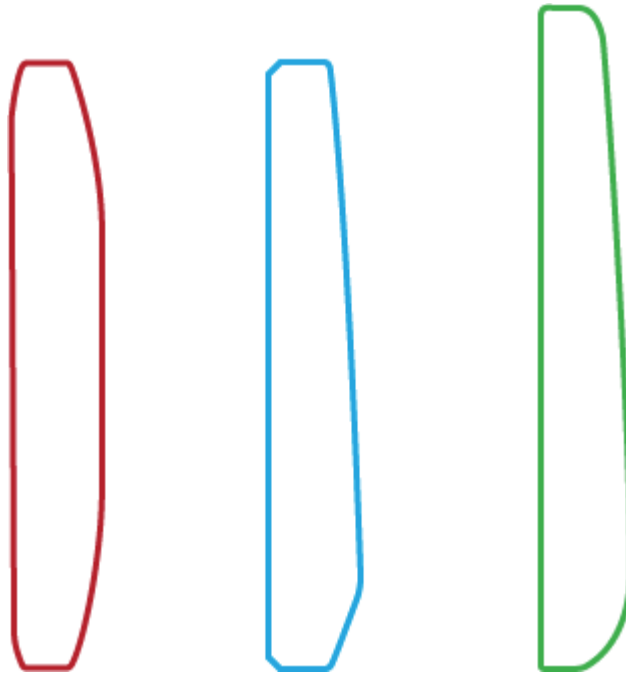


Figure 9.19 Overall shapes

The shapes discussed in the idea generation process were realized in rough sketch models to get a proper feel for which shapes worked and which didn't. The three shapes illustrated (in profile) above are the shapes we wanted to evaluate further. The first two, red and blue, are slide phones, while the green shape is a stick phone. The goal was to achieve an ergonomic, stable grip during use. The red one uses a smooth, "basic" shape, while the blue and green shapes are bottom-heavy in order to lower the center of gravity.

Additional features

The placement of the on/off button, as well as the clear key (C) was also investigated in the concepts.

9.5 COMPUTER VISUALIZATION

The concept elements presented were put together to create three concepts. The concepts were modeled in Alias AutoStudio and ProEngineer, and rendered in Bunkspeed HyperShot.

9.5.1 Concept A



Figure 9.20 Concept A

Concept A is a slide phone, with a basic round shape on the back. The navigation device is a large circular rocker key, with matching soft keys. The on/off button is placed on top to the left, with the volume key being placed up high on the right side. The alphanumeric keys are distinguished and bulging, with the clear key (C) being placed above them. The concept also features a thumb index at the bottom, in order to clarify the sliding mechanism for first-time users.

9.5.2 Concept B



Figure 9.21 Concept B

Concept B resembles concept A, but has some major differences. Its backside shape makes the center of gravity lower, which stabilizes the grip when reaching for the alphanumeric keys. Also, the rocker key is square, offering more clear directions. The alphanumeric keys are larger and flat, creating a simpler look. The clear key is placed to the right below the navigation keys, offering more space for the alphanumeric keys on the lower part of the phone. The volume key is placed slightly lower than on concept A, and its on/off button is larger and centrally placed.

9.5.3 Concept C



Figure 9.22 Concept C

Concept C is a stick phone with all features and functions visible directly. However, the space available for the display and the keyset is limited. The gamer-style navigation device is used, and the alphanumeric keys are a bit smaller than on concept A and B. However, they are still well separated. The volume keys are divided into two separate round keys, placed fairly high on the right side. The shape of the phone is rounded and drop shaped to maximize the comfort of the grip.

9.5.4 Rapid prototyping

The concepts were converted to STL files for prototype manufacturing using a stereolithographic machine (SLA), i.e. *rapid prototyping*. The prototypes are made of synthetic resin (plastic).



Figure 9.23 Concept prototypes

9.6 EVALUATION AND TESTING

A usability test, according to the hallway testing method, was performed with the three concept models. Due to the limitations of the models, e.g. the lack of clickable buttons or other functionality, it was difficult to properly test typing performance. Therefore the tests focused on how the users experienced the shape, size, grip and placement of elements. The user group was largely the same as for the usability test: six users, 25-65 years of age. The users sat down with the models and were given the following questions:

- *Which shape offers the most comfortable grip?*
- *Which set of navigation keys do you prefer (regarding tactility, size, shape)?*
- *Which set of alphanumeric keys do you prefer (regarding tactility, size, shape, layout)?*
- *Which placement of the clear key do you prefer?*
- *Which placement and design of the volume keys do you prefer?*

9.6.1 Test results

Grip: All users preferred the drop shape of either B or C. The shape makes the phone feel comfortable and sit well in ones hand. Concept A:s shape made it difficult to comfortably reach the lower keys while maintaining a good grip.

Navigation keys: Most users felt that Concept B:s square rocker key was distinct and easy to locate by feel (i.e. good tactility). One user commented that the square rocker worked fine when navigating up and down, but not as well sideways, due to the shape of the thumb. Concept A was better at this with a wider impact area. Aesthetically-wise, it was a 50-50 draw between the square rocker (B) and round rocker (A). The gamer style-rocker of the C-concept was considered to have clear directions visually, but had poor tactility and felt too small and cluttered according to all users.

Alphanumeric keys: The small, flat buttons of concept C was disliked by most users. The well separated, bulging buttons of concept A, and the large flat buttons of concept B was liked equally, but for different reasons. The large buttons (B) are easier to locate by vision, but the bulging smaller buttons are easier to feel tactility-wise. Many users suggested a combination of these buttons, i.e. making the bulging buttons slightly larger.

Clear key: Concept A hade the clear key placed just above the alphanumeric keyset, which was appreciated by most users due to its proximity to the typing keys. However, some users felt that it was squeezed in too tightly and hard to press with one's thumb. Concept B has the clear key placed on the upper part of the phone, but well separated from the navigations keys, making it easy to locate and use, although not being as comfortable as on Concept A. Concept C had the clear key grouped with the upper keyset (navigation keys), which is a "standard" placement and was neither liked nor disliked.

Volume keys: The shape of the volume key on concept A was liked by many, being easy to feel. However, some users claimed that it was placed too high, causing the thumb to reach out too far, and thereby compromising the grip of the phone. The placement on concept B was like by some, making it more accessible during a call, although some users thought it was placed a bit too low. Also, the distinguished symbols (+/-) were generally liked.

9.6.2 Expert evaluations

Arne Svensk was again asked to participate in an expert evaluation. He was faced with the same questions given to the users above.

Svensk's thoughts matched the general user opinion, confirming that the drop shaped back of concept C (and B) was comfortable in one's hand, providing a stable grip when reaching the different buttons of the concept. Also, he confirmed that the square rocker of concept B had the best tactile feel, while the gamer style rocker on concept C looks usable, but is quite hard to handle. On the alphanumeric keys, he commented that the bulging buttons on concept A has "character" and are easy to locate by feel.

He felt that Concept A's clear key had a good placement visually, but is squeezed in and easy to access by mistake. On concept B, the separate placement of the clear key makes it easy to locate and manage. Regarding the volume keys, concept B was appreciated the most. The lower placement makes the keys easy to locate and use during a call.

With Svensk, we also discussed placement of the on/off-button. Being placed on top, should it be positioned to the left, to the right or in the middle? Placing it in the middle offers the most universal use, however, Svensk states that a break of symmetry will cause it to stand out better, being easier to find.

Lena Sperling: For this evaluation, we also interviewed Lena Sperling who is working with design and hand ergonomics at IKDC. Sperling commented on that the center of gravity of a hand-held device shall be placed inside the hand to achieve a good grip which conforms to our ideas with the slightly drop shaped back. Sperling also gave us feedback regarding the shape of the phones' edges, claiming that both concept A's and B's sharp corners can be problematic for some users, especially females and seniors. Female users have higher sensibility in their hands, causing the sharp edges to feel more uncomfortable. Sharp edges also affect senior users, or users with rheumatism that has to use a greater percentage of their strength to grip the phone. This has to be considered in order to reach a large demographic and be compliant with the Universal Design thinking.

Sperling also pointed out the importance of using as many senses as possible. Especially, the haptic feel is of large relevance in our project. Proprioception, i.e. the ability to sense the body's position, movement and orientation, is an important factor when designing hand-held devices. The phone should not only have a good tactile feel, but also be comfortable to grip regarding hand movement, strength etc.

9.7 DESIGN DECISIONS

The final concept was designed using the input from the concept evaluation, combined with the expert opinions. This design should not only feature the basic shape and button layout, but also color choices, symbols and numbers, correct material and aesthetical features.

9.7.1 Choice of material and colors

The material of the phone should provide a good grip and a nice feel friction-wise. The choice of material on the analyzed Sony Ericsson phones has been discussed briefly earlier. However, to get a clear picture of what choices are available, a mood board representing different materials on mobile phones was created.



Figure 9.24 Materials

As shown in the mood board (figure 9.24), several different materials are used on today's phones. One of the most popular phones, the iPhone 3G, uses a glossy plastic material, while its precursor, the original iPhone, had a matte aluminium finish. The soft touch³ rubber-like matte plastic material is widely used on Sony Ericsson's phones as well as on Google's Nexus One. Some cheaper models use a standard matte plastic finish.

One problem with the soft touch material is that with brighter colors dirt easily sticks to the surface. HTC has tried to solve this problem by using a Teflon coating.

Grip-wise, the soft touch material is superior, offering a rubber-like high friction surface. This material was also promoted by Lena Sperling. Therefore, the choice of material for the phone concept will be soft touch (on the back of the phone).

Use of materials and colors

Selecting colors for the design wasn't easy. They have to convey elegance and style and at the same time be in high contrast to each other in order to clarify buttons and functions.

When choosing colors, they are highly dependent on the choice of material. High contrast colors, such as black and white, can still be hard to distinguish if the material is reflective.

To differentiate functions and buttons, it's useful to mix different materials. The above mentioned soft touch material mixed with a glossy plastic creates a contrast, both visually and texture-wise.

Figure 9.25 represents some inspiration used when selecting colors. The primary mindset is to use basic colors like black, grey and white, adding a complementing "sharp" color (e.g. orange or green) to differentiate important functions and buttons, making them easy to find. The board also presents some interesting material combinations of plastics and aluminium.

³ Soft touch materials, i.e. thermoplastic elastomers, (TPE) are plastic materials with rubber-like features. They are suitable for injection molding and mass production. For instance, DuPont offers their "Hytrel" line of soft touch materials [17].



COLOR / MATERIAL

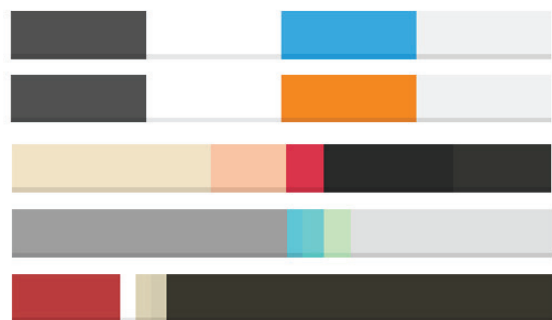
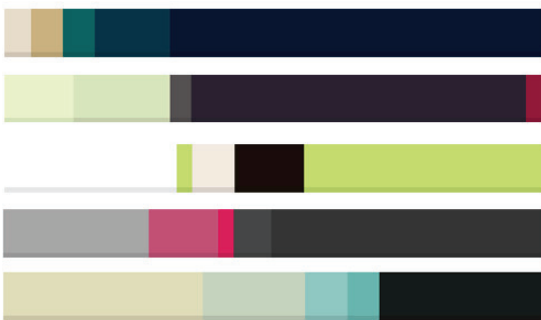


Figure 9.25 Color and material board

9.7.2 Symbols and fonts

Before completing the concept, the design of the symbols had to be decided, as well as what fonts and colors to use for letters and numbers.

Six main symbols are needed;

- On/off
- Volume up/down
- USB connector/charger
- Headphone connector
- SIM card
- Battery

For some of these, there are established conventions that could be used, only focusing the design on aesthetic details and colors. This includes the SIM card-, battery-, on/off- and headphone symbols.

For the volume keys, various designs exist using different arrows and symbols. Using plus and minus symbols is however very straight-forward and clear. Therefore, it was decided to use these in the spirit of Universal Design. These symbols are representative for increasing and decreasing something in many cultures and contexts.

For the USB connector there is an established symbol. However, the USB connector will also be used as a charger (due to environmentally friendliness and simplicity aspects as discussed earlier), and a new symbol is needed, explaining both the USB connectivity and the charger functionality.

The existing USB symbol is also only recognized by experienced users of computers.

For stand-alone chargers, different symbols occur on today's consumer products. Various designs of stylized lightnings are used, as well as symbols for AC voltage (e.g. Apple MacBook).

Finding one universal symbol symbolizing both the USB and the charger turned out to be very difficult. Therefore, it was decided to divide them and use two symbols. For the USB symbol, simply the text "USB" is used. This is due to the fact that the official USB symbol is not recognized by many of the potential customers.



Figure 9.26 USB symbols (not being used on the phone design)

For the charger, a simplified lightning symbol was considered the most understandable choice.



Figure 9.27 Symbols for headphones, charger/USB and on/off

When deciding on fonts for the concept design, some alternatives were discussed. Gill Sans MT and Century Gothic Pro are both clean, visible sans-serif fonts. Also, the existing Sony Ericsson font set is clear with high visibility.

Gill Sans MT	1 2 3 ABC
Century Gothic	1 2 3 ABC

Figure 9.28 Fonts

However, we were not really satisfied with any of the numbers of neither Gill Sans MT nor Century Gothic; they did not convey the desired modern look. It was instead decided to go with the Sony Ericsson font on the numbers. This decision will also make the concept consistent with the Sony Ericsson style.

For the letters (ABC, DEF, GHI etc.) on the keys (used for texting), we decided to go with Century Gothic. This font is very visible and clear, as well as being modern looking and it matches well with the Sony Ericsson font numbers.

1 2 3 4 5 6 7 8 9 0

Figure 9.29 Sony Ericsson font

ABC DEF GHI JKL MNO PQRS TUV WXYZ

Figure 9.30 Century Gothic



Figure 9.31 Combination of SE Font and Century Gothic

With decisions on symbols, font, materials and colors, it was time to model the final concept design.

10 Final concept design

This chapter presents the final design concept developed during the project. The phone's main design features are presented, as well as functionality and interaction features.

10.1 CONCEPT MERGING

The final design is based on a merger between the different concepts. It's based mostly on the slide concepts (A and B), but features the rounded backside shape of concept C. The square rocker and soft keys from concept B are the most distinguished and therefore used in the final concept. However, the width of the rocker key has been increased in order to accommodate to the findings from the prototype testing. The alphanumeric keys are as large on concept B but provide the nice tactile feel from concept A. The volume keys are placed slightly higher than on concept B. The thumb grip from concept A was considered the most comfortable (and aesthetically appealing) and is therefore used.

10.2 PRESENTATION OF THE DESIGN CONCEPT

10.2.1 Overall design

The phone was designed to be quite neutral; it should fit *most* users and not be obtrusive. The front has a soft white color that conveys friendliness. The overall design resembles the products presented in the mood boards (section 9.2), i.e. presenting its functionality clearly. This mindset resembles Dieter Rams' principles. Only the most important features are visible, focusing on the phone functionality (*visibility*, see Norman section 2.6). The shape is simple and kind, lowering the visual complexity.



Figure 10.1 Design concept

Three main soft keys and a rocker key are the most prominent features on the front together with the display. All three soft keys are aligned and look alike, conforming to the theories of Norman and the gestalt laws (section 2.6). Also, the clear key (C) is placed below the main keys to the left. It is visible and clear but still discrete.

At the bottom, the thumb index is visible, implying an opening-movement upwards. This design element adds *affordance* to the opening mechanism.

The navigation keys were thoroughly redesigned from a standard Sony Ericsson handset, with only three soft keys and a rocker, instead of seven or eight buttons. Also, the buttons are able to light up in order to explain their current function. By keeping the number of buttons down, unnecessary complexity can be avoided.



Figure 10.2 Backside

The back (and sides) of the phone are dark grey and of soft touch material, providing a comfortable tactile feel and a good grip. The back only contains a discrete camera and symbols on the battery cover for battery and SIM card. Again, simplicity and functionality is the main focus.

10.2.2 Alphanumeric keys

As the concept is a slide phone, the alphanumeric keyset is only visible when the phone is unslid. The alphanumeric keys are black, in contrast to the white background. The numbers and letters are white and easy to read. The buttons are large with clear spacing, making it easy to navigate by tactile feel. The buttons are slightly bulging, enhancing the button affordance. The rectangle shaped buttons resembles the phone design in general, adding consistency to the concept.



Figure 10.3 Alphanumeric keypad and dialing interaction



Figure 10.4 Close-up of the alphanumeric keys

10.2.3 Features

A discrete orange border (see figure 10.5) is separating the two parts of the phone, clarifying that it can be opened to reveal the alphanumeric keypad. The border directs attention to the separated parts of the phone, and hints at the hidden alphanumeric keypad.

The on/off-button placed on the phones top is highlighted with the same orange color to make it instantly visible. The details are clear and obvious but not over-explicit.



Figure 10.5 Side view

At the bottom of the phone, there are connectors for USB (also used for charging) and headphones, with clear, white symbols (figure 10.6). The design is simple and features no unnecessary design elements.



Figure 10.6 Bottom connectors



Figure 10.7 Concept measurements (mm)

The concept has a height of 100 mm, a width of 50 mm and its thickness varies between 10 mm and 16 mm due to its drop shaped back. The concept is slightly wider and taller than a standard slide phone. When the phone is un-slided, it has a height of 145 mm.

10.3 INTERACTION

The red and green call keys are discarded, and their function is applied to the soft keys. To clarify the current event, e.g. when receiving a call, the keys light up in green and red through a small transparent band outside the soft key (figure 10.8) to enhance the soft key mapping. This helps the user to easily connect the soft key to its current function.



Figure 10.8 Green and red lighting around soft keys

10.4 SHOWCASE

Further images, renderings and user scenarios.



Figure 10.9 User scenario



Figure 10.10 User scenario



Figure 10.11 Alternative color scheme: *Mocca*



Figure 10.12 Standard and alternative color scheme

10.5 PHYSICAL MODEL

Two mockup prototypes showing the concept's two different states (opened and closed) were built using rapid prototyping. The models were then processed with various tools and painted. Finally, stickers were applied in order to increase the level of detail. However, these mockups do not fully represent all the features of the design concept.



Figure 10.13 Mockups



Figure 10.14 Mockups

11 Discussion

This chapter is a reflection of this project and its outcome. The goal of this master's thesis was to present a set of guidelines as well as a design concept based on usability tests and research. These goals were achieved, as both a very thoroughly developed set of guidelines and a fully feasible design concept has been presented.

Throughout this project new challenges and problems occurred, and new knowledge had to be gained in order to complete the project. The process has been very interesting, inspirational and fun, but also very challenging.

This project and its outcome is a very good testament of our education, as it is cross-disciplinary and combines different subjects related to product development. These subjects include human factors, usability testing, marketing, industrial design and mechanical engineering. The co-operation with Sony Ericsson worked out well and gave the project a realistic feel.

All together, we are very satisfied with this project and its outcome.

11.1 RESULT DISCUSSION

11.1.1 Guidelines

The guidelines developed were based on our own review, the expert reviews and the usability test. These three main sources were fused into a set of practical guidelines. Also, inspiration was drawn from existing mindsets like the gestalt laws and Donald Norman's theories. When developing the guidelines, we wanted the level of abstraction to be fairly low. There are a number of existing principles (e.g. Universal Design and Dieter Ram's Ten Commandments) that are abstract and universal. Our guidelines are more hands-on, but still leave room to freely explore different design ideas and concepts.

We feel that the guidelines are ready to be used for developing commercial products, and that many companies could benefit from using them in their design projects. They are based on mobile phone design, but could also be deployed when designing other hand-held devices.

11.1.2 Concept design

The design presented in this thesis is a fully feasible concept. It is based on Sony Ericsson's standard graphical interface and demands no new technology development.

The style of the phone is unobtrusive and neutral, being accessible for a lot of different user groups. We have successfully managed to combine appealing aesthetics with high usability (both usability impression and actual usability). The concept includes two major usability improvements: the simplified navigation keyset and the ergonomic drop shape, as well as a lot of other smaller improvements making the phone easier to use. The design contains large and clear buttons and symbols making it usable for people with decreased vision or dexterity, as well as minor cognitive disabilities. However, it is not exaggerated neither regarding size nor design features. It is subtle and obvious rather than over-explicit.

11.1.3 Usability impression

Quite early in the process, a brand new term was established: *usability impression*. This term became guiding throughout the entire project. It became clear that phones that were easy to use, were not always conveying this fact, and vice versa. The term *usability impression* defines the user's initial thoughts and expectations on a phone. If these expectations aren't met, the user will not be satisfied with the phone, and maybe chose another brand the next time he or she is purchasing a phone. Therefore, it is of extremely large relevance that a phone conveys an appropriate feel regarding usability. If a phone is easy to use, it should convey this. This thesis' outcome has also proved that usability and style doesn't have to interfere.

11.2 PROJECT DISCUSSION

11.2.1 Time plan

Developing the time plan was one of the first things we had to encounter during this project. Initially, we had little knowledge of how the project should be carried out and it was hard to estimate how much time every step in the process needed.

We had never before developed and conducted a usability test, and we didn't know how long the planning and post-test analysis would take. After discussing the tests with Sony Ericsson, and visiting their testing site, a preliminary time plan could be established.

The actual project time was three weeks longer than expected. This was due to two main factors;

- The analysis and interpretation of the usability test data took longer than expected.
- The design process also took longer than expected, due to technical problems with 3D modeling and prototyping.

From this project, we have learned that developing a time plan is very hard, and it is important to be careful when distributing the time for the different steps in the process. We cannot expect all steps of the process to run smoothly, as new problems and questions often occur unexpectedly.

11.2.2 Method

The method used in this project was a combination of existing methods for design projects and usability testing. The method for usability testing established by Jeffrey Rubin was accurate and easy to apply. The difficult part of the usability testing was to act as a test moderator, and knowing how to behave in this role to make the test person comfortable. When performing tests and asking questions it's important not to lead the user into certain answers or be too controlling. The users has to be given time to make their own conclusions.

The decision to perform a pilot test before the more extensive test was good, since we got experience from moderating test sessions. In general, the usability testing went well. A lot of good data was collected, which helped us a lot further along in the project.

The design methodology as described by Eckhardt is fairly loose and adaptable, which suited our project well. We could use the basic design strategies presented, but adapt them to our situation (e.g. we used our guidelines and test findings to evaluate the concepts instead of a standard function analysis).

In general, we are satisfied with the choice of methods.

11.2.3 Limitations

The initial limitations set up for the project mainly regarded the extent of the design concept, but also what facilities and equipment to be used.

As for the extent of the project, we chose to focus on hardware usability (with little or no software usability focus). As the project went forward, we realized that hardware usability on mobile phones is an extensive topic, and there is a massive amount of design factors to consider when both testing and designing a mobile phone.

During the usability testing, the research automatically focused on the most important design questions, such as navigation keys, alphanumeric keys, size, grip and shape. Smaller details such as on/off and volume keys, connectors and placement / design of battery cover and space for SIM and memory card were not as thoroughly investigated.

Looking back at the project, we realize that the limitations set should be more extensive, to make the project focus more narrow (e.g. limit the research to the keyset). As it turned out, some questions are more thoroughly investigated while others aren't. The time and resources for the project simply couldn't cover all the factors that we wanted to investigate when starting the project.

11.2.4 Usability testing

The usability testing was discussed briefly in the method discussion. As mentioned, we are satisfied with the result and we have learned a lot about both usability issues as well as how to prepare and monitor a test session.

The key to success was the pilot test. The results from this test were not very accurate or useful, since we did not know how to act as moderators. However, the experience gained from this session was invaluable. For every test, we got more comfortable in the role and could focus more on the actual test than on our behavior. When it was time for the more extensive usability tests, we could perform good test sessions right away.

In a standard product development process, usability testing is often used to confirm (or deny) design ideas that have been developed by designers. When the design is tested in usability tests, changes in the design can be made in order to make the phone more usable. In this project, we wanted a stronger foundation for usability before designing the phone, in order to reach a phone with high usability. Therefore, the phone design was based on usability tests from similar phones in order to solve the main usability issues directly.

This alternative take on usability testing and product development is something that companies should apply more when developing products. Some major usability problems can be easily avoided and resources can be saved.

12 Conclusion

The purpose of this thesis was to investigate usability issues on mobile phones in order to develop a set of design guidelines and a design concept. The main challenge was to combine appealing aesthetics with usability, which we have proven to be possible. Even though demands on usability increases, demands on style and aesthetics do not decrease.

The guidelines are thoroughly developed and ready to use in a real product development process. They are aimed at mobile phone design but could be used for development of other hand-held devices.

The design concept could be used as a foundation for a commercial product development process. The initial market study shows that as of today (early 2010) there is a gap on the market for a product of this nature.

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