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Abstract

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Over one billion people own or use cellular mobile telephones. Therefore, industry practitioners are faced with a question: how big steps can they take when designing the user interfaces for their new products, or how closely should they stick with the already existing user interface conventions that may already be familiar to the consumers. The objective of this research work is to create and communicate new knowledge for design and usability practitioners about how to design and evolve interaction style conventions in mainstream, voice-centric mobile telephones. In the context of this study, interaction style denotes the framework consisting of the physical interaction objects, the abstract interaction elements, and the associated behavior or interaction conventions that are applied throughout the core functionality of the mobile phone, but excludes the stylistic appearance elements of the user interface.

The main research problem — *how do mobile phone interaction style changes affect the initial usability of a mobile phone for users with earlier experience with mobile phones* — is approached via several methods. A literature study compares the interaction styles applied in mainstream computing domains against the aspects relevant in the mobile phones domain. A heuristic analysis of contemporary mobile phones is used to formulate an understanding of the available interaction styles and analyze whether there is convergence towards specific types of interaction styles in the industry. An empirical usability testing experiment with 38 test users is conducted with a novel mobile phone interaction style to investigate differences between users who are already familiar with different mobile phone interaction styles.

The study reveals that interaction styles applied in contemporary mobile telephones are designed around menu navigation, and they implement the three primary operations — Select, Back and Menu access — with dedicated hardkeys, context-sensitive softkeys, or using special control devices like joysticks or jog dials. The control keys in the contemporary interaction styles are converging around various two- and three-softkey conventions.

The aspects related to indirect manipulation and small displays pose specific usability and UI design challenges on mobile phone user interfaces. The study shows that the mobile handset manufacturers are applying their usually proprietary interaction styles in a rather consistent manner in their products, with the notable exception of mobile Internet browsers that often break the underlying interaction style consistency.

Based on the results from the empirical usability testing, we claim that despite differences between interaction styles in contemporary mobile phones, users do not face significant difficulties when transferring to a novel mobile phone model.

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Keywords Mobile telephone, user interface, interaction style, interface style, usability testing, initial use, learnability

"Today, switching from one phone to another, or from one carrier to another, requires learning new menus and screen designs. The differences -- maddening as they are -- rarely add any value to the user experience."

— *BusinessWeek, 21-Nov-2002*

"Dad. What do I press? There is no red key."

— *Kristian Kiljander, 5 years*

Preface

The research work reported in this thesis has been conducted in the cellular mobile telephones research and development environment at Nokia. This is not a traditional academic research setting but instead a more business-driven, product creation project environment. Likewise, the spirit and approach in this study is applied research.

During 1995 – 1997 I was conducting mobile phone usability research work, and participated in several user interface concept creation projects at Nokia Research Center. In 1998 – 1999 I was working as a usability engineer in communicator and mobile phone product development at Nokia Mobile Phones. In 1998 I was also nominated to the Nokia-internal doctoral development program, which gave a concrete boost to this thesis work. In 1999 – 2000 my team's responsibilities included the creation of the mobile phone user interface strategy and roadmap of the company. During 2001 – 2002 I was heading another team in the user interface software development organization; now involved with the user interface design management and usability activities for Nokia's high-volume mobile handsets. From 2003 I have been working on the holistic management of Nokia's mobile terminal user interfaces and UI policies.

These different viewpoints to cellular mobile telephones usability research, user interface design and development, and strategic decision-making gradually have made me realize that there is a need for a more thorough and solid understanding of the application of the various user interface elements the industry is commonly applying in mobile telephones. The importance of ease-of-use as a product attribute is generally acknowledged, user-friendliness is a buzzword frequently used by top executives, and user-centered design methods are commonplace in the product creation process. However, I believe there are still gaps in our understanding of how we should evolve the products' user interfaces when a growing number of users already have experience in using a mobile phone. Similarly, there are signs and attempts of user interface convergence in the industry, and we should better understand what to converge and how to harmonize. I believe this thesis will increase and deepen the level of knowledge in these issues.

Tapiola, 31st October 2004

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Last but not least, I would like to express my very deepest gratitude to my family, my wife Maarit, and our children Kristian and Julia. This dissertation would have never materialized without the enormous amounts of peace, love, and understanding they have been giving to me over these years. :-)

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Glossary

1G First generation, circuit-switched analog cellular telephone systems introduced in early 1980s for speech services: e.g. AMPS (Advanced Mobile Phone Service) in the United States, NMT (Nordic Mobile Telephones), NTT (Nippon Telephone and Telegraph), and TACS (Total Access Communication System) in the United Kingdom

2G Second generation, circuit-switched digital cellular telephone systems introduced in late 1980s for speech and low bit rate data with more advanced roaming than in 1G: e.g. GSM, IS-95 (U.S. CDMA; Code Division Multiple Access), PDC (Personal Digital Cellular) in Japan, and US-TDMA (D-AMPS; Digital AMPS)

3G Third generation, packet-switched digital cellular telephone systems with better spectrum efficiency and bandwidth up to 2 megabits per second for higher rate data services: EDGE (Enhanced Data rates for GSM/Global Evolution), cdma2000, W-CDMA

API Application Programming Interface is a function library that application programs use to utilize services offered by the operating system

ARPU Average Revenue Per User is the (monthly) average amount of money received by the mobile operator or service provider from its wireless customers

Series 60 Nokia's smart phone interaction style and software platform

CE Consumer Electronics

(Cellular) mobile (tele)phone

A portable handset for use in telecommunication such as voice calling, data transfer, or multimedia messaging. Sometimes also *cellular phone*, *mobile phone*, or *wireless phone*.

Contextual inquiry

A structured field interviewing and discovery method used in user-centered design, and used e.g. by Motorola and Nokia.[1]

CUI Character-based User Interface presents the output of applications on a display screen of an array of boxes, each which can hold one character. CUI PC screens are typically divided into 25 rows and 80 columns. The character set dictates the available letters of the alphabet, digits, special characters, and graphics symbols.

Customer Mobile operators purchasing mobile phones in bulk from a mobile phone vendor are customers of the vendors. Likewise, consumers (or *end users*) purchasing phones from the mobile operators or directly from the phone vendors are customers. The

[1] Incontext. CLIENT LIST. 2004. [Cited 06-Jul-2004]
Available from WWW: <http://www.incent.com/clients.html>.

other stakeholders described in this study — e.g. content developers — are not referred to as customers in the context of this work.

Digital convergence

Convergence of contemporary computing capabilities, new digital multimedia technologies and content, and new digital communications technologies

ETSI European Telecommunications Standards Institute

Feature cannibalization

Cross-category feature cannibalization denotes a situation where a company introduces a product with features copied — and possibly improved — from another product or product category of its own or by another company, resulting in a decrease in sales of the original product

GPS Global Positioning System

GSM Global System for Mobile (Tele)communications is currently the most widely used technology standard for 2G mobile networks and phones. It provides digital voice and data services at maximum 14.4 kilobits per second. Improvements to the original GSM standard have increased the data rates: High Speed Circuit Switched Data (HSCSD) at maximum 115.2 kilobits per second, and General Packet Radio Service (GPRS) at maximum 182.4 kilobits per second (depending on the coding). As of March 2004, there were 1050 million reported subscribers in GSM networks worldwide.[2]

GUI Graphical User Interfaces apply the following basic components: a movable *pointer* symbol that is used to select objects and commands; a *pointing device* (usually a mouse, joystick, trackball, or touchpad) that is used to control the pointer; small *icons* that are used to represent commands or objects, a display-wide *desktop* where icons representing computing resources such as files, computers, documents, or printers, are grouped; *windows* that present the output from the executing applications to the user; and *menus* that are used to present available commands to the user.

HCI Human-Computer Interaction; sometimes also Computer-Human Interaction (CHI)

HTML Hyper-Text Markup Language

i-mode NTT DoCoMo's packet-based information service, technology, and business model to deliver Internet content to mobile phones

Idle (state) The basic or standby state of a mobile phone (user interface) where the phone is waiting for user input — e.g. a phone number to initiate a call. Usually there is a 'panic button' or 'global exit' in the user interface providing quick exit to the idle state from the menu structure or from applications with a single key press.

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[2] GSM Association. GSM FACTS AND FIGURES. 2004. [Cited 12-Oct-2004] Available from WWW: <http://www.gsmworld.com/news/statistics/index.shtml>.

Interaction style

Mobile phone interaction style is the framework consisting of the physical interaction objects, the abstract interaction elements, and the associated behavior or interaction conventions that are applied throughout the core functionality of the mobile phone. Within the context of this study, the interaction style definition excludes the stylistic appearance elements of the user interface, that are often referred to as the 'look' of the user interface.

Java A hardware-independent programming language developed by Sun Microsystems

LSK Leftmost **softkey**

MIDP Mobile Information Device Profile is a set of Java APIs for mobile devices

MMS Multimedia Messaging Service is an advancement over **SMS** allowing for non-real-time transmission of various kinds of multimedia content like images, audio, video clips, etc.

MSK Middle **softkey**

Navi™-key Nokia's one-softkey interaction style; first applied in the Nokia 3110 phone model

Navi™-roller Nokia's two-softkey-and-roller interaction style; first applied in the Nokia 7110 phone model

OEM Original Equipment Manufacturer is a company manufacturing a product to be marketed under another company's brand

OLED Organic Light-Emitting Diode display technology

PDA Personal Digital Assistant

Personal Trusted Device, PTD

Personal Trusted Device is a device with the following aspects: it is personal, controlled, and used by one person and carried by that person most of the time; it has an application platform with associated user interfaces for transaction related services such as banking, payment, bonus programs; it has the security functionality required for transaction related services: secure sessions, authentication, and authorization

PIM Personal Information Management

Qwerty The de facto standard alphabetic keyboard layout named after the six leftmost characters in the top row of alphabetic characters

R&D Research and Development

RSK Rightmost **softkey**

SDK Software Development Kit

Smart phone

A smart phone is a digital mobile phone that enables the user to perform daily personal information management tasks without compromising voice communication functionalities; these tasks may include text messaging and email, access to mobile Internet, personal time management, etc.

SMS Short Message Service is a service used in mobile communication systems by which users can send and receive short textual messages.

Softkey A multi-function key usually positioned beneath the mobile phone display with the corresponding textual or graphical function label shown on the display

Symbian Operating system for data-enabled mobile phones and other communication devices

UI User Interface

Universal design

Universal design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design

Usability 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 1998)

Usability knee

Abstraction to illustrate how a user interface has a breakpoint in the curve representing ease-of-use as a function of functionality

User Interface

Those aspects of the system that the user comes in contact with (Moran 1981)

User interface segmentation

Marketing strategy where a manufacturer is applying different user interfaces to support product differentiation

VAS Value-Added Service

WAP Wireless Application Protocol is a technology linking wireless devices to the Internet by translating Internet information so it can be displayed on the display of a mobile phone or other portable device

W-CDMA Wideband CDMA and cdma2000 are third-generation mobile radio system technologies providing speech and data services at up to 2 megabits per second. As of September 30, 2004, there were 132 million reported subscribers in the world's first W-CDMA and cdma2000 services worldwide.[3]

WIMP Windows, Icons, Menus, and a Pointing device; the type of user interface commercialized by the Macintosh and Windows operating systems. Nowadays synonymous to **GUI**.

WWW World Wide Web

XHTML eXtensible Hyper-Text Markup Language

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[3] 3G Today. 3G SUBSCRIBERS. 2004. [Cited 12-Oct-2004]
Available from WWW: <http://www.3gtoday.com/subscribers/>.

1. INTRODUCTION

This study investigates the concept of *interaction style* in the domain of cellular mobile telephones. There is no standardized user interface or interaction style widely used in the mobile telephones industry; instead, the manufacturers apply slightly different UI and interaction conventions when designing their mobile handsets. There is anecdotal evidence like the BusinessWeek quote below indicating that these differences are considered at least partially harmful:

> *"Today, switching from one phone to another, or from one carrier to another, requires learning new menus and screen designs. The differences -- maddening as they are -- rarely add any value to the user experience."*[4]

This study will analyze the elements of the cellular mobile telephone user interface, investigate and illustrate the interaction styles applied in contemporary mobile phones, and report of an empirical usability study conducted to shed light on how people with different mobile phone usage backgrounds can handle a completely new mobile phone interaction style. Consumer and product segmentation approaches used in the industry are illustrated to gain insight into how they are related with the concept of user interface segmentation.

1.1 Background

The modern cellular mobile telephone dates back to the late 1970s and early 1980s when the first cellular networks were launched in Japan and Scandinavia (Kiljander 1997). During the following 25 years the mobile phone has undergone a transition from a technology-focused professional tool of the early adopters and wealthy businesspeople, first to a yuppie show-off status gadget, and finally to a mass-market, consumer product and a highly integral part of the daily life of hundreds of millions of people globally. It must be noticed, though, that the mobile phone is still mostly a phenomenon of the developed countries in the world, as the least-developed countries have no or poor telecommunications infrastructure, and the current phones and subscriptions are too expensive for the majority of people in those markets.

The wireless communications business is now of substantial size and continues to grow. The estimated mobile phone subscriber and sales volume growth is shown in **Figure 1** below.

[4] BusinessWeek, EUROPE'S CLUELESS WIRELESS OPERATORS. 21-Nov-2002. [Cited 06-Jul-2004] Available from WWW: <http://www.businessweek.com/technology/content/nov2002/tc20021121_9441.htm>.

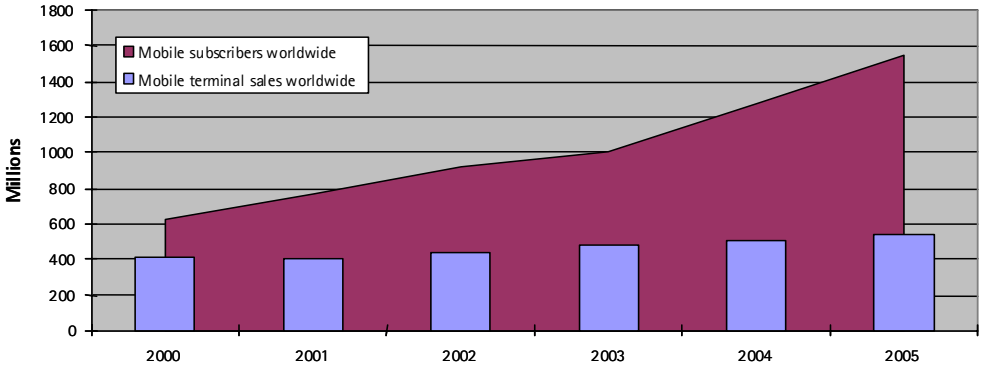

Figure 1. Mobile telephone subscriber and terminal sales estimates[5]

Telecommunications equipment manufacturers Ericsson, Motorola and Nokia entered — and established — the emerging cellular mobile telephones industry leveraging their presence and know-how in the military and industrial communications devices and telecommunications infrastructure components development and manufacturing (Mäkinen 1995). A detailed analysis of the cellular mobile telephones business and industry is outside the scope of this study except when it is related to the user interface aspects of the products, services, and technologies.

The evolution of the mobile telephone started from the early, car-mounted devices and has now reached a phase where the phone fits in one's palm. Häikiö (2001) defines the following evolutionary mobile phone product generations:

Car-mounted phones | Transportable phones | Handportable phones | Pocketable phones | Palm phones

Figure 2. Mobile phone product generations

The mobile phone user interface has gradually started to attract commercial and scientific interest. In the early 1990s, Motorola was the industry leader with a global market share of over 50%, while Nokia was a follower.[6] Nokia executives have later stated that at that time the company made a strategic decision to focus

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[5] The worldwide cellular mobile telephone subscriber volume estimates and sales volumes are consolidated from Prohm et. al. (2002, 2003) and from the following WWW sources [Cited 17-Apr-2002]:
<http://www.asee.org/prism/oct01/manbetting.cfm>,
<http://www.cto-ict.org/pages/forum/general/tech/global_issues/de_bono.html>,
<http://www.emc-database.com/website.nsf/index/pr020319>,
<http://www.iwvaluechain.com/Features/articles.asp?ArticleId=1224>,
<http://www.nokia.com/investor/eip/files/presentation.pdf>,
<http://www.qsigroup.com/istats.html>,
<http://www.wirelessnewsfactor.com/perl/story/12030.html>.

[6] PDAStreet.com. FORMER SUN EXEC HAS BIG PLANS FOR MOTOROLA. 18-Dec-2003. [Cited 06-Jul-2004] Available from WWW:
<http://www.pdastreet.com/articles/2003/12/2003-12-18-Former-Sun-Exec.html>.

on usability and industrial design to increase the appeal of its products among consumers (Häikiö 2001, Funk 2002). In that context '*usability*' has likely been used in a somewhat different meaning than the current, official definition of it: '*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 1998) With 'usability', mobile phone manufacturers were often referring to aspects like larger displays and taller display fonts than what the norm used to be, to more consistently designed interaction sequences, to softkey-based interaction styles compared to non-softkey-based styles, to aesthetically pleasing industrial design of the devices, or even to reduced amount of communications technology jargon in advertisements. Nevertheless, these product attributes are now commonly considered to be highly relevant in the industry.[7] Since the early 1990s the manufacturers' market shares have changed, and an implication of the relevance of the user interface is e.g. a recent piece of news: "*Working to revamp its image and catch-up with industry leader Nokia, … Motorola plans to ship handsets with a more attractive and easier-to-use interface…*" (Carew 2002).

The industry-wide emphasis to make mobile telephones easier and more appealing to use has generally resulted in improved product attributes such as larger displays, more logical menu structures and navigation conventions, more comprehensible display texts and readable fonts, and enhanced user interface personalization possibilities — such as ringing tones and graphics — for the end users, without forgetting the industrial design as a major element in creating emotional appeal. It is unlikely that mobile phone penetration would have been able to reach the current levels without the manufacturers' efforts to make the devices easier to use and more appealing to possess.

The cellular mobile telephones industry and business are evolving constantly. New technologies — packet data transfer GPRS, multi-mode terminals, Wireless LAN, 3G, multimedia messaging, voice control, positioning, and Bluetooth; to name but a few — are being introduced and are changing the way the users will use their devices.

As the mobile telephone industry is maturing, we can start to notice some signs of user interface convergence, as described in this study. This phenomenon follows the prediction of Mohageg & Wagner (2000) when they discuss user interface proliferation in the domain of information appliances: "*Initially, a variety of user interfaces and features will be available on a multitude of devices. … Of the devices that succeed, only a limited number of user interfaces will remain viable for each device. For any given class of device, a particular approach will be accepted or followed as a de facto standard.*" Some convergence activities are a result of user interface platformization – e.g. the cases of Microsoft Smartphone and Nokia Series 60 – and some seem to be happening without explicit manufacturer coordination, such as the convergence around a two-softkey mobile phone user interface. This study will investigate these user interface convergence activities in order to understand their effect on mobile handset usability and interaction style evolution.

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[7] Dow Jones Business News. 14-Oct-2003. "*Orange Chief Executive Sol Trujillo at the ITU Telecom World event in Geneva stressed that 'the industry must make its services easier to use'*"; "*Many companies have successfully redefined their brand image through strong focus on product design. Most senior managers recognize that design excellence brings stronger brand recognition and better profitability.*" [Cited 06-Jul-2004] Available from WWW: <http://www.wipo.org/sme/en/documents/wipo_magazine/03_2002.pdf>.

A change is also on its way in the mobile phone consumer base: in some countries the number of mobile phone subscriptions has already surpassed the number of inhabitants, since many people e.g. have separate mobile subscriptions for work and private use, like in Sweden, where the mobile phone subscription penetration rate reached 100.1% in March, 2004.[8]

The handsets need to be highly intuitive and convenient to use to be embraced by the 'late majority' — for a definition of *late majority* and other consumer groups see **Section 2** or Moore (1995) — and at the same time they must fulfill the expectations of the growing amount of replacement customers. These customers already have experiences from using their previous phone or phones and their expectations towards the new models may be different from those of the first-time buyers. E.g. changing from an already learned user interface to another is difficult for the user due to the challenge of learning new ways to perform familiar tasks (Ketola 2002).

At the same time there is consolidation happening in the mobile operator business and globally operating operators have started to emerge[9]. Their needs and position differs from the smaller operators. The overall cellular mobile telephones value chain is also widening as a broad scope of wireless services is being introduced. Ten years ago cellular mobile telephones were used for voice calling, after that we have a seen tremendous growth in the usage of text messaging in the GSM markets in Asia and Europe, and now we are in the middle of the wireless Internet services take-off that has already taken place in markets like Japan. The mobile device user interface plays a key role in enabling these new services in the cellular mobile telephones business and industry.[10] This interplay is examined in this study.

In the early 1990s the product renewal cycles were significantly longer in the mobile phones industry than what they are today, and there were much fewer products — e.g. in 1995 Nokia introduced six mobile phone models[11] whereas the number of mobile phone announcements made by Nokia during the first half of 2004 is eighteen[12] — so it was possible to design and develop the user interface for a new product or product generation almost from the scratch. There was no widely accepted de facto concept of a cellular phone user interface and thus it was possible even to break the UI conventions of the previous generation to some extent when doing the design work for a new phone model. Today a successful

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[8] Yahoo News. 02-Jul-2004. [Cited 06-Jul-2004] Available from WWW: <http://story.news.yahoo.com/news?tmpl=story&cid=1510&ncid=1510&e=6&u=/afp/20040702/tc_afp/sweden_telecom_040702142923>.

[9] Strategy Analytics. [Cited 06-Jul-2004] Available from WWW: <http://www.strategyanalytics.com/press/PRPK009.htm>.

[10] Dow Jones Business News. 14-Oct-2003. "*Orange Chief Executive Sol Trujillo at the ITU Telecom World event in Geneva criticized the design of Motorola Inc mobile phones, saying that Nokia Corp's handsets are easier to use; Orange customers using Motorola handsets sent on average 14 text messages a month compared with 45 a month sent by owners of equivalent Nokia phones. Orange believes that this is due to the simpler Nokia user experience.*"

[11] Nokia. [Cited 18-Apr-2002] Available from WWW: <http://www.nokia.com/investor/annual/pdf/ar1995_1.pdf>.

[12] Nokia. [Cited 04-Aug-2004] Available from WWW: <http://www.nokia.com/nokia/0,1522,,00.html?orig=/2004/Q2/index.html>.

company must churn out new products every quarter, and there is simply no time nor designers to redesign everything for every new product.

The handset manufacturers apply various approaches to mobile phone segmentation: there are inexpensive mobile phone models for first-time buyers and young people, more conservative 'classic' phones for business customers, premium phones for style and fashion-conscious customers, and heavy-duty handsets for mobile workers in harsh environment. Nokia is exercising an approach the company calls 'user interface segmentation' in its product portfolio management. This means creating and maintaining a set or a portfolio of different *user interface styles* to be applied in specific products (Kiljander & Järnström 2003). As the expressiveness of the different styles varies, so does the number and type of features that can be designed in an usable manner for a mobile phone product applying a specific style, as described further in **Section 2.3.5.**

This study has been conducted in a business-driven R&D environment at Nokia. During 1999 – 2000 I was facilitating the creation of the mobile phone user interface strategy and roadmap of the company. The user interface roadmap is the grand plan outlining the planned evolution of the user interfaces platforms, styles, and concepts of the future. Nokia has a strong roadmapping culture, and the user interface roadmap was situated in a focal point between the business unit strategy and product marketing functions, and the product creation and software development organizations. The numerous discussions we had with product roadmappers, product category managers, product marketing managers, product creation project managers, user interface designers, usability engineers, software architects and developers, industrial designers, and marketing research experts were usually progressive and fruitful but occasionally we spent time searching in the darkness with no obvious direction. Gradually it became evident to me that the organization needed a more solid and sound mechanism to be used as a basis for maintaining and evolving the cellular mobile telephones UI roadmap. User-centered design can obviously be used in a single product development project but for outlining the strategic directions for the overall mobile device roadmap, it was not seen able to provide all the needed answers. Being an engineer and a scientist, I wanted to see if it is possible to shed some light into the moments of darkness. The thoughts and structure presented in this thesis begun to evolve during 1999 in a user interface concept development exercise where we in a small concept creation team had high-flying ambitions to design the ultimate mobile phone user interface that would solve the usability problems we've ever had with our handsets.[13] We were creating a new interaction style for future mobile phones and future mobile phone functionality, and we were somewhat unsure of how to take into account the fact that most of the end users for the new UI would already have experience from using another kind of user interface – maybe from Nokia, maybe from some other manufacturer.

The reality check to my thinking goes back to years 1995 – 1998 when I was conducting usability research, interaction design, and usability engineering work

[13] The goal sounds quite ambitious. One of the tangible results was the Three-softkey interaction style first applied in Nokia's first 3G W-CDMA phone, the Nokia 6650 (**Figure 71**).

in product development projects[14] at Nokia Research Center and Nokia Mobile Phones. During 2001 – 2002 I worked in the user interface software development organization focusing on UI requirements management, design management and usability activities, and being involved with the development of the user interface design process and UI prototyping tools. Looking at the practical user interface development issues with a more focused R&D mindset gave a new perspective to the outlined questions and made it possible to refine and validate my earlier thoughts. Starting from 2003 I have been responsible for the holistic global management of Nokia's mobile phone user interfaces and UI policies, which is a good opportunity to apply these structures and theories.

There is plenty of research, textbooks, developer resources, conferences, consultants, educational opportunities, organizations, and discussion fora about general human-computer interaction[15]. Most of that work focuses on the 'mainstream' computing environments — in fact it is the HCI research that has created the mainstream, desktop computing environments as we know them: the direct manipulation paradigm, the mouse, windowing environments, and hypertext were all pioneered first in university research projects before moving into corporate research and eventually into commercial products (Myers 1998). With the proliferation of the World Wide Web, the academic and industrial usability community has started to look also at browser-related research and WWW usability (Myers 1998, Nielsen 2002b).

Mobile phones are consumer electronics products designed and developed by industry practitioners and professionals within explicit business constraints, and thus from an academic viewpoint they can be seen a bit mundane. Kuutti (2000) sees this everyday image of the devices and their user interfaces being one reason to why the academic HCI research has a blind spot around small user interfaces and therefore shuns the research domain. It must be noted that the academic human-computer interaction research community is in the process of gradually broadening its focus to cover also the non-traditional computer user interface domains.[16]

1.1.1 Some Terminology Issues

Throughout the thesis, we will be using the terms *consumer*, *customer*, *end user*, and *user* to denote the person who will purchase a mobile phone or is using it in his or her daily life. The terms *consumer* and *customer* stem from the marketing research domain, whereas the term *end user* is preferred in the field of human-computer interaction. In this study these terms are used with the same meaning. In case a different notion or content is needed, a more appropriate and detailed

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[14] In 1995 – 1997 I participated in product and UI concept creation projects developing the Two-softkey interaction style for the 6100 phone series, and the Series 60 interaction style for the 7650 and later Symbian smartphones. In 1998 I was responsible for the usability engineering activities of the Nokia 9290 communicator product development project.

[15] The interested reader is encouraged to look at e.g. Gary Perlman's extensive bibliography on human-computer interaction resources; [Cited 06-Jul-2004] Available from WWW: <http://www.hcibib.org/>.

[16] The Sixth International Conference on Human Computer Interaction with Mobile Devices and Services took place in September 2004; [Cited 25-Oct-2004] Available from WWW: <http://www.cis.strath.ac.uk/~mdd/mobilehci04/>.

term is used, such as e.g. *trade customer* to denote a cellular network operator purchasing high volumes of mobile phones from mobile phone manufacturers and later marketing and selling those to the actual consumers.

In the thesis we will also discuss the companies designing, developing, manufacturing and marketing mobile telephones. In some cases the same company is responsible for all these activities for a given mobile telephone model. Quite frequently, however, some activities like manufacturing and logistics management are carried out by partners or subcontractors i.e. *original equipment manufacturers* (OEMs).[17] In these cases the company branding the mobile phone is actually a *vendor*. In this study we do not make an explicit distinction between *vendors* and *manufacturers* and will use the terms interchangeably. In case there is an explicit need to describe the different roles of the vendor and the original equipment manufacturer, we will state the roles explicitly in the text.

A key concept used as a reference point throughout the thesis is the conventional desktop user interface. This denotes the established, commercially available graphical user interfaces (GUIs) that are also sometimes referred to as *WIMP* interfaces (Windows, Icons, Menu, Pointing device). This user interface paradigm was introduced in the Xerox Star computing system and later commercialized by the Apple Lisa and Macintosh, and Microsoft Windows.

The names of actual companies, products, and services mentioned herein may be the trademarks of their respective owners. Any mention of such in this thesis is done where necessary for the sake of scientific accuracy and precision, or for background information to a point of technology analysis, or to provide an example of a technology for illustrative purposes, and should not be construed as either positive or negative commentary on that product or that vendor.

1.2 Research Objectives

The topic of this research work is the interaction style evolution and convergence — and divergence — in the high-volume cellular mobile telephone mass market. In the study we will look at the interaction style from the end user viewpoint instead of the designers' one. However, there are a number of non-consumer stakeholders in the mobile communications industry and business, and these parties also share an explicit or implicit interest on the devices' user interface, and on the user interface evolution in the industry. Thus, since the end user is not the sole driver affecting user interface design and evolution, we will briefly look at the needs and requirements of cellular mobile operators, service providers, content developers, after-market support organizations, and other related parties, whenever the user interface of the mobile device is of particular interest to them.

The objective of this research work is to create and communicate new knowledge for usability engineering practitioners and product strategy managers about how

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[17] "*Flextronics to manage Ericsson's mobile phone operations.*" In: Flextronics press release. 26-Jan-2001. [Cited 06-Jun-2002] Available from WWW: <http://www.flextronics.com/Press/releases/2001/20010126SJA.asp>;
"*Original equipment manufacturers make 20% of Nokia's phones.*"
In: Talouselämä 20/2002, 24-May-2002, p. 42.

to design and evolve interaction style conventions in mobile telephones. Instead of being a detailed 'design guidelines document' or 'user interface cookbook', the thesis aims at providing an understanding of how relevant a stable interaction style is to the end users, specifically to the ones replacing their old mobile phones with newer models, or would it be possible or even advisable to proceed in a more revolutionary, and discontinuous manner with the mobile device user interface design and evolution.

Elaborating on the title of the study — ***Evolution and usability of mobile phone interaction styles*** — from the different viewpoints further illustrates the research objectives:

A. Evolution *and usability of mobile phone interaction styles*

The study will investigate the user interface and interaction style evolution in the mobile telephones domain. The study will analyze the contemporary mobile phone interaction styles and highlight trends and developments in the industry around user interface evolution and convergence. Various signs of user interface convergence are visible in the cellular mobile telephones industry. On the one hand the standards bodies and consortiums are promoting unified user interface solutions within emerging mobile device technologies like WAP and Java, on the other hand manufacturers like Microsoft[18] and Nokia[19] are marketing their user interface platforms for other manufacturers to license. The study will consider how these user interface convergence trends will affect the interaction style evolution in the mobile telephones industry. The study will also contemplate whether a mobile phone user interface dominant design exists or is about to emerge in the mobile phone industry. For the study it is relevant to investigate the emergence of possible converging user interface conventions due to e.g. their ramifications related to mobile internet usability.

B. *Evolution and* ***usability*** *of mobile phone interaction styles*

The study is investigating the usability aspects of the different interaction styles. The ISO 9241 (ISO 1998) standard defines usability 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."*

Mobile phone interaction style evolution can be driven from the usability viewpoint but also with a corporate branding, software engineering, or any other relevant emphasis. The majority of customers purchasing mobile phones in the developed markets already have experience in using a mobile phone, and it is crucial that the industry does not unnecessarily complicate the take-up of new products and services.

C. *Evolution and usability of* ***mobile phone*** *interaction styles*

The focus in this study is on mainstream, high-volume, voice-centric, consumer-oriented cellular mobile telephones. The mainstream mobile phone is a quite mature product concept and consumers are familiar with the basic functionality

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[18] Microsoft. [Cited 06-Jul-2004] Available from WWW: <http://www.microsoft.com/mobile/phones/default.asp>.
[19] Nokia. [Cited 06-Jul-2004] Available from WWW: <http://www.series60.com/>.

and form factor of the devices. From the ergonomic usage and form factor point-of-view we can categorize the contemporary pocketable communication devices into *wearable communication devices*, *single-handedly used devices*, *two-handedly used devices with a stylus*, and *communicators*. Canalys (2001) defines the following form factor categories: *handset*, *tablet*, and *clamshell*. Within these categorizations the focus in the research work is on the single-handedly used handsets.

The focus in the study is not on the emerging product categories around the cellular mobile telephones domain such as handhelds, tablets, clamshell devices, or various other digital convergence products such as wireless instant messaging terminals or gaming devices. These relatively recently emerged categories, product concepts, and the corresponding user interface conventions are not fully stabilized yet and for the time being they are still low-volume product segments compared to the mainstream cellular mobile telephones as we see if we compare e.g. the worldwide PDA sales volumes of 13.11 million units[20] in 2001 with the mobile phones sales volumes of 402 million during the same year (Prohm et. al. 2002).

D.** Evolution and usability of mobile phone **interaction styles

The interaction style is a key element in the mobile device user interface. The style definition and documentation is the underlying framework for the product's user interface that will keep the overall product user interface consistent despite the fact that a large team of designers is working on the numerous features and applications for the product; in a large company these design teams are often also geographically dispersed (Kiljander & Järnström, 2003). Interaction style is fundamentally a design concept and abstraction that allows the designers to have a common framework and language for the various activities in the user interface design process. Obviously, conformance to an interaction style alone is not sufficient for creating a good user interface, but a user-centered design approach is also needed. In this study we investigate the interaction styles from the usability viewpoint, instead of using the design process viewpoint.

The study will model the overall user interface of a mobile phone, and investigate the role of the interaction style in the overall user interface. To investigate the relevance and significance of the interaction style in affecting end users' perception of the product, the study will analyze a set of contemporary mobile phones, and also conduct a set of empirical usability evaluations to find out how differences in the interaction styles affect usability.

1.2.1 Research Problem

This research aims at qualifying and quantifying the role and significance of mobile phone interaction style changes when users are switching from one product to another. The concept of *mobile phone interaction style* is the core artifact in this study; hence it needs to be defined before the research problem definition. In the context of this work the following definition will be used for the interaction style:

[20] Silicon Strategies. [Cited 06-Jul-2004] Available from WWW: <http://www.siliconstrategies.com/story/OEG20020213S0032>.

> ***Mobile phone interaction style*** *is the framework consisting of the* ***physical interaction objects****, the* ***abstract interaction elements****, and the associated* ***behavior or interaction conventions*** *that are applied throughout the core functionality of the mobile phone.*[21] *Within the context of this study, the interaction style definition excludes the stylistic appearance elements of the user interface, that are often referred to as the 'look' of the user interface.*[22]

Section 2.3 will illustrate the relationships between the mobile phone interaction style and the other user interface components in the whole mobile phone product user interface. **Section 3** will further review the mainstream HCI concepts and notions of interaction style and elaborate on the nuances between the mainstream definitions and the mobile phone one.

The study aims at improving the understanding of how relevant a stable interaction style is to the mobile phone end users, specifically to the ones replacing their earlier handsets with newer models. This will enable the usability practitioners and product strategy and marketing managers to make more justified design decisions when user interface and interaction style evolution directions are considered in the product creation process.

With the fundamental concept of interaction style defined, we will formulate the core research problem as:

> How do mobile phone interaction style changes affect
> the initial usability of a mobile phone
> for users with earlier experience with mobile phones?

Figure 3. Research problem

From the research problem we can deduce the following, more detailed research questions:

1. What is the interaction style applied in contemporary mobile telephones, and how does it differ from the interaction styles in mainstream HCI?

2. What is the effect on usability caused by specific changes in the mobile phone interaction styles between products?

1.2.2 Research Scope

As the title of this research implies, the focus of the study is on the *interaction styles* of mainstream, high-volume, voice-centric cellular mobile telephones. The study investigates mobile phone interaction styles primarily from the usability viewpoint, not from a user interface software implementation process or e.g. brand management viewpoint.

By focusing on the mainstream cellular mobile telephones, we exclude various wireless digital convergence products like handhelds, tablets, and clamshell

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[21] In this context the core functionality denotes call management, messaging, and the PIM functionality that is incorporated in the device.
[22] The definition of interaction style is further illustrated with an example in **Section 3**.

devices equipped with small QWERTY keyboards. We want to focus on the established product categories since the largest user segments can be found around these. The established consumer product market is also different from the emerging convergence device marketplace since the digital convergence device users are more likely to be Moore's (1995) *innovators* and *early adopters*, and their requirements, expectations, and preferences of the devices' user interface are possibly different than the ones in the mainstream mobile phones consumer base. The user interface market positioning and the business model in the handheld device business are also different from the high-volume mobile telephones industry. In the handheld industry there are few major user interface platforms — Palm and Microsoft Pocket PC — whereas in the high-volume mobile telephones industry the user interface landscape is more heterogeneous.

This study is primarily not about organizational or process research or development. Interaction design disciplines, methods, and processes are illustrated and discussed, whenever appropriate, but the primary objective is not to create new knowledge in these domains. The constraints derived from software engineering and software architectures are discussed in the relevant contexts but the work does not e.g. aim at creating a software architecture model for mobile device interaction styles. The work also does not aim at creating new usability engineering approaches to interaction style development or evaluation, but mainly applies established methods. Organizational aspects related to interaction style development are very briefly discussed but the focus is not on creating an organizational theory of any kind.

In the study we will not conduct any specific marketing research type studies such as customer visits and surveys, or focus groups. The study will analyze data produced by marketing research activities and this is categorized as *secondary research* in marketing research terminology (McQuarrie 1996). The empirical usability testing reported in the study is based on a conventional usability testing approach. In the empirical tests conducted in a laboratory setting the focus is on investigating the initial usability of a new mobile phone interaction style.

This work is also not about business development or product strategy creation as such. The product strategy and product segmentation model of a company should guide the user interface design management work. Also, the product strategy of a company is not static and therefore changes in it create modifications and discontinuities in the interaction style portfolio. Naturally, the innovations created and deployed in the interaction design work should be reflected in the overall strategy work in an appropriate manner.

This is not a user interface design guidelines book or a style guide. The objective of the research is not to define or select the absolute optimal interaction style for cellular mobile telephones — besides, there is likely to be no absolute optimal interaction style as real-world product management and product creation always involve numerous compromises when specific product attributes are promoted and some others demoted.

1.3 Research Methods

The objective of this research work is to create and communicate new knowledge to usability engineering practitioners and product strategy managers about how to design and evolve interaction style conventions in mobile telephones.

In **Section 1.2.1** we defined the fundamental research problem as "How do mobile phone interaction style changes affect the initial usability of a mobile phone for users with earlier experience with mobile phones?"

Based on the research problem, we also defined two, more detailed research questions:

1. What is the interaction style applied in contemporary mobile telephones, and how does it differ from the interaction styles in mainstream HCI?

2. What is the effect on usability caused by specific changes in the mobile phone interaction styles between products?

March & Smith (1995) present an information technology research framework that is created around the assumption that a researcher will select the applicable research method based on the planned research activities and potential research outputs. From a slightly different angle, Järvinen (2000a, 2000b) builds his research framework around the core concept of the research question driving the research approach selection. In this study, the fundamental research problem has evolved and gained more focus in the course of the research work, and the individual research questions have gone through several rounds of iteration. It has been more natural to plan and select applicable research activities within smaller contexts, and to some extent also to revise the core research problem in the intersection of the individual research questions and research activities.

Several different methods have been applied in the study when investigating the mobile phone interaction styles and searching for answers to the abovementioned research questions.

Research question 1 — What is the interaction style applied in contemporary mobile telephones, and how does it differ from the interaction styles in mainstream HCI? — enables us to draw conclusions on the applicability of the mainstream interaction styles in the mobile phones domain. We analyze the different elements of the mobile telephone user interface to be able to define the mobile phone interaction style within the context of this study. We investigate the existing definitions for interaction styles and interface styles in HCI literature to understand what aspects of these are applicable in the research domain. We analyze the interaction styles in contemporary mobile phones to gain an understanding of whether there are differences between the styles that are applied between different manufacturers, or whether the industry is using more homogeneous approaches to mobile phone UI design. We study this by selecting a representative set of mobile phone models from the largest mobile phone manufacturers, and by defining a representative scenario of user tasks that are then used to conduct a heuristic evaluation of the mobile phones and their interaction styles under study. We also investigate the evolution of the interaction styles in the mobile phone industry over time to see whether there is convergence or divergence taking place, and whether dominant designs are emerging. This investigation and analysis will lead to an understanding of the interaction styles on the current mobile phone market. This is needed in resolving the research question 2.

Research question 2 — What is the effect on usability caused by specific changes in the mobile phone interaction styles between products? — will apply an empirical usability testing method on a new mobile phone model with a novel interaction style. Users with differences in their mobile phone usage experience

are selected as test users in an experiment to find out how their earlier usage experience affects the initial use of the mobile phone with the new interaction style. In order to understand why the differences in the earlier experience interaction styles lead to measurable usability differences when a new interaction style is used, we investigate the differences between the interaction styles and analyze what specific interaction style element changes lie behind the usability differences.

Based on the findings and results to the abovementioned research questions we will draw conclusions on how mobile phone manufacturers can design new mobile phone interaction style variations without compromising the usability of the new devices in the initial usage context.

1.4 Related Research

This section will summarize the existing research knowledge in related domains from the thesis viewpoints. It must be noted that the aim of this section is not to present a thorough review of these broad research disciplines but to probe the research domains for relevant works of research related to the mobile phones user interface and usability domain.

There is ample amount of research conducted in HCI since the 1960s (see e.g. the retrospective overview of Myers 1998), about methods and approaches for consumer segmentation (see e.g. Peppers et. al. 2000), on processes and tools for product creation (see e.g. Ulrich & Eppinger 1995), and on cognitive psychology (see e.g. Anderson 2000b). However, when it turns to mobile telephones user interface domain, we can see that an equally solid research foundation is yet to be established — albeit emerging. The fundamentals of user-centered design are valid also when developing mobile user interfaces, but e.g. the small physical footprint of the mobile devices restricts the application of information visualization approaches that are commonplace in mainstream HCI, and the implications of the mobile context e.g. makes conventional usability testing in a usability laboratory setting inadequate. The differences also include the user bases, as Brouwer-Janse (1997) writes: "*Most HCI research is devoted to applications for which target users are known or can reasonably well be defined. In contrast, consumer products ... have no explicitly defined users. ... users of these products do not expect to operate a computer system; they span all ages; and their preferences, capabilities, and motivations vary.*" Ruuska-Kalliokulju et. al. (2001) state that "*user interface design for mobile communication devices has not been a central research topic in the past.*"

One obvious reason to the lack HCI research in the mobile phone domain is that the domain is relatively new, or at least newer than the mainstream computing domain. Another possible reason may be the fact that the cellular mobile telephone user interface work is to a large extent conducted in corporate research laboratories and product development organizations. Mainstream HCI, on the other hand, has a major part of its roots firmly in the academia, and in that domain the research artifacts do not necessarily involve highly expensive wireless communication infrastructure equipment, embedded systems development environments, hardware design, and mechanics prototyping skills, that are often necessary in mobile device HCI work. Kuutti (2000) argues that the academia shuns HCI research focused on small user interfaces. He lists and discusses the following five excuses supporting this behavior:

1. The research problems with small user interfaces are so straightforward that they are not worth serious research.
2. The problem space is so similar to PC user interfaces that no dedicated research is needed.
3. The design challenges will fade away with technological advancements so there is no need to focus HCI research resources in the domain now.
4. There is little interest in further advancement in small user interfaces and therefore the research has no need nor audience.
5. Some other reason makes the small user interfaces uninteresting.

After disproving these hypotheses Kuutti further speculates that the everyday nature of small user interfaces in consumer electronics devices may be the reason to why the academia has a blind spot around small user interface HCI research. Researchers in mainstream HCI often work with state-of-the-art user interface technologies unlike the business-driven constraints around the small user interfaces that must fit into a small physical footprint, should cost as little as possible, and work on hardware platforms with limited processing power, memory space, and battery life. It is hard to envision or create imposing or compelling demonstrations with small user interfaces — Kuutti argues that the majority of systems presented and demonstrated in e.g. the CHI conference are very complicated or technologically advanced and thus far from everyday life.

Nielsen (2002b) is along the same lines — with a broader perspective — when suggesting a reason to why the academia seems to disdain applied HCI research:

> "*… university departments seem to view the best HCI research as both too mundane and too resource intensive. Many academics disdain research topics that are closely connected to real-world needs. For proof, look no further than the appalling lack of Web usability research. There are more papers on unworkable, esoteric 3-D browsers than on how hundreds of millions of people use the biggest real-time collaborative system ever built.*"

The research reported in this thesis directly investigates how more than a billion mobile people[2] can use the global telephone system, the world's biggest machine[23].

1.4.1 Smart Products and Information Appliances

Mohageg & Wagner (2000) define *information appliances* as computer-enhanced consumer devices dedicated to restricted sets of tasks. They argue that the contemporary UI design approaches initially established in the desktop personal computing domain are not sufficient enough when designing and developing information appliances, such as PDAs, Internet phones, or pagers. The main reasons to the differences in appropriate UI approach between desktop computing and information appliances are that 1) information appliances are intended for a wide base of consumers, and 2) the characteristics of information appliances often make the prevailing GUI desktop metaphor unusable (Mohageg

[23] Ericsson. "*The global telephone system is the world's biggest machine.*" [Cited 06-Jul-2004] Available from WWW: <http://www.ericsson.com/annual_report/2000/eng/pdf/expert.pdf>.

& Wagner, 2000).[24] Norman (1998) stresses the *simplicity* of information appliances and argues that if information can be easily interchanged among appliances, there is no penalty of owning a variety of task-specific, distinct appliances. A key challenge in mobile device user experience, which has been identified at Nokia, is interoperability between mobile devices, and information interchange plays a major role in this.

Keinonen et. al. (1996) define *smart products* as design products with a dense user interface; this definition includes mobile telephones and other, interactive, embedded system products. They further introduce the *Smart Product Evaluation Space* as a reference model to order HCI-related evaluation criteria in the consumer purchasing decision-making process. Keinonen (1998) further elaborates on the usability attribute reference model in the study of the influence of the *expected usability* on consumers' product preference.[25] End users recognize the importance of usability on a general level, but their usability-related product evaluation is simplified by the *feature heuristic* — they regard the number of features or the existence of specific features as an indicator of product quality — and by the *one-dimensional usability heuristic* — only the number of buttons and display elements are applied to assess the versatility and complexity of the products.

Ruuska-Kalliokulju et. al. (2001) list the following factors differentiating mobile devices from the stationary office-based systems:

1. Physical, social, and cultural contexts of use affect they way in which the terminal is operated via its user interface.
2. *Personalization* of mobile devices is a central design issue.
3. *Applications and services* are the driving force from the end user perspective.
4. Communication and personal computing devices get more task-specific, increasing the need for *inter-device communication* as the only way to simplify the task of the user in the most transparent way.

Koivunen et. al. (1996) classify smart products, such as mobile telephones, along three usability dimensions: the groups of *intended users*, the *intended tasks,* and the *environment*, which is referred to as the *situation of use*. They describe the following common usability defects often recognized in smart product usability testing situations:

1. The most common and most restricting feature is the small size of the screen; with wearable and portable products also the whole product size is small which leads to the navigation buttons being overloaded with functionality.

2. The terminology and grouping of user interface objects such as menus does not often match with the users' mental model of the system.

3. Too little feedback is given to the user of her current location in the menu hierarchy, which often confuses the user and makes her reluctant to select

[24] It must be noted that the fundamental principles of user-centered design do apply also when designing information appliances.
[25] Keinonen tested non-users, users, and designers (n=93) to examine and rate six heart rate monitors based on the expected usability.

menu items, as she is afraid of inadvertently committing undoable operations.

4. Feedback from successful and unsuccessful operations is misleading or nonexistent.

5. Frequently needed and central operations are hidden in the user interface, and in general the operating buttons are overloaded with functions.

6. Often the device buttons do not offer adequate tactile feedback and sometimes the buttons could be replaced by knobs or other input devices for easier usage.

1.4.2 Design of Mobile User Interfaces

User-centered[26] product development is the widely promoted design approach for smart product or information appliance development (see e.g. the abovementioned Keinonen et. al. 1996; Norman 1998; Mohageg & Wagner 2000); it is also a standardized design methodology by the International Organization for Standardization (ISO 1999). User-centered design begins by analyzing and understanding the users and their use contexts. Users' needs for mobile communication systems are partly different from the desktop-focused or office-based practices and therefore it is crucial to study the real use contexts when designing mobile phone user interfaces (Väänänen-Vainio-Mattila & Ruuska 2000).

Väänänen-Vainio-Mattila & Ruuska (2000) argue that the mobile phone HCI challenges stem mainly from the constraints of indirect manipulation in the user interface. The user gives input to the system mainly through sequences of key presses and may in turn get feedback by tactile feedback, sounds, and textual or graphical messages on the miniature display of the device. The mapping of the user's key presses to the device's actions is not always straightforward as the number of buttons is limited. It is often the case that users face challenges in establishing an accurate mental model of the phone interface that may constantly switch between modes and use telecommunications or computing jargon in its feedback messages.

Nieminen argues that there exists plenty of research on methods and tools for usability design and evaluation but typically these methods and tools have been presented without tight-enough connections to the development processes and development organizations (Keinonen et. al. 1996). Ketola (2002) reports on integrating systematic usability activities in the form of a usability plan into a mobile phone product creation organization developing products with a concurrent engineering approach. He argues that the basic usability engineering problems — namely the lack of management support, and usability activities conducted too late in the product development process — can be minimized or avoided if the usability engineering activities are linked tightly with the concurrent engineering product development activities through an early-phase *usability assessment*, the creation and execution of a *usability plan*, and through the application of *usability risk management* activities. Similarly, Rieman (2003) stresses the tight linkage between the usability engineering activities and the

[26] Often also 'human-centered'.

overall product development process, when illustrating the concept of 'just-in-time usability engineering' at Nokia. The difference to Ketola's approach is that the 'just-in-time usability engineers' work in the UI platform development organization instead of focusing on a specific mobile phone product. Just-in-time usability engineering denotes an approach where the usability engineers rapidly and flexibly respond to novel situations, without always following a rigid or tedious usability engineering approach involving planning, testing, and iterative UI improvement. Instead, the practitioners apply a more opportunistic approach, which resembles the 'lean production' systems introduced by the Japanese car manufacturers in the 1950s.

Hyppönen (2000), Keinonen (2000) and Wikberg & Keinonen (2000) report on three user-centered design projects to design novel mobile communication devices: a safety-oriented mobile phone mainly for elderly and disabled users, a sports phones for active users, and a miniature mobile phone with the size of about 20 cubic centimeters[27,28]. The safety phone project combined universal design principles[29] with user-centered design. The miniature concept creation project applied a comic strip scenario approach to illustrate the different users and usage contexts of future miniature communication devices. The sports concept project emphasized the definition of few but strong design drivers to steer the concept creation work. All the design projects stress the importance of the designers interacting actively with the end users and also setting themselves in the actual usage contexts, whenever possible.

Säde (2001) describes an adaptation of the Bridge GUI design method to the design of non-GUI interactive consumer products. Bridge is a fast design method that involves participatory design elements to bridge the user requirements with the object-oriented GUI designs. In the specific case study Bridge was turned into "Bridge for Buttons" — a user-centered, but not participatory, approach. Bridge for Buttons leaves out the object-oriented GUI modeling aspects of the original Bridge. It is a discount usability engineering method, and can thus be applied by practitioners having no deep usability knowledge or experience.

Jokela & Pirkola (1999b), Kiljander (1997, 1999) and Säde (1996, 2000) describe the product or user interface prototyping techniques in mobile phone or smart product design and development. The various applicable prototyping methods can be classified according to their level of *focus* versus *comprehensiveness*, and they also range from purely *analytical models* to *tangible artifacts*, as shown in **Figure 4**. Kiljander (1997) argues that there is no single optimal prototyping method to be applied in mobile phone user interface development, but different methods need to be applied in different phases of the overall process. The most resource-friendly methods (e.g. scenarios, storyboards, or paper prototypes)

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[27] As a reference, the popular Nokia 8310 phone was 66 cm^3 by volume, and anecdotal evidence tells that many people considered it inconveniently small.

[28] The described design projects did not directly lead to commercial products, although concepts, features, and design methods developed during the course of the projects have been carried forward in more recent development projects. Some design concepts have also been commercialized by other manufacturers fully separately from the abovementioned activities.

[29] "*Universal design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.*" In: The Center for Universal Design. [Cited 06-Jul-2004] Available from WWW: <http://www.ncsu.edu/www/ncsu/design/sod5/cud/univ_design/ud.htm>.

should be applied in the early phases of the design process when major design issues need to be addressed, and the more expensive, higher-fidelity methods (e.g. computer simulations or hardware prototypes) are applicable in the later phases when smaller changes are made regarding e.g. layout or terminology. Jokela & Pirkola (1999b) list the main benefits of paper prototyping in cellular phones UI development to include their development speed, possibility to cover a wide spectrum of applications and UI design solutions, and possibility to find almost all those usability problems that can be found with computer simulations.

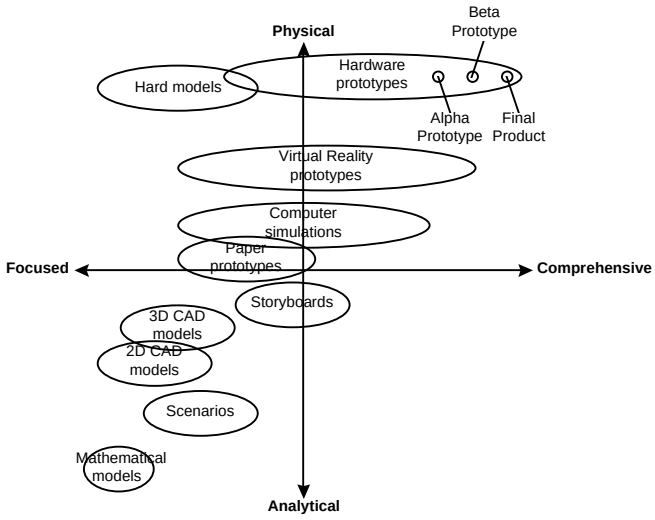

Figure 4.
Classification of mobile phone user interface prototyping methods (Kiljander 1997)

Jokela & Pirkola (1999a) report about a mobile phone user interface concept creation project that applied quantitative usability goals to assist in selecting the design direction for the set of keys and type of display in the new phone. This is one of the few studies discussing the interaction style element of a smart product, information appliance, or mobile device. The usability attributes of *average efficiency* and *overall usability* were measured through expert evaluation and keystroke analysis, and a reference product was also evaluated. The proposed UI concept outperformed the reference product in the evaluation, and the method itself proved to be relatively easy and fast to apply. The results were not validated in actual, long-term product usage, though.

Jokela (2001) develops a user-centered design performance assessment framework and applies it in five industrial settings, one of them being an organization developing new application functionality for mobile phones. Jokela introduces a preliminary theory of *usability capability*; the three dimensions of usability capability are 1) user-centered design infrastructure, 2) performance of user-centered design in product development projects, and 3) usability in business strategy. The author's study aims at improving possibilities to utilize usability reasoning when a business strategy is being created.

The traditional approach to design through evolution is not easily allowed by the multiple forces of a competitive market. Norman (1988) notes that objects such as automobiles, appliances, or computers, which periodically come out in new models, could benefit from the experience of the previous model. The time pressures involved in designing and manufacturing these products, however, dictate a system in which the next product generation is already under development before the previous one has been released to customers.

Mechanisms to collect consumer feedback through various forms of after-market services — e.g. consumer support telephone lines and the Internet — do exist, but it is commonplace that the link from the feedback collecting to new product development does not always work seamlessly. Large, multi-national and multi-site design organizations also can no longer rely on the tacit information implicitly available in the heads of the design gurus, as the gurus cannot be available everywhere every time. Norman further reports of a telephone designer describing how hard it is to remove features of a newly designed product that had existed in an earlier version. If a feature is in the genome, and if that feature is not associated with any negativity (i.e. no customer gripe about it), then the feature hangs on for generations.

Don Norman has gained a reputation of a design critic who is constantly emphasizing effectiveness and understandability in product design. More recently he has started to widen the message to promote also beauty and emotional impacts of the designs (Norman 2002, 2004). Earlier studies conducted by Tractinsky (1997) and Kurosu & Kashimura (1995) indicate that the aesthetics play a significant role in establishing the notions of apparent usability.

1.4.3 User Interface and Interaction Styles

User interface or *interaction styles* are frequently discussed concepts in mainstream HCI literature. Hix & Hartson (1993), Nielsen (1993a), Preece et. al. (1994), Draper (1996), Whiteside et. al. (1985), and Temple et. al. (1990) introduce and describe categorization of user interface or interaction styles used in computing environments over the last 50 years. These categorizations and definitions form the vocabulary that is used as the baseline in this study.

Hix & Hartson (1993) define interaction styles as a *collection of interface objects and associated techniques from which an interaction designer can choose when designing the user interaction component of an interface*. Interaction styles provide a behavioral view of how the user communicates with the system. Hix & Hartson describe the following interaction styles: *windows, menus, forms, boxes, typed-command languages, graphical interfaces*, and *other interaction styles, including touchscreen and voice I/O*.

Nielsen (1993a) classifies computer user interfaces in chronological generations — the generations of user interfaces aligning with the changes in the underlying computing hardware technology. Besides the obvious advancements in hardware technology, there are several other aspect related to computing and user interfaces that have changed during the last 50 years: the operating mode of the apparatus, the programming languages, the terminal technology, the user types, and the advertising image. Nielsen lists the following user interface paradigm generations: [0)] Pre-historical generation (– 1945) No user interface paradigm as direct hands-on access to the hardware was the important thing; [1)] Pioneer generation (1945 – 1955) Batch programming user interface paradigm; [2)] Historical generation (1955 – 1965) Command language user interface paradigm; [3)] Traditional generation (1965 – 1980) Full-screen, strictly hierarchical menus and form fill-in user interface paradigm; [4)] Modern generation (1980 – 1995) WIMP (Windows, Icons, Menus, and a Pointing device) user interface paradigm; [5)] Future generation (1995 – ?) Noncommand-based user interfaces. The World Wide Web phenomenon has emerged after Nielsen's 1993 definitions but the Web UI still fits into the WIMP UI paradigm with a networked single or multi-user operating mode. In the Future generation Nielsen envisions embedded

systems and the computer as an appliance — mobile telephones are obviously not explicitly present in a prediction written in early 1990s — and later he argues in (Nielsen 1997) that data phones[30] would probably be more usable, and more successful, if they were designed around a computing user interface paradigm instead of applying a telephone user interface with a data add-on.

Preece et. al. (1994) discuss the design trade-offs of using different interaction styles. They define interaction styles as *a generic term to include all the ways in which users communicate or interact with computer systems*. The various interaction styles are not mutually exclusive, as designers and systems usually apply a combination of styles. Preece et. al. describe the following interaction styles: *command entry, menus and navigation, question and answer dialogues, form-fills and spreadsheets, natural language dialogue*, and *direct manipulation*. They further discuss the cognitive issues in direct manipulation. *Semantic directness* concerns the relation between what the user wants to express and the meaning of the expressions available at the interface. *Articulatory directness* concerns the relation between the meanings of expressions and their physical form.

Draper (1996) discusses a deeper categorization of interface styles. The commonsense interaction styles of *command languages, push-buttons (function keys), direct manipulation, form filling,* and *menu systems* can be further scrutinized along two kinds of underlying dimensions: *technical*, computer science aspects, and *cognitive*, user-oriented aspects. The computer science properties are related to imposing sequential constraints on the user, and whether or not user actions depend for their effect on combinations of inputs. With the cognitive issues, a tradeoff between the *learning burden* and the *cost of execution* is evident. Draper argues that all existing and possible interface styles can be seen as different solutions to this tradeoff: usability and learnability of a system are directly linked with the amount of useful information displayed. Draper further argues that all the traditionally defined interface styles mostly focus on organizing user input: they all facilitate the user to enter information to a computer system. Draper expects this balance in HCI to shift towards output styles with the proliferation of multimedia and computing applications like virtual reality.

Whiteside et. al. (1985) report on the performance and subjective reactions of 76 users testing 7 different user interfaces representing command, menu, and iconic interface styles. The research findings indicate that there are large usability differences between the tested systems, that there is no necessary tradeoff between ease of use and ease of learning, and that the interface style is not related to performance or preference (but careful user interface design is). They conclude that the new interface technologies did not solve old human factors problems.

Temple et. al. (1990) compare a desktop graphical user interface (GUI) against a corresponding character-based user interface (CUI).[31] Their research results

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[30] *Data phone* is a term used in the mobile communications industry before the *smart phone* term became popular; it denotes phones integrating telephony and computing.

[31] The study was commissioned by Microsoft and Zenith Data Systems. The CUI environment was represented by IBM-compatible PCs running MS-DOS, and in the GUI tests Macintoshes were used for the novice users, and PCs with Microsoft Windows in the expert user tests. No statistically significant difference was found between the

support the hypothesis that GUI provides benefits over CUI in white-collar work environments[32]. The report describes the following benefits provided by a GUI: GUI users work faster and work better (complete more of their tasks accurately) than CUI users, and therefore have higher productivity than CUI users; GUI users express lower frustration and perceive a lower fatigue after working with microcomputers; GUI users are better able than CUI users to self-teach and explore and to learn more capabilities of applications. Temple et. al. introduce a "navigation theory" to posit that the *intuitive metaphors embodied by GUI facilitate exploration, use, and retention of the functions of one or more applications, making users more productive, self-sufficient, and confident*. They argue that the navigation theory suggests that GUI is superior to CUI for all corporate microcomputer users — clerical, professional, and managerial — and that as the knowledge-intensiveness of work grows, the value of GUI to the user and the corporation will increase.

Different user interfaces applied in mobile phones are described in Ketola (2002), Kiljander & Järnström (2003), and Väänänen-Vainio-Mattila & Ruuska (2000). Introducing new, evolutionary mobile phone user interfaces instead of introducing revolutionary discontinuities is assumed to benefit the end users, as they can find familiar elements from their new phone models; controlled evolution is also seen necessary as the importance of stabile software platforms is steadily increasing in the mobile phones industry. Ketola (2002) argues that the users will find it difficult to change from one UI to another when upgrading their phone; the diversity of contemporary mobile phone user interfaces has led to a situation where the users have to learn new ways to perform familiar tasks.

1.4.4 Mobile Phone Usability

Ziefle (2002) and Bay & Ziefle (2003) study the influence of mobile phone user interface complexity on performance, ease of use, and learnability of mobile phones with different user interfaces. The study of Ziefle (2002) also investigates the effects of user expertise. Bay & Ziefle tested 20 children with no previous mobile phone experience. They refer to Jean Piaget's theory of describing a child's development in four main stages, where at the age of about seven years the child is entering into the stage of concrete operations. These concrete operations involve representing operations mentally, and being able to understand reversibility, thus enabling understanding and solving hierarchical classification tasks. Bay & Ziefle claim this age is sufficient for the children to successfully interact with the menu structure of a mobile phone. In their experiment, children using a Siemens C35i spent double the time on the test tasks and undertook three times as many detour steps and hierarchical steps back as children using a Nokia 3210. Bay & Ziefle claim this is because of the significantly more complex menu structure and control keys in the Siemens phone. Ziefle (2002) conducted usability tests with sixty university students working on three different mobile phones (Nokia 3210, Siemens C35i, and Motorola P7389). She confirms an effect of expertise, though suboptimal interfaces are lessening the advantage of expertise. The highest performance measures (effectiveness, shortest solution time, and smallest number of

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Macintosh and Windows GUIs. The participants never worked directly with the operating system.

[32] Both novice and experienced users were tested with everyday business tasks such as word processing, spreadsheet usage, and mixed tasks requiring use of both applications.

misleading steps) were accomplished with the phone with the smallest complexity in menu and navigation keys (Nokia 3210).

3G LAB (2002) conducted a usability evaluation on the first two camera-equipped phones in the UK in September 2002. The test focused on initial use and it was carried out with six representative novice users, aged 22–34, with a mix of education levels and occupations. The usability test scenario was defined to cover everyday camera usage and multimedia messaging tasks. The Sony Ericsson T68i was initially chosen as the preferred phone by the usability test participants based on its stylish physical appearance and aesthetically pleasing design, but after completing the usability test tasks the test users quickly switched allegiance to the Nokia 7650. The test users were disappointed with the complexity of the Sony Ericsson menu system, its poor screen display, and phone's build quality. The Nokia model was seen as "chunky" and "brick-like" initially, but after test completion, all test users said they would purchase the Nokia phone over the Sony Ericsson model. As reasons the participants cited Nokia's easier and more intuitive menu system, the best screen size & display, and the generally higher build quality of the phone.

Ziefle (2002), Bay & Ziefle (2003), and to some extent also 3G LAB (2002) describe the role of the mobile phone interaction style in making some phones perform better than the others in the usability tests they conducted.

Eight MMS-equipped phones[33] were tested by SirValUse (2003). The usability test focused on MMS sending functionality. As a general usability finding, most tested phones suffered from complicated menu prompts faced by the user when storing, renaming, and sending captured images. Some of the tested handsets supported an optional plug-in camera, which leads to usability problems when installing and activating the camera. The Nokia 7650 was the only phone to get a good result of the test (*two* on a *one…five* scale, with *five* being the most difficult). The most complicated phones to use were Sony Ericsson T300 (with the score *five*), and Siemens S55 and Panasonic GD-87.

Kiili (2002) conducted a usability study focusing on WAP user experience with the Nokia 7110 handset; he concludes that the WAP interface in the 7110 is hard to learn, as the interface does not offer as clear cues to WAP services as to basic functions. The cues of the WAP user interface did not direct subjects (n=40) to the right path and most of the subjects were confused because they did not have a clue what they should do. Other WAP-related problems were lack of feedback and difficulties with exiting services. Kiili names the lack of consistency between the select key and the softkeys to be a key usability problem in this user interface. Many of the problems reported by Kiili have been identified by Nokia usability practitioners to be design problems with the interaction style in the 7110 phone.

1.4.5 User Interface Consistency

Nielsen (2002a) promotes UI design consistency by illustrating the benefits of consistency to include possibility for users to transfer their skills from one system to another, thus leading to ease of learning and ease of use. Consistency also

[33] The handsets tested included those from Motorola (T720i), Nokia (7650 and 6610), Panasonic (GD-87), Samsung (V200), Sharp (GX10), Siemens (S55) and Sony Ericsson (T300).

improves productivity and user satisfaction, and eventually boosts users' feeling of mastery and self-confidence. For companies UI consistency leads to lower training costs, and reduced need for user support. For software and system vendors UI consistency will reduce development and maintenance costs, and possibly lead to increased software consumption. Consistency also has the potential to lead to more aesthetic user interfaces. Nielsen lists the downsides of UI consistency to include cost associated with implementing consistency, conflicts of interest, lessened design motivation, and difficulties if suddenly an inconsistent user interface needs to be used.

Grudin (1989) argues that enforcing a blanket consistency in the UI will damage the interface. If a consistent user interface supports learning and is optimized for that purpose while simultaneously impeding skilled performance, then consistency is working against good design. Grudin concludes that the interface design priorities must be established carefully.

When something cannot be designed without arbitrary mappings and difficulties, the user interface can be designed around a standard, and if an applicable user interface standard does not exist, one can be established. Norman (1988) argues that the good thing about standardization is that no matter how arbitrary the standardized mechanism is, it has to be learned only once. People can eventually learn it and use it effectively. Difficulties related to standardization include industry-political difference in viewpoints, finding the right time to standardize[34], and the basic fact that the users will need to spend some effort before they can fluently master the standardized user interface.

Stallman (1991) of the League for Programming Freedom[35] argues that monopolies on user interfaces do not serve the users and do not "*promote the progress of science and useful arts*." (The Constitution of the United States 1787) He strongly advocates for user interfaces being common property for all, and heavily criticizes Apple Computer, Ashton-Tate, Lotus, and Xerox — the plaintiffs in the user interface copyright lawsuits in 1990s.

The *dominant design* paradigm has been researched extensively with the focus on some specific industries such as rigid disk drives (Utterback et. al. 1998). The cellular mobile telephones industry has not been covered.

1.5 Thesis Structure

Section 1 defines the research domain, usability of mobile telephone interaction styles, and the industrial environment where the research work has been conducted. The section introduces the research objectives, defines the fundamental research problem, describes the constraints around the study, and discusses the research methods. Related research in the fields of smart products and information appliances usability, mobile device user interface design, user interface and interaction styles, mobile telephone usability engineering, and user

[34] Early standardization makes it easier for everyone to start developing and using a standard user interface but standardization should not take place before the technologies and procedures are mature enough.
[35] The League for Programming Freedom. [Cited 06-Jul-2004] Available from WWW: <http://lpf.ai.mit.edu/>

interface consistency, are covered through a literature study conducted by the author.

Section 2 will give the reader an overview of the mobile phone consumer base and the other stakeholders that often have an interest in the mobile phone user interface. Consumers can be categorized based on their earlier experience in mobile phone usage, based on their attitude towards technology adoption, or using various socio-cultural lifestyle segmentation models. The various segmentation approaches are illustrated based on literature studies and the author's experience as a user experience practitioner. The other stakeholders include cellular network operators, wireless service providers and mobile content creators, salespeople, and after-market services and support personnel. The mobile communications business value chain and the involved parties are presented as many of them are influencing or are affected by the products' user interface. The section will further illustrate the different mobile terminal categories, and mobile phone segmentation models, before focusing on the mobile phone user interface. The focus in this study is on the high-volume, mass-market, voice-centric products, instead of the emerging — and often also soon disappearing — novel devices and product categories. The section will describe the fundamental element affecting mobile user interfaces, the mobile context of use. A mobile telephone user interface elements model developed by the author is introduced. The related concepts of external interface and service interface are explained, based on the discussion in Ketola (2002). The concepts of user interface segmentation, usability knee, user interface customization, personalization, and branding in the user interface are discussed. The chapter concludes by briefly discussing the foreseeable evolution trends in the mobile device user interface domain. The section is based on the author's experience in user interface style creation, user interface design management, usability research, and user interface brand management.

The fundamental concept of mobile phone interaction style is investigated in detail in **Section 3**, and compared with the framework of the mainstream HCI definitions for interaction styles. The section investigates different aspects of mobile phone interaction styles, such as menu presentation and interaction, navigation devices, item selection and canceling, softkeys, voice call handling, non-menu interaction styles, direct manipulation, and simplified interaction styles. The categories are based on the usability research conducted by the author. The section then reports of a heuristic interaction style analysis conducted by the author with a team of other usability practitioners at Nokia on a set of contemporary mobile handsets. The analysis is based on commercially available products and other publicly available information. The section presents the study findings about the mobile Internet browsers in the handset user interface often breaking the otherwise quite consistent interaction styles, and discusses the Select-Back-Menu functions commonly available in mobile device user interfaces. The section investigates user interface dominant designs and user interface convergence by analyzing the existing and emerging mobile phone user interface conventions and standards. This includes standards defined by international or national standards bodies such as ETSI, standards and conventions driven by manufacturers, and commercially available or proprietary user interface platforms. The section also elaborates on user interface divergence, before concluding by briefly reviewing user interface convergence developments that are happening in some related industries. The section is based on competitor product analysis, literature studies, and industry analysis conducted by the author.

Section 4 reports on an empirical usability study that investigates measurable usability differences related to users transferring between mobile phone interaction styles. The objective is to analyze user-group-specific differences between the intuitiveness and learnability of a new mobile phone interaction style, especially when the users already have previous experience from some other interaction style. The empirical study was designed by the author with a team of other usability practitioners, and the evaluations and analysis were conducted by the same team.

Section 5 will consolidate the research findings of the heuristic evaluation of commercial mobile phone interaction styles, and the empirical usability testing of the new interaction style. The focus is on the major results; namely mobile phone interaction style convergence, and the measured usability of the new Three-softkey interaction style. Based on the findings of the study, the section also suggests some approaches to be used in mobile phone interaction style design evolution. The section will also describe the contribution of the author in detail, discuss the applicability of the research methods, and propose research ideas for further work.

Section 6 will conclude the research background, the research objectives and the key research problem, the methods that have been applied in the study, and briefly summarize the key research findings.

2. MOBILE PHONES, THEIR USERS, AND USER INTERFACES

This section will illustrate the domain of cellular mobile telephones, their users, and user interfaces. Users, mobile network operators, content creators, salespeople, and support personnel all have an explicit or implicit interest in the mobile phone user interface. The role of the various industry players and the connections between them are described. The different consumer segmentation approaches is the mobile telephone industry are illustrated.

Cellular mobile telephones are consumer electronics products, information appliances, embedded systems devices, or fashion items — depending on the viewpoint and the viewer. This study focuses on the established high-volume category of mainstream mobile telephones, not e.g. on personal digital assistants or the emerging (and often also soon disappearing) digital convergence devices. These other mobile device categories are briefly illustrated in this section, as are the different approaches to mobile phone segmentation.

Mobile phone user interface aspects and attributes are described based on the fundamental principle of mobile context of use. A mobile telephone user interface elements model developed by the author is introduced. The related concepts of external interface and service interface are explained. The concepts of user interface segmentation, usability knee, user interface customization, personalization, and branding in the user interface are explicated. The section concludes by briefly discussing the foreseeable evolution trends in the mobile device user interface domain.

2.1 Consumers, Customers, and Other Stakeholders

> *"… consumer products … have no explicitly defined users. … users of these products do not expect to operate a computer system; they span all ages; and their preferences, capabilities, and motivations vary." (Brouwer–Janse 1997).*

> *"Modern consumers have little patience for learning how to operate new products, and without bothering to consult the user manual, they expect the user interfaces to be self-evident." (Mohageg & Wagner 2000).*

The first mobile phones had their roots in the earlier military mobile radios, and they were used by wealthy businesspeople. By the end of 1990s mobile phones had evolved into consumer products purchased by people of all ages and professions. The majority of mobile phone purchasers are no longer first-time buyers but replacement customers instead (Strategy Analytics 2002). Their requirements and anticipations on the device user experience are likely to be different than the ones of the first-time buyers. **Figure 5** illustrates the different phases in the consumer life cycle: *pre-purchasing* behavior preceding the actual *purchasing* phase, and *ownership* at some point often leading to a *re-purchasing* phase.

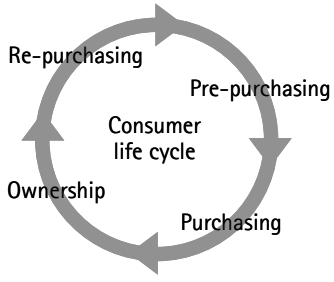

Figure 5. Consumer life cycle

To better understand consumer behavior and purchasing decision-making mechanisms, various consumer segmentation strategies and models are utilized in the industry. Mobile phone manufacturers try to match the consumer segments with corresponding product segmentation. E.g. according to Nokia, about two thirds of all mobile phones sold are inexpensive ones, most often bought by young people, and Nokia claims to have focused on this segment to gain market share and retain high profitability.[36] Some manufacturers like Motorola and Nokia have communicated their respective approaches in applying different user interfaces in different product categories or for different user segments; this is described in more detail in **Section 2.3.4**.

There is no longer a uniform or stereotypical model of the consumer — if there ever was. In the mobile phones industry, vendor differentiation is becoming increasingly complex due to growing technical standardization and saturation in major markets. Consequently, branding and a heightened end-user focus are crucial both for the established manufacturers and new entrants. For example the strategy of the U.K. based mobile phone manufacturer Sendo is to offer terminals with carrier branding and user interface customization opportunities.[37] This is already apparent in focused application and lifestyle consumer segment specific devices, such as messaging terminals or handsets for fashion-conscious consumers. Within this framework the handset manufacturers need to understand the needs of the various consumer segments, identify key segments for future growth, and create compelling, focused products for the different segments.

Several relevant dimensions for categorizing consumers in the mobile telephones business exist. Baffoy (2000) describes four general types of segmentation orientations:

1. Geographic segmentation: regions, countries, states, cities, etc.
2. Demographic segmentation: age, sex, family, income, occupation, etc.
3. Behavioral segmentation: usage rate, brand loyalty, use occasions, etc.
4. Psychographic or lifestyle segmentation: attitudes, values, perceptions, etc.

Ketola (2002) lists three approaches that are applied in clustering consumers:

1. Expertise-based categorization: novice, casual, and expert users
2. Product adoption behavior based categorization: early and late adopters
3. Categorization based on (marketing research) segmentation, especially lifestyle segmentation

Users can also be categorized based on their differences in spatial memory and reasoning abilities, and preferred learning style (Nielsen 1993a; Anderson 2000b). Approaches like these do not usually fit into the resource-constrained realities of mobile phone product definition and development.

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[36] Infoworld. [Cited 16-May-2002] Available from WWW: <http://www.infoworld.com/articles/hn/xml/01/05/04/010504hnnokia.xml?sponsor=BUSINESSNEWS>.

[37] Sendo. "*Cingular will brand the front of the terminal, Sendo will customize the user interface for Cingular … This will help … building brand equity.*" [Cited 10-May-2002] Available from WWW: <http://www.sendo.com/news/newsitem.asp?ID=52>.

From a usability-engineering viewpoint the most often-applied user categorization is one based on the users' experience. Nielsen (1993a) defines three dimensions along which users' experience differs: *experience with the system*, *with computers in general*, and *with the task domain*; Ketola (2002) applies Nielsen's dimensions for mobile phone use as shown in **Figure 6**.

Nielsen argues that most user interfaces are intended for both novice and expert users and thus need to support both user types. The novice-expert categorization is frequently applied in mobile phone usability engineering, although e.g. in many countries where Nokia has product creation activities, it is becoming increasingly hard to find novice users of mobile phones as representative consumers for user testing. We can argue, though, that in the mobile telephone domain the significance of novice users is gradually decreasing as an increasing amount of customers are purchasing their second, third, or perhaps tenth handset. 52% of the sold handsets were replacements in 2001, and by 2006 the figure is expected to rise to 77% (Strategy Analytics 2002).

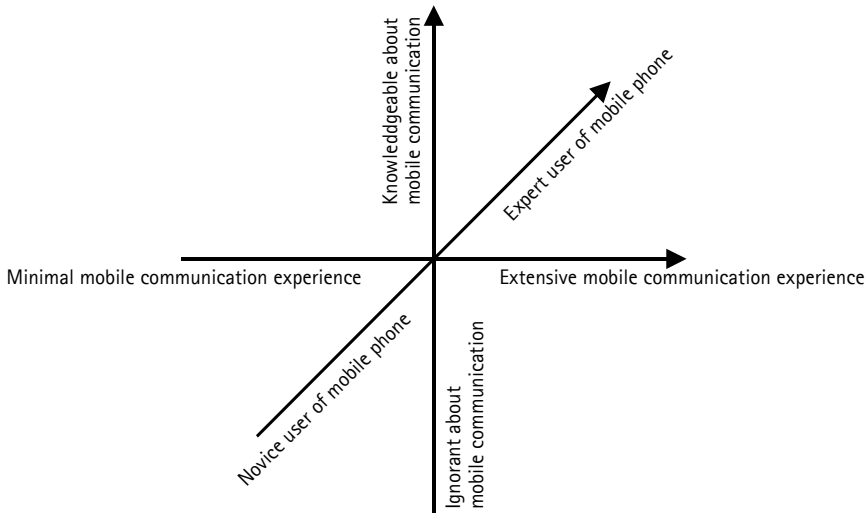

Figure 6. Three main dimensions on which users' experience differ (Ketola 2002)

The following sections will illustrate the UI-related differences between first-time users and replacement users. Moore's (1995) Technology Adoption Life Cycle is introduced as a model for different customer types embracing new technology products. The various socio-cultural and socio-demographic models that are applied in the mobile communications industry are illustrated via manufacturer cases. The section concludes by analyzing the relevance of the user interface among the mobile operators, service providers, and other stakeholders in the mobile communicating value chain.

2.1.1 First-time Users and Replacement Users

During the 1980s and 1990s the mobile phone manufacturers were mostly targeting consumers who had no previous experience with mobile telephones. The manufacturers were focusing mostly on basic mobile telephony functionality: the objective was to remove the wire from the plain old telephone, and market the benefits of wireless, mobile calling to the masses. The situation is still roughly the same when we look at the developing markets such as India, Russia, or China. However, the more saturated mobile phone markets in the Americas, Europe, and Asia have moved to a phase where most people are no

longer purchasing their first mobile phone, so vendors, operators and service providers are trying to lure consumers to purchase new phone models with enhanced features, and by offering various mobile, value-adding services. In the U.S alone, during the year 2002, 75% of mobile phone purchases were replacement ones.[38] This trend will continue to increase in the most developed markets (Strategy Analytics 2002).

A Nokia-internal marketing study conducted in early 2003 listed the following reasons why first-time users purchase a mobile phone[39]:

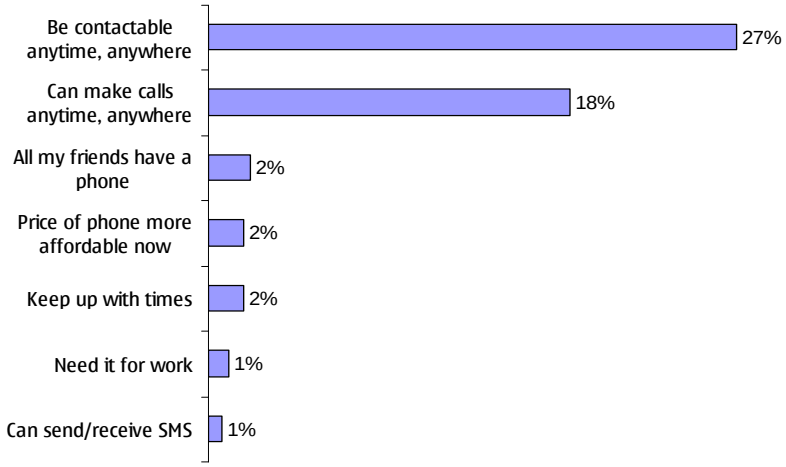

Figure 7. Main reasons for first-time users to buy a phone

On the other hand, the reasons to purchase a replacement phone model are different. **Figure 8** from a survey focusing on the Nokia 7650 phone purchasers reveals that upgrading to new technical features and functionality such as a camera are key reasons for people to replace their earlier mobile phone[40]. Camera phones are expected to boost replacement demand for mobile phones globally as the trend is already visible in Japan.

The first-time purchasers in China did not mention the user interface or ease-of-use at all when prompted for their purchasing criteria. On the other hand, of the replacement users who bought the 7650 phone, 2% spontaneously mentioned menu or user interface as the main reason for choosing just that model. These findings are roughly in line with other studies conducted at Nokia — replacement consumers pay slightly more attention to the user interface than the first-time buyers.

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[38] Strategy Analytics. REPLACEMENT SALES DRIVE 7% GROWTH IN USA MARKET. 18-Mar-2003. [Cited 06-Jul-2004] Available from WWW: <http://www.cellular-news.com/story/8507.shtml>.

[39] Post-launch user study of 285 first-time mobile phone users who had purchased the Nokia 2100 phone in China. The study was conducted in March – April 2003.

[40] Post-launch user study of 403 Nokia 7650 phone purchasers. The study was conducted in Hong Kong, Germany, and the U.K. in November 2002 – January 2003.

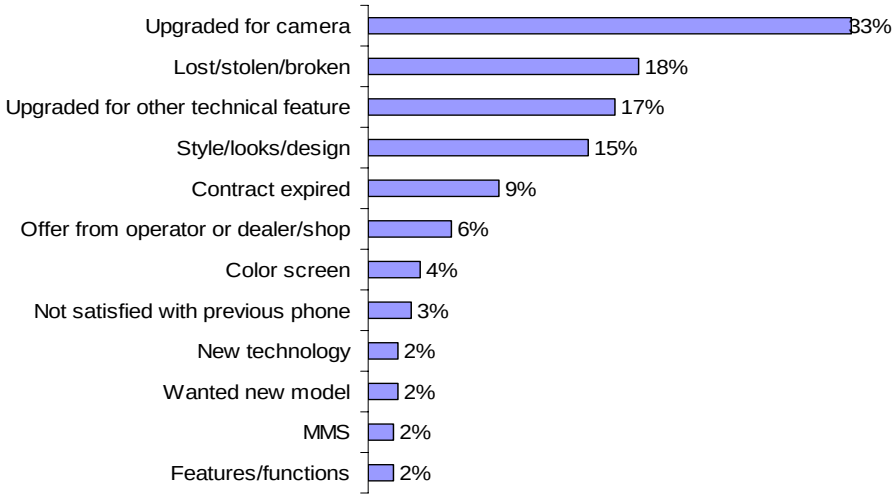

Figure 8. Main reasons to replace previous phone

Consumers rarely like to spend significant effort learning to use a new consumer appliance such as a mobile phone, but they often value smaller, intuitive improvements making the handset faster or easier to use. An example outside the mobile phone UI domain is the computer keyboard. It has its roots in the typewriter keyboards but has added function keys, arrow keys, a delete key, and a control key. Yet the layout of the typewriter keys is still largely unchanged (Stallman 1991). The most recent evolutionary enhancements to the computer keyboard include the Microsoft Windows shortcut keys, and various Internet access keys. Donald Norman writes in (Bergman 2000):

> *"So now we come to the world of high technologists and their craving for newness and better and faster and bigger and more powerful… The rest of the population, the vast majority of people (perhaps 75 to 80%), doesn't want that. They don't want to change their systems every six months, not even every year. They want stability. They want a very slow evolution toward improved devices, slow enough that they can grow with them, learn them, and feel comfortable with them. They want slow, steady evolution, not those big gigantic changes every six months."*

Figure 9. Vertu

In the mobile phones industry, Norman's description of slow evolution is realized by mobile phones by e.g. the Vertu luxury brand as illustrated in **Figure 9**. The exterior casing and interaction style of the luxury phone can remain the same while the internal components can be upgraded to more advanced cellular technologies or user interface hardware such as an upgrade from a grayscale display to a color one.

According to Johnson (1992) and Anderson (2000b), in problem-solving situations experts can recognize patterns of elements that repeat over problems. Also, as people become more expert in a domain, their ability to store and retrieve problem information in long-term memory improves. However, expertise can often be quite narrow; there is often failure to transfer skills to similar domains and virtually no transfer between very different domains. In

some cases there is very large positive transfer between two skills having the same logical structure even if they have different surface elements; e.g. there is large positive transfer between different word-processing systems[41], between different programming languages, and between the application of calculus in economics problems and solid geometry problems. The positive transfer is bounded by the different problem domains involving the same facts, productions, and patterns, i.e. the same abstract knowledge elements. Anderson (2000b) further concludes that there seldom is negative transfer denoting a situation in which learning one skill makes a person worse at learning another — skills do not interfere. However, Pollock (1988) and Knowles (1989) report on both positive and negative transfer on users moving between software tools such as word processors and computer-aided design programs. Johnson (1992) argues that the user interface designer should aim at utilizing the user's existing knowledge of the domain and task. Wherever it is possible without constraining innovation and enhancement, the designer should attempt to maximize the amount of opportunity for positive transfer and minimize the occurrence of negative transfer of the user's knowledge and skill.

User experience continuity affects the easiness of switching from one phone to another: new menus and screen designs may have to be learned. Reinhardt (2002) writes that the differences rarely add any value to the user experience, and they are really just designed to slow customer drop-off. A familiar user interface can be used as a sales argument like e.g. Nokia did when introducing the CDMA2000 6370 phone model in 2002, and Microsoft is doing with the Microsoft Smartphone platform:

> *"Despite the powerful new features of the Nokia 6370 phone, previous Nokia users will find that the familiar menu structure and keypad layout makes learning how to access the new functionality quick and easy."*[42]

> *"This ease-of use is an important part of what will make Smartphone 2002 a success: if you know how to use a cell phone, you can pick up the Smartphone 2002 and start using it."*[43]

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[41] Ample amount of research on text editors has been conducted in the academia as reported in the editor research bibliography of Ediger (2002). Polson et. al. (1987) describe tests between similar screen editors, between different line editors, between text editors and graphic editors, and from line editors to a screen editor. In the tests they found large positive transfer effects even though the editors to be tested were chosen to be maximally confusing. Since only the surface commands were different but the underlying operations of the editors were similar, the test subjects had no major difficulties when transferring from one editor to another. Knottenbelt (1999) conducted a comparative study of the editors Vi and Emacs from the perspective of novice and regular users. Emacs with its more predictable nature outperformed Vi with respect to time taken to perform the tasks and the amount of help needed with the sample of novice users. For a regular user of one editor there appears to be no advantage to switch to the other. The thesis author recalls from his own university period from the late 1980s that both students and researchers spent considerable amounts of time arguing about and tinkering with their favorite text editors. The amount of scientific, analytical research on the same topic was far smaller.

[42] Nokia. NOKIA BEGINS SHIPMENTS OF ITS FIRST CDMA2000 1X HANDSETS. 10-Jun-2002. [Cited 06-Jul-2004] Available from WWW: <http://press.nokia.com/PR/200206/862789_5.html>.

2.1.2 From Innovators to Laggards: Technology Adoption Life Cycle

Moore (1995) introduces the *technology adoption life cycle* to model and understand the attitude of different consumer types towards new products. The attitude towards adopting new technology is important when radically new products are marketed; these products introduce *discontinuous innovations* that force us to change our behavior or to modify other products or services we rely on. In contrast, *continuous innovations* products do not require us to change our behavior or existing products. High-tech industries routinely introduce discontinuous innovations, such as digital mobile phones to replace analog ones — that demand significant changes by not only the consumer but also by the infrastructure[44]. The technology adoption life cycle model shown in **Figure 10** describes the market penetration of any new technology product in terms of a progression in the types of consumers it attracts throughout its useful life.

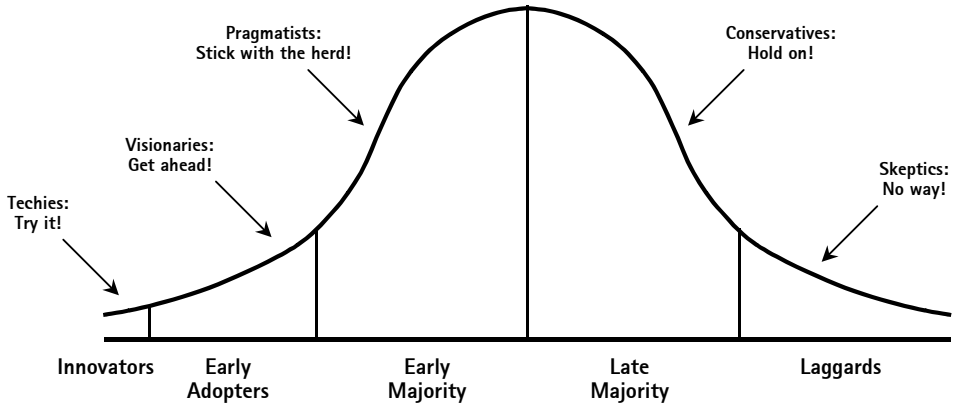

Figure 10. Technology adoption life cycle

Each consumer group in the model represents a unique psychographic profile. *Innovators* pursue new technology products aggressively as they have technology as a central interest in their lives, no matter of the function of it. *Early adopters* are not technologists but they find it easy to imagine, understand, and appreciate the benefits of a new technology in an optimistic manner. The *early majority* is driven by a strong sense of practicality so they wait and see how other people are making out before they buy in themselves. The *late majority* shares the attitude of the early majority but it is not comfortable with new technology, so they will wait until something has become an established standard, and then they will prefer buying from large, well-established companies. The *laggards* don't want anything to do with new technology and they generally buy technology products only when these are buried inside another products. High-tech product marketing is built around this profile: to develop a high-tech market a company must work the curve from left to right, focusing on one customer segment at a time, growing that market, and then moving to the next market segment. The

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[43] Pocket PC Insiders. INTERVIEW OF MICROSOFT'S JUHA CHRISTENSEN. 03-Dec-2002. [Cited 06-Jul-2004] Available from WWW: <http://technologyreports.net/wirelessreport/?articleID=1284>.

[44] As Sonera shut down the Finnish NMT900 and NMT450 analog mobile networks (in 2000 and 2002, respectively), the (few) users still using the service had to upgrade their handsets to digital GSM models. Some complaints were risen as in e.g. some barren areas in Finnish Lapland the GSM coverage is still not as good as the old NMT network was.

crucial aspect is to keep the process moving smoothly without discontinuities in the progress; if the momentum is lost at the transfer from one consumer segment to the next one, it will be extremely hard to win the potential consumers again. Another motive for maintaining momentum is to keep ahead of the competition; if the product gets sold to consecutive consumer segments, there is no window of opportunity for a competing technology product to lure the consumers. Moore (1995) argues that there is a dividing *chasm* between the early adopters and the early majority. The early adopters are buying the new product as a *change agent* with all the inevitable bugs and glitches that accompany any innovation just coming to the market. By contrast, the early majority want to buy a *productivity improvement* to minimize discontinuity with the established ways of doing business. The early majority does not want to buy the product without reliable references and the only applicable reference for an early majority customer is another member of early majority: catch-22.

A real case from the mobile phone domain to illustrate the technology adoption model is Wireless Application Protocol, or WAP. The wireless industry launched WAP with considerable marketing effort and hype in 1999 to bring the wireless Internet to the millions of mobile phone users:

> *"The Nokia 7100 series' Wireless Application Protocol (WAP) compatible media phone … puts the Internet in your pocket, ready to access whatever you want whenever you want."*[45]

Mobile service developers cranked out services, innovators and early adopters bought new handsets, but the momentum did not reach the early majority, as the phones and services were not useful or usable enough and the cost for the services was too high. The early majority was not interested in the technology but expected utility instead, and WAP could not deliver.[46]

> *"… The 7110 is, if you want the ultimate geek-phone, the ultimate-geekphone. … So, buy a 7110? No,don't! … Most of us don't need it. The ones that do, like me, we need it bad. But don't think that the WAP features will save your day. Basically, today, WAP sucks. The phone rocks, it's a good phone with the latest TechFeatures, but, does the common man need it, NO. Developers need it. …"*[47]

Microsoft and its mobile phone vendor partners are currently in the process of introducing the first mobile phones made on the Windows Powered Smartphone 2002 operating system and user interface platform.[48] Juha Christensen of Microsoft outlines Microsoft's plan of reaching the consumer market by using the technology adoption life cycle framework:

> *"… I think the first place to break through is the enterprise users - they are more rational! We can get all the apps and all the plumbing working and then go out*

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[45] Nokia. ANNUAL REPORT 1999. [Cited 25-Apr-2002] Available from WWW: <http://www.nokia.com/investor/annual/docs/eng99.pdf>.

[46] More scientific and detailed evidence of the usability problems associated with 1st-generation WAP handsets and services is provided by Ramsay & Nielsen (2000).

[47] Jocke Selin. 09-Mar-2000. [Cited 15-Jul-2002] Available from WWW: <http://jocke.selincite.com/nokia_7110.php>.

[48] **Section 3.3.7** of the thesis provides more details of the Windows Powered Smartphone 2002 UI platform.

and break through to the consumer market. A lot of people are getting together and getting out to the enthusiasts, the enterprise users an early adopters."[49]

2.1.3 Socio-cultural Lifestyle Segmentation

The established consumer marketing and segmentation models are often based on demographics such as the consumers' income, level of education, age, gender, or type and place of residence. These can no longer reliably represent the consumer base due to the ongoing fragmentation of the consumers' lifestyle and consuming patterns. Consumers' values change very slowly whereas their life-styles change faster, as e.g. a teenager hanging around discos turns into a parent five years later (Zeime 1997). Various psychographic methods are increasingly being used to model the consumer base and the purchasing decision motives. In this kind of *lifestyle segmentation*, detailed or deep knowledge is needed about the consumers' real-life usage and thinking patterns (Zeime 1997, Ketola 2002). **Figure 11** illustrates the hybrid demographic-lifestyle segmentation model developed by marketing research consultancy Ovum; this model is based both on the age of the consumers and their lifestyle (Helin 2002).

	Core consumer segments defined by Ovum		
Children	**Tweenies**	**Early teens**	
Youth	**Conformists**	**Hedonists**	**Creative misusers**
Middle youth	**Nesters**	**Status seekers**	
Mature	**Explorers**	**Solid worth**	
Retired	**Silver traditionalist**	**Silver surfers**	

Figure 11. Core consumer segments for wireless devices

Mobile phone manufacturers are currently applying various socio-cultural lifestyle segmentation models, and they share somewhat similar views on the different consumer segments. The following tables illustrate the evolutionary development of the consumer segmentation models of the major manufacturers.

Figure 12 illustrates the user segmentation model evolution of Ericsson and Sony Ericsson (Zeime 1997, Baffoy 2000, C&K Management 2002, Mannermaa 2003). Ericsson's Take 5 segmentation model was established around 1997, and it was based on background information from annual surveys conducted in 33 countries and biennial surveys in 24 other countries; approximately 2500 – 3000 people selected randomly were surveyed in each country with a survey of 144 trend-reflecting statements (Zeime 1997). Zeime argues that categorization of people based on age or market analysis based on demographics is no longer an accurate yardstick as societies have become increasingly individualistic.

Motorola's consumer segmentation strategy has been established in 1998. The model is established based on 140,000 interviews carried out globally over the period of three years (Baffoy 2000). C&K Management (2002) and Baffoy (2000) describe the four consumer segments of Motorola shown in **Figure 13**.

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[49] Wirelessreport.net. FROM THE BEGINNING TO THE END: A GREAT DEVICE EXPERIENCE. 2002. [Cited 10-Jul-2002] Available from WWW: <http://www.wirelessreport.net/pocketpcinsiders/november/juhachristensen.html>.

Ericsson 'Take 5' model (Zeime 1997, Baffoy 2000)	Ericsson 2002 (C&K Management 2002)	Sony Ericsson 2003 (Mannermaa 2003)
◆ **Pioneers**: Active individualists and explorers, interested in and knowledgeable about advanced technology; motivated by innovation and intensity; impulsive buyers, attracted by strong brands. Prominent in Latin America. Prefer leading-edge performance and design; will pay for quality. ◆ **Achievers or Careerists**: Hard-working, competitive people, who consciously seek success. Prominent in Sweden, Australia. Prefer luxury products marketed as status symbols with user-friendly and time-saving technologies; willing to pay for quality. ◆ **Materialists**: Attracted to strong and trendy trademarks; look for status and recognition; group affiliation important; like to have fun; easy to influence and not particularly loyal. Prominent in the U.K., the Netherlands. ◆ **Sociables**: Interested in social issues, and culture; rational purchasers and loyal customers. Prominent in China, Finland. Prefer sophisticated, easy-to-use products with sober design features. ◆ **Traditionalists**: Prefer harmony to change, established products, well-known trademarks. Prominent in Germany, Japan[50], Taiwan. Prefer reliable and user-friendly products; satisfied with limited number of functions; reasonable prices.	◆ **R-Segment**: tech-savvy individuals who prefer their instruments to be feature-rich and state-of-the-art. ◆ **T-Segment**: individuals who require their instruments to have some class and style. ◆ **A-Segment**: individuals who are using their first mobile and prefer an easy-to-use instrument.	◆ **Professional forerunners**: technology freaks who want the latest gadgets the others don't have yet. ◆ **Discriminating forerunners**: typically 20-50 year old men who want quality, reliability, social prestige, design, and style. ◆ **Fun-loving youth**: they want to be individuals like all their friends, and want to have games in their phones. ◆ **Practical consumers**: usually 28-50 year old men who embrace family values, and want a reliable phone.

Figure 12. Ericsson (Sony Ericsson) consumer segmentation model evolution

Motorola 2000 (Baffoy 2000)
◆ **Technophiles**: Prefer visionary state-of-the-art technology. Lifestyle and values similar to Ericsson's Pioneers. Heavy mobile phone users. Visionary design: combat pilots featured in ads. 'Accompli' brand. ◆ **Achievers**: Phone as time manager - be efficient in professional life - reachable wherever you are across the continents of the world. Heavy mobile phone users. Modern but sober business design. 'Timeport' brand. ◆ **Design freaks** are on the go, urban, trendy and fun. Social life (friends) important. Fashionable design. Functionality less important. 'V.' brand. ◆ **Ordinary people**: have basic communication needs, and value reliability and safety; keeping up with your family and the rest of your social network. Light mobile phone users. Design and special functions (WAP, calendars) less important. 'Talkabout' brand.

Figure 13. Motorola consumer segmentation model

Motorola (2002) themselves define the consumer and product segments in their personal communications portfolio slightly differently as illustrated in **Figure 14**.

[50] This is in contrast with the common understanding of technology-savvy Japanese consumers. However, the relatively slow take-off of NTT DoCoMo's 3G wireless service in Japan has shown that also the Japanese marketplace does not hold an indefinite lust for new wireless technologies: "… *Nearly 60 percent of the Japanese own cellphones, and persuading them to trade in their trusty year-old models for newfangled ones is becoming tougher. … the 3G handsets, packed with cameras and stereo sound, are twice as expensive as are the older handsets with similar functions. … The Japanese consume technology as few others do, but are videophones and 30-second movie clips crucial to everyday life?*" In: The New York Times. [Cited 26-Apr-2002] Available from WWW: <http://www.nytimes.com/2002/04/22/technology/ebusiness/22PHON.html>.

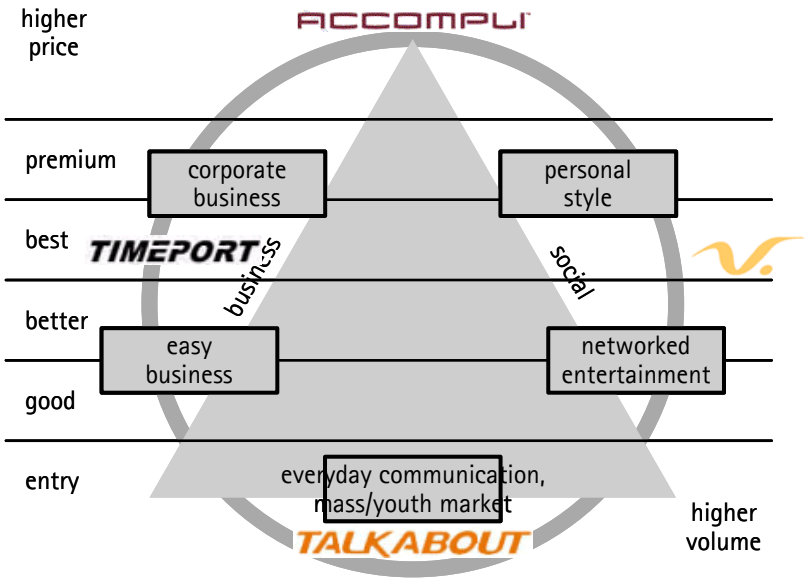

Figure 14. Motorola consumer and product segmentation (Motorola 2002)

One of Nokia's success factors is generally considered to be the leading application of consumer and product segmentation (Koo 2000, Mannermaa 2003). Nokia's evolutionary approach to consumer segmentation is illustrated in **Figure 15**. Nokia's current consumer segmentation model is called 'Mindstyles', and it is based on a questionnaire conducted among 8000 people in the US, Brazil, Germany, Italy, Japan, South Korea, China and Taiwan. This sample of consumers was asked to respond to 59 statements of general attitudes and values. The result is a better understanding of different life strategies present in today's global society. Mindstyles describes six consumer segments, their core life strategy, behavior, cost-sensitivity, loyalty, aesthetics and functionality (Nokia 2003).

A market-specific lifestyle segmentation survey is reported by (ACNielsen 2002) regarding the China market.[51] ACNielsen claims that instead of focusing on the low-end market with heavy price competition and excessive advertising, the mobile phone vendors should listen to the consumers' needs and market their products to the full potential also among the middle and high-price segments. The survey defined five consumer segments based on consumers' different shopping attitudes and price expectations for mobile phones, as illustrated in **Figure 16**.

Market area specific differences are commonplace in the split between consumer segments: for example in the reported survey Shanghai was dominated by Value-hunters (31%), and in Guangzhou, Herds were dominant (one third). Beijing had a relatively balanced mix of user segments. The report further states that Motorola and Nokia, the leading brands in China, appeal to all consumer segments, Samsung appeals to most Adventurers, and Ericsson is popular among Value-hunters and Worker Bees. We can see that the **Adventurers** resemble the

[51] 1500 consumers were interviewed in a telephone poll covering Beijing, Shanghai and Guangzhou. They were asked about their preferred brands and preferred prices for products in popular categories like shampoo, instant noodles, bottled water, toothbrush, mobile phone and discman.

mobile phone manufacturers' **Pioneers** segments, and the **Worker bees** are similar to the Business users of **Hi-fliers**. The **Value-hunters**, **Herds**, and **Laggards** are a more Chinese-specific phenomenon, as e.g. the domestic brands have a prominent role in the Chinese marketplace.

Nokia early 1990s (Ketola 2002, Winblad 2000)	Nokia 2000 (Baffoy 2000)	Nokia 2002 (C&K Management 2002)	Nokia Mindstyles 2003 (Nokia 2003)
◆ **Trendsetters**: Mainly technology oriented male, wanting to keep up with the latest features and functions, appreciating personal freedom. ◆ **High-fliers**: Mainly career oriented male professionals, positive about technology, appreciating work efficiency; heavy users of data and text services. ◆ **Social contact seekers**: More female than men, family and friends important, appreciating ability to be in contact wherever and whenever; mainly personal use. ◆ **Posers**: More males than females, sociable and willing to impress others, trendy and fun-loving; both business and personal usage.	◆ **High flyers** ◆ **Trendsetters** ◆ **Poseurs** ◆ **Reachables** like outdoor life, sports, adventure and wild land life. They often exert professions like constructor or craftsman. As the name and the nature of the job imply, they have to be reached at all moment. That is why they value reliability and durability. ◆ **Social contact seekers** ◆ **Assured**: The assured are rationalist hard-working people who see the phone primarily as a working tool. They price technique that is well established and reliable. WAP is seen as a complementing feature. The Nokia 6150 model is the natural choice as its reputation of quality is renowned.	◆ **Trend-setters** ◆ **Hi-fliers** ◆ **Social contact** seekers ◆ **Assured**	◆ **Experiencers** are the most extrovert, sociable and fun loving. They have a youthful and optimistic approach to life. They are always on the move, living fast, seeking the new and the different and are easily bored. ◆ **Impressors** are more astute at understanding the subtle rules of society and are better at managing their relationships than the other segments. They are very conscious of the impression that they make on other people. They like shopping. They are also very organized and good at looking after the people who are important to them. ◆ **Controllers** are more quiet and reserved than other segments. They value their own space and try to create their own space to think about things in their own time and their own way. They are quite independently minded and don't appreciate people who try to influence them – they seek the facts and try not to be swayed by the way they are presented. ◆ **Maintainers** successfully manage to concentrate on the important things in life – in particular the people and the values that are important to them. They are devoted to their family and friends. They probably enjoy nature and try to find time to appreciate the simple pleasures of life. They are good at assessing the real value of things rather than being swayed by the promise. ◆ **Balancers** have a busy, even hectic lifestyle. Time is at a premium and they are looking for ways to streamline their life so that they can get everything done but in less time, leaving time for the people and activities that they enjoy. So they can be impatient with people who try to give them too much detail or who try to make up their mind for them. They are very capable of judging for themselves what is best for them. ◆ **Sharers** have the most mature and confident approach to life. This makes them open-minded and flexible and able to live life on their own terms. They are less concerned with how they appear to others than most, but are concerned with living in accordance with their own ethical code. They are more emotionally aware than the other segments and able to take a balanced view of their own and others' needs.

Figure 15. Nokia consumer segmentation model evolution

Consumer segments – 'the five faces of Chinese consumers'	
Adventurers	Eager to try new things and spend money on new technologies or new gadgets.
Worker bees	They strongly believe in quality and will be willing to pay for high quality brands.
Value-hunters	They seek best bargains and are willing to wait to get the best value for money.
Herds	Herds are people who are vulnerable to influence of advertisement.
Laggards	Brand-conscious but don't discriminate between international or local brands.

Figure 16. Chinese consumer segmentation model

Wilska (2002) investigated the purchasing behavior of 16 – 20 years old teenagers and their adoption of and attitudes towards information technologies and mobile telephones. Teenagers' attitudes towards information technology and mobile phones align with their attitudes towards consumption in general. There is correlation between techno-positive and environmentally negative attitudes, and vice versa. Wilska further identifies the following consumer groups regarding the usage styles of mobile telephones: **addicts**, **trendy users**, and **economy users**. Addicts were more likely to be girls, and trendy users were more likely to be boys. The consumer groups, their mobile phone usage characteristics, and product purchasing criteria are summarized in **Figure 17**. 91% of Wilska's sample of 637 teenagers possessed a mobile phone with the average length of mobile phone ownership being about 2.5 years. When comparing the study findings to earlier studies, it can be seen that teenagers have started to use more the new phone features such as the alarm clock, calendar, calculator, downloadable operator logos and ringing tones. A phone is no longer used only for voice calling and text messaging.

Teenager segment	Gender	Mobile phone usage characteristics	Mobile phone purchasing criteria
Addicts	More likely to be girls	Values operational utility, important to make phone calls and send text messages even with nothing real to say, uncomfortable to be without a phone, calls and messages are checked regularly, calling in public places appropriate, frequent changing of ringing tone and operator logo, potential problems with the phone bill	
Trendy users	More likely to be boys	The phone must fit the owner's image, the network subscription must be by a cool operator, frequent changing of ringing tone and operator logo	The latest model, newest technology features, Internet connection (e.g. WAP)
Economy users	Both girls and boys	Usage is about necessary communication	Price is the driving factor, the phone can be an older model

Figure 17. Teenager consumer types of mobile phones

Wilska argues there is no significant correlation between the amount of available money or the socio-economical status of the family with the attitude towards mobile phones and information technology consumption among teenagers. However, there is strong correlation between the attitudes towards mobile phone usage characteristics and consumption behavior in general. Also, gender is a factor in explaining the differences in mobile phone usage characteristics but it does not correlate with mobile phone ownership or with the money spent on the phone bill. Trendy users' purchasing behavior lacks environmental awareness whereas the economical users consider themselves as deliberate and environmentally aware consumers.

Wilska concludes there is no single norm of mobile phone usage among teenagers. Mobile phones are still considered technological gadgets, albeit easy to use, and there are differences between the usage characteristics of boys and girls. Mobile phones are necessities to teenagers, but phones do not (yet) comprise the biggest single proportion of consumption for them, as clothes, travel, transportation, and hobbies possess an equal share.

It is difficult if not impossible to make one common projection of the various consumer segmentation models where all segments from individual models could be represented. Baffoy (2000) presents the following overview of how the consumer segments from Ericsson, Motorola, and Nokia relate to each other.

Ericsson	Motorola	Nokia	Benefit / Core Need
Pioneers	Accompli	High Flyers (Trendsetters)	The latest
Achievers	Timeport	Assureds	Efficiency at work
Materialists	V.	Posers	Fashionable/status
Sociables	(V.)	Social contact seekers	Social life support
Traditionalists	Talkabout		Basic – phone used for talking
Reachables	Reachable[52]	Reachables	Durability

Figure 18. Ericsson, Motorola, and Nokia consumer segments aligned

The abovementioned segmentation models show some obvious similarities and yet there are consumer segments in some models that are missing from others: Motorola does not have a segment that stresses durability, and Nokia is lacking a segment of price-sensitive traditionalists. Nokia's current Mindstyles segmentation model describers consumers' life strategies, whereas Ericsson's (or Sony Ericsson's) model is more aligned with Moore's technology adoption life cycle. The approach applied by Motorola is a mixture of demographic and handset functionality-based segmentation.

2.1.4 Mobile Operators and Service Providers

Mobile operators (e.g. Cingular, NTT DoCoMo, Radiolinja, and Vodafone) are gatekeepers between the mobile user and the mobile voice and information services. In some markets the operators[53] purchase mobile terminals from the terminal vendors in mass volumes and market them to consumers by bundling the terminal and the service contract together; in some other markets this coupling does not take place due to regulatory or other reasons, and the handset vendors sell their devices via ordinary consumer electronics or other sales channels. *Service providers* offer mobile telecommunications services to consumers via a telecommunications network leased from a mobile network operator.[54]

Mobile operators have a specific interest on the mobile device user interface. The handset user interface is a key enabler from several perspectives:

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[52] Motorola does not have a 'Reachable' segment even though Baffoy (2000) lists one.
[53] In the U.S. the commonly used term is *carriers*.
[54] TheFeature.com. [Cited 06-Jul-2004] Available from WWW: <http://www.thefeature.com>.

Average Revenue Per User (**ARPU**). An appealing and easy-to-use handset is likely to enable the users to make more phone calls, send more text messages, download content, and have less difficulties in accessing the operator's mobile Internet services.[55] Before the mobile Internet era, mobile handsets were used primarily for voice calling, text messaging, and occasional game playing. With the advent of the mobile Internet, and e.g. the multimedia messaging services, mobile operators have broadened the spectrum of mobile services they offer. In addition to the voice and text communication, the operators now increasingly provide operator-branded mobile Internet services or act as a wireless gateway to the Internet. As with voice and text services, the operators are interested on the usability of the terminals — and obviously of the services, too — in order to maximize the access to and use of their services:

> *"Even handsets with simpler navigation systems encouraged users to send text messages and browse WAP sites much more frequently than devices where navigation was more difficult or time-consuming. Nokia users, for example, were found to send on average 45 SMS messages a month compared with 14 for the average Motorola user."*[56]

An appealing user interface is also an element that can reduce *churn* i.e. the proportion of subscribers terminating their mobile contract.

Brand. Like the handset vendors, the mobile operators are investing considerable sums of money in their brands[57], and they are very keen on making the brand visible in the terminals as well. The contemporary cellular phone user interfaces with high-resolution, color displays, provide a powerful enabler for branded mobile content and services provided by the mobile operator. Vodafone, for example, has been actively promoting its branded Vodafone Live! service that is delivered via a Vodafone-branded user interface in the handsets:

> *"Mobile phone giant Vodafone Group PLC plans to launch mobile handsets … using the Vodafone brand name and a user interface designed by the company, said industry sources. … "The phones will be very different. We are talking colour screens and cameras and the whole customer experience will be Vodafone's and not Nokia's," said a source close to the company. … "Although this is unconfirmed, it appears that Vodafone has gained approval from Asian handset vendors to take control of the handset user interface," said the broker. "This signals a shift in strategy and could have a potentially significant impact on the*

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[55] *"The networks are looking at how much revenue they are making from each handset. They will know that they make more money from a Nokia phone than from another model."* (BBC 2001)

[56] *"Orange blames over-complexity for slow take-up of mobile data services in Europe."* In: Telecoms.com. 27-May-2003. [Cited 01-Jun-2003] Available from WWW: <http://www.telecoms.com/NASApp/cs/ContentServer?pagename=telecomsportal/render&var_element=content/article_display&auth_pubcode=MC&var_article_id=1034683339605&var_seqnum=354&display_channel=home>.

[57] Samsung increased its marketing in 2001 and this resulted in a 30% increase in its brand value from 2001 to 2002. Samsung was planning to spend $200 million on advertising as it attempts to challenge Nokia. In: Motley Fool. 2002. [Cited 06-Jul-2004] Available from WWW: <http://www.fool.co.uk/news/comment/2002/c020731b.htm>.

business model of handset vendors such as Nokia, Motorola, Siemens, Sony Ericsson, et al," it added."[58]

"Vodafone and Orange are the latest in a growing number of global operators to specify their own devices with the high profile launch of the Vodafone Live! service package and the Orange SPV feature phone. A Sharp device with a graphical user interface designed by Vodafone lies at the heart of the Live! service."[59]

Section 2.3.7 will investigate the user interface as a branding element in more detail.

Customer support. An intuitive mobile handset user interface makes it easier for a novice user to start using the device, and is likely to reduce the need for customer support by the mobile operator, or by the handset vendor. Unlike the branding aspect, where the operator wants to differentiate from the competitors and from the handset vendors, the operators' customer support does benefit from the handsets of different vendors conforming to some harmonized usage conventions, as the support personnel need to master fewer different user interfaces, and educating the subscribers becomes more straightforward.

2.1.5 Other Stakeholders

Besides the consumers and mobile operators, the mobile handset user interface is of particular interest to some other interest parties.

Mobile service developers and content creators develop services, applications, and content to be accessed or used with mobile handsets. These solutions are developed based on the underlying development application programming interfaces (APIs) and the device user interface. The developers need to be familiar with at least the following attributes of the device user interface:

- User interface development libraries and toolkits
- User interface components or widgets
- Display resolution, color depth, and physical size
- Display frame rate, availability of display accelerators (e.g. 3D)
- Available input devices: joysticks, keypad configurations, touchpads
- Sound support capabilities, vibration effects
- End-to-end service development conventions and constraints
- User interface design guidelines and conventions

Numerous mobile user interface development platforms are available for mobile service developers to choose from. Some of these support only the deployment of standalone terminal applications while some others include the complete end-to-end chain and business model. Contemporary service UI platforms include – but

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[58] Ananova. "*Vodafone to launch 'own brand' mobile handsets in big ad push – sources.*" 25-Sep-2002. [Cited 06-Jul-2004] Available from WWW: <http://www.ananova.com/business/story/sm_678005.html>.
[59] Ovum. "*Sendo's shock announcement proves operators are taking the driving seat says Ovum.*" 07-Nov-2002. [Cited 06-Jul-2004] Available from WWW: <http://www.ovum.com/go/press/mediareleases/015991.htm>.

are not limited to: Brew, i-Mode, Java, Microsoft Smartphone, MMS, Nokia Series 60, Nokia Smart Messaging, WAP, and XHTML.

Retail and sales personnel are the last element in the delivery chain before the consumer. The prospective consumer usually purchases a mobile phone in a store environment. These locations vary from operator stores and consumer electronics chains to department stores or supermarkets. A Nokia-internal sales channel study conducted in the USA in 1996 concluded that the handset is considered very late in the purchasing process, and that the user interface is playing a role in affecting the purchasing decision-making.[60] Also, the retail people are reluctant to sell handsets that are difficult to configure and program, since the programming takes up valuable selling time and adds more stress. Obviously it must be noted that there are differences between the market regions and the market situation between 1996 and today: e.g. the relative amount of first-time buyers has decreased significantly from 1996.

2.1.6 Mobile Communications Business Value Chain

The mobile communications business is not only about the handset manufacturers (e.g. Motorola, Nokia, or Samsung), the mobile operators (e.g. Cingular, NTT DoCoMo, or Vodafone), and the mobile phone users spending airtime. Some but not all of the mobile phone manufacturers are also wireless infrastructure equipment makers, software and service platforms are developed by third parties, applications such as games, and the vaguely defined 'content' are becoming increasingly important. All of these parties affect the mobile device UI or expect something from it. This section will briefly outline the role of these stakeholders in the overall mobile communications business value chain as shown in **Figure 19**.

Figure 19. Mobile communications business value chain[61]

Infrastructure manufacturers (e.g. Alcatel, Ericsson, Nokia) make the communications network elements — e.g. mobile switches, base stations, routers, and gateways — that connect the wireless and wired networks together. New infrastructure elements facilitate the bandwidth increases required to deliver new, richer forms of services and content to the mobile terminals. Some communications infrastructure manufacturers also make terminals (e.g. Nokia and Siemens) and sometimes in major business deals between manufacturers and operators the deals include both infrastructure and terminal equipment.

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[60] If the users did not handle a live handset in the store, they usually preferred a Motorola handset, but if they were able to interact with a functional handset, they usually chose a Nokia model.

[61] TheFeature.com. [Cited 06-Jul-2004] Available from WWW: <http://www.thefeature.com>.

Mobile wireless terminals include e.g. mobile telephones, communicators, wireless PDAs, and pagers. The *terminal* is the end point for voice communication and for mobile Internet services that the end user or consumer is accessing via the terminal's user interface.

Platforms or *middleware* are (*de facto* or *de jure*) standardized hardware or software to link devices, applications, and network services. Companies like Intel, Microsoft, Nokia, and Texas Instruments have recently announced smart phone reference designs or open platforms targeted at making it easier, faster and more inexpensive for a mobile phone manufacturer to create mobile phones compatible with the standard platform. The reference designs from e.g. Microsoft and Nokia include a standard user interface platform — Microsoft's Windows-derived Smartphone UI, and Nokia's Series 60 UI, respectively. Companies in the mobile communications industry are working in special interest groups to create and standardize middleware software such as e.g. Bluetooth[62], mobile Java[63], MMS[64], and WAP[65]. Other examples of middleware include various authentication, m-commerce, and virtual private network platforms.

Applications for personal information management, news and stock quotes, mobile email, mobile banking and stock trading, and last but not least mobile games are developed by application developers applying various middleware platforms such as Java, WAP, HTML, or mobile device operating systems such as Microsoft's Pocket PC, the Palm operating system or the Symbian operating system.

Mobile content denotes the information accessed via the wireless device: text, icons, animation, video, sounds, music, or in many cases a combination of several of these formats. *Content developers* and *providers* create and deliver mobile content to mobile subscribers, whereas *content aggregators* gather and reprocess content from content providers for mobile subscribers. *Portals* like Zed[66] are entry points or starting sites for mobile (Internet) services containing a combination of content and services and usually providing some personalization possibilities for the end user.

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[62] Bluetooth Special Interest Group. [Cited 06-Jul-2004] Available from WWW: <http://www.bluetooth.org>.
[63] Sun Microsystems. JAVA TECHNOLOGY. [Cited 06-Jul-2004] Available from WWW: <http://www.java.sun.com>.
[64] mobileMMS.com. [Cited 06-Jul-2004] Available from WWW: <http://www.mobilemms.com>.
[65] WAP Forum. [Cited 06-Jul-2004] Available from WWW: <http://www.wapforum.org>.
[66] Zed. [Cited 06-Jul-2004] Available from WWW: <http://www.zed.com>.

2.2 Mobile Telephones

In this research work we are studying the interaction style of a physical artifact, the cellular mobile telephone as illustrated in **Figure 20**. This section will illustrate the mobile phone on a level of detail that is relevant in understanding the role and relationships of the user interface within the whole product; in **Section 2.3** we will describe the mobile phone user interface in more detail.

Figure 20. Nokia 6610

Contemporary mobile telephones are direct descendants of the first car phones (see **Figure 2**) that have their roots in the earlier radio phones for military, utilities, and other closed organizations (Kiljander 1997). The major mobile phone manufacturers have been developing mobile communicating devices already for decades.[67] The companies operate on a global scale and make handsets compatible with the various cellular network systems across the globe. The mobile phone manufacturers with the largest market share in 2003 are listed in **Figure 21**.

Mobile phone manufacturer	Market share 2003	Sales 2003 (millions)
Nokia	34.7%	181
Motorola	14.5%	75
Samsung	10.5%	54
Siemens	8.4%	44
Sony Ericsson	5.1%	27
Others	26.8%	139
Total	100.0%	520

Figure 21. Global mobile phone market shares (Gartner 2004)

Mobile phones are *smart products*, or *information appliances*. Säde (2001) defines smart products to fulfill all or some of the following attributes:

- interactive
- physical products
- equipped with digital technology
- consist of original hardware and software

[67] Ericsson's first transportable phone from 1889 was targeted primarily for 'railroad and canal works, military purposes, etc.' [Cited 06-Jul-2004] Available from WWW: <http://www.privateline.com/TelephoneHistory2A/ericsson.htm>.
The first Motorola two-way AM police radio system was installed in Bowling Green, Kentucky, USA, in 1940. [Cited 06-Jul-2004] Available from WWW: <http://www.motorola.com/content/0,1037,118-283,00.html>. Nokia developed its first mobile radio telephones in the early 1960s for the Finnish Defense Forces (Häikiö 2001).

- dedicated for certain specific functions
- process information
- able to perform certain automated tasks
- often connected to information networks, wired or wireless
- equipped with limited input/output devices

Norman (1998) defines information appliances as:

> ***Information appliance*** *n. An appliance specializing in information: knowledge, facts, graphics, images, video, or sound. An information appliance is designed to perform a specific activity, such as music, photography, or writing. A distinguishing feature of information appliances is the ability to share information among themselves.*

From another perspective, a mobile phone is a fashion element and a crucial part of one's identity that many people claim they could not live without.[68] It is also a highly integrated consumer electronics device with ample digital signal processing performance. Fulfilling all these requirements and integrating the required technologies and disciplines into a commercially viable and highly usable end product is a continuous challenge to the mobile phone manufacturers. There are several design areas that need to be developed and integrated in a mobile phone product development project, and most if not all have a linkage with the user interface of the product:

- The performance and functionality capabilities of a mobile phone depends on the device **hardware**. The transmitter-receiver, display, amplifier, filter, oscillator, memory, ASIC processor, and other components[69] are tightly integrated on the printed circuit board. Platformization facilitates the flexible creation of software-configurable product variants on top of a common hardware platform. The early mobile radio telephones were hardware-engineered with no embedded software, but with the proliferation of the contemporary consumer-friendly and feature-laden mobile phones the mobile phone manufacturers have realized they are in the software industry (Ketola 2002; Kiljander 1997).

- **Industrial design** is a key factor for the consumer when assessing a mobile phone. Traditionally, industrial design and industrial designers have been also the main contributors to a product's user interface but with the explosion in smart products, and the recognition of mobile HCI, it's the interaction designers and usability engineers who are gradually taking the main responsibility of interaction design for mobile devices (Kiljander

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[68] According to a study conducted by Continental Research for Vodafone UK in 2002, 48% of British business travelers state that their mobile phone is the one item they couldn't live without while on a business trip, and even more important than clean underwear, toothpaste and a razor. [Cited 07-Jun-2004] Available from WWW: <http://www.m-travel.com/20429l.shtml>. In another study, conducted by Codacons in Italy in 2001, mobile phones were taken away from 300 volunteers, and 15 days later 70% of them reported having sexual problems, loss of appetite, depression, and a general blow to their confidence. [Cited 06-Jul-2004] Available from WWW: <http://www.wired.com/news/business/0,1367,48008,00.html>.

[69] The number of hardware components in a typical mobile phone is around 400. In: Talouselämä 20/2002. 24-May-2002.

1997). The industrial design work starts from early design concepts and continues through aesthetic, ergonomics, and manufacturability considerations until appealing, segment-focused, and brand-supporting designs are found. Industrial design together with mechanical design researches and defines the product materials and finishes.

- **Mechanical design** links the hardware design with industrial design. The mechanical designers' task is to fit all the hardware components inside the industrial design — simultaneously ensuring that the manufacturability, reliability, durability, and cost-related requirements are fulfilled. Mechanical design is gradually becoming more challenging as new mechanical elements such as hinged cameras, sliding and flipping keypads, damped cover mechanisms, miniature joysticks, roller wheels, touchpads, and e.g. detachable memory cards are incorporated into the devices, and still the products should be ergonomic and appealing to use, while being as small and lightweight as possible. For example designing an ergonomic keypad is often a question of some tenths of a millimeter in the right (or wrong!) place.

- Much like to hardware platformization, mobile phone manufacturers are increasingly turning to the application of **software** platforms in the design of mobile telephones. About 60 – 80% of the software in a contemporary mobile phone is user interface related. The rest is cellular systems protocol software, operating system software, hardware driver software, and digital signal processing software. *Proprietary UI software platforms* like Nokia's Series 30 and Series 40 are developed in-house and there is usually no easy way to get development know-how from outside the company. On the other hand, the proprietary software platforms are usually the most efficient in handling the device hardware resources and the manufacturer has the most flexibility in tailoring the software for a specific device. *UI software platforms* like Symbian, MIDP Java, Microsoft Smartphone, SavaJe, and the Palm Operating System, allow third party application software development. Development tools, courses, and support are available, and competent software developers can be found across the world. The drawback with open software platforms include them being potentially more resource-unfriendly, requiring a device manufacturer to pay license fees to the platform owner, and possibly being somewhat inflexible to allow manufacturer-specific software tailoring.

- A contemporary mobile phone is not appealing to the consumers without a set of accompanying **accessories** like headsets, chargers, car mounting kits, desk stands, PC synchronization software, or e.g. fashionable wristbands. Many accessories like chargers and headsets live longer than just for one mobile phone product generation but for the accessories that are new for a specific mobile phone model, the development of these devices is a sub-project in the overall mobile phone development project, and requires timely milestones and coordination with the phone developers.

- The **sales package** integrates all the various elements of the end products together. One of the crucial elements of the user experience with contemporary mobile phones is initial use that is sometimes also called *out-of-box use*. Consumers face several challenges when taking a new mobile phone into use (Ketola 2002): the SIM card needs to be inserted,

the device battery must be charged, and the device settings may have to be configured. The user guide developers need to find a balance between being too superficial and producing a book that is forbiddingly thick[70] while keeping in mind the fact learned from user studies that many users simply do not read the manuals.

- No matter how good the product is, it does not sell itself, and mobile phones are becoming increasingly complex by their functionality. At the same time the efficiency pressures in the sales channel have shortened the time a sales person can spend to demonstrate and sell a product to a prospective purchaser. The mobile phone vendors need to train the sales people so that they learn to use the new phones proficiently, learn to demonstrate the key selling points in the device, and have sufficient knowledge of the product in order to be able to answer the customer's questions.[71] Vendors are educating retailers of new mobile phone models with e.g. computerized mobile phone simulators that are available before the product shipments start. These and other related informative and motivational **training material** need to be developed and distributed to the sales channels in time. Similar training must be designed and offered also for the company-internal after-market services people and customer assistance personnel staffing the telephone and Internet helpdesks.

With a user-centered design and development approach, the mobile phone is naturally not a technology-driven exercise with the products and features envisioned solely by engineers in their research labs. The product marketing, industrial design, usability engineering, interaction design, graphic design, software design, and other participating groups conduct research on user needs, draft out device features, develop concepts and prototypes that are evaluated with real users, and gradually hand the appealing and usable designs over for implementation. This idealistic approach is obviously often challenged and compromised due to business, engineering, or organizational constraints. Full treatment of the mobile phone design and development process and organizations is outside the scope of this work. The interested reader may consult e.g. Ketola (2002), Rieman (2003), or Väänänen-Vainio-Mattila & Ruuska (2000) for discussions about applying usability engineering and user-centered design in mobile phone product development.

The mobile phone industry is one of the strongest indicators of the overall global economy. The growth in the worldwide consumer electronics business is to a large extent dependent on the sales of mobile phones. It was only the mobile phones, DVD players, video cameras, and computers, whose sales increased during the late 1990s (Alkio & Raeste 2002). The global average selling price of a mobile terminal device was 238 Euros in 2001 (Prohm et. al. 2002). The hardware and software components of an average mobile phone constituted a bill of materials figure of around 104 Euros in the same year (Alkio & Raeste 2002).

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[70] The sales package boxes are usually standardized, so there is a specific maximum volume reserved for the user guide. The user guide booklet(s) must fit in a space that is X millimeters wide, Y millimeters tall, and Z millimeters deep.

[71] Nokia-funded marketing research conducted in several markets worldwide in 1996 indicated that the retail staff want support and recognition from the mobile phone vendors and this will increase their willingness to recommend products from a specific manufacturer.

This figure does not include the assembly costs, supply and logistics costs, and the marketing and brand management costs.

2.2.1 Mobile Terminal Categorization

The focus of this study is on the interaction styles of mainstream, high-volume, voice-centric cellular mobile telephones. By *mainstream* and *high-volume* we mean the established, mass-market handsets that consumers readily associate with the concept of a mobile phone. Another viewpoint on the research focus is the voice-centricity; by this we mean focusing on handsets with the primary functionality being in or originating from voice communication, instead of devices primarily regarded as personal digital assistants with the voice functionality being more like an add-on.

Devices can be categorized based on their ergonomic usage and form factor. The primary input mechanism is a key driver affecting the ergonomic usage of a device. Some devices are designed to be used with one hand only, whereas some other devices require the user to hold the device in one hand and use it with the other one. Some wearable products can be attached to the user's body or clothing so that the user no longer has to explicitly hold the device when using it. Nokia has applied a usage ergonomics based categorization into three device types: *phones*, *PDAs*, and *communicators*, as illustrated in **Figure 22**. With the gradual introduction of various wearable communication devices we can add a fourth device type ergonomic form factor: *wearables*.

Device type	Phones	PDAs	Communicators	Wearables
Primary input mechanism	One-handed operation	One hand holds the device; the other operates the devices with a stylus or finger	Both hands hold the device; thumb typing with keyboard	Device is attached to body or clothing; one-handed use
Usage ergonomics				
Sample devices	 Philips Fisio 820	 Sony Ericsson P900	 Nokia 9300 Communicator	 Samsung Wristphone

Figure 22. Usage ergonomics based product type categorization

Roughly equivalent to Nokia's categorization, Canalys (2001) defines three mobile device form factors: *handsets*, *tablets*, and *clamshells*. They further divide these three categories into *phones*, *browser phones*, *feature phones*, *smart phones*, *handhelds*, and *wireless terminals*, based on the available functionality. This functionality-based categorization of Canalys is no longer fully relevant as the functionality boundaries between devices are no longer as clear as they may have been. E.g. the contemporary Nokia 3410 phone has a browser, it supports downloadable games and applications via Java technology but it does not come with PIM synchronization. Form factor based categorization remains thus a

more appropriate approach to differentiate different mobile communication devices.

Weiss (2002) divides *handheld devices* into *mobile phones*, *PDAs*, and *pagers*, based on the primary use, UI conventions, and functionality. He calls devices combining all features *communicators*.

Figure 23 lists a somewhat broader set of communication devices categorized based on their functionality and user interface. In many cases the boundaries between devices have become blurred as e.g. most of the contemporary basic phones contain a browser to access simple WAP-based Internet services and some mobile phone models have GPS functionality.[72]

In this study the focus is on mobile *phones* or *handsets* operable single-handedly. The possibility to use a mobile phone single-handedly is one of the very basic requirements in the HCI of mobile phones (Väänänen-Vainio-Mattila & Ruuska 2000). Basic, critical tasks such as call answering or storing a name to the phonebook must be possible with one hand only as the other hand may be needed in another, simultaneous task. E.g. vendors like Microsoft[73], Nokia[74], and Sony[75] stress single-handed use with their mobile phones and smart phone platforms.

Furthermore, the mainstream mobile telephones in the focus of this study are designed with voice-centric usage being the key driver. The product concepts have evolved from the earlier handsets supporting voice communications only. Internet browsing, digital imaging, and digital audio features have been integrated into contemporary mobile phones without sacrificing the underlying voice communication capabilities and functionality. *Smart phone* is a term increasingly used to denote the feature-rich voice and data communication devices. Ketola (2002) defines smart phone as a *digital mobile phone that enables the user to perform daily personal information management tasks, fulfilling the basic human communication needs of a wireless village citizen in the mobile information society*[76].

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[72] E.g. The Benefon ESQ has a built-in GPS receiver and the ability to download maps.
[73] Microsoft. "*You only need one hand. Simple one-handed operation lets you access any application, browse your contacts, calendar, emails or SMS text messages and scroll through web pages.*" [Cited 04-Jun-2002] Available from WWW: <http://www.microsoft.com/mobile/phones/smartphone/onehand.asp>.
[74] Nokia. "*Series 60 has been designed for mobile phones that are single-handed operated and feature a color screen and graphical user interface.*" [Cited 04-Jun-2002] Available from WWW: <http://download.forum.nokia.com/download/Series_60_FAQ.pdf>.
[75] Sony Ericsson. "*The Jog Dial is your guarantee for the single-handed simplicity of operation that Sony mobile phones are known for.*" [Cited 04-Jun-2002] Available from WWW: <http://www.sonyericsson.com/uk/spg.jsp?template=PS1&B=ie&PID=9780&LM=PSM_V&gal=105>.
[76] "*Mobile information society is a concept used to denote the explosion in mobile communications, coupled with the boom of the Internet, and people's need to stay connected, independent of time and location.*" In: Nokia Corporate Vision. [Cited 05-Jun-2002] Available from WWW: <http://www.nokia.com/corporate/vision.html>.

Mobile devices	UI (display, keypad, style)	Applications and Services
Pagers	Character based; some keys	Receive numeric or text messages
Two–way pagers	Character or pixel based; some have GUI and QWERTY keypad	Receive and send numeric or text messages
Cordless phones	Character based, keypad	Voice calling
Low–end cellular phones	Character based, keypad	Voice calling
Mid–range cellular phones	Character or pixel based; keypad	Voice calling, one or two–way text messaging depending on cellular system, possibly access to VAS
High–end cellular phones	Character or pixel based; keypad	Voice calling, one or two–way text messaging, access to VAS, PIM features
Smart phones	Pixel based, possibly touchscreen, GUI features; phone keypad, possibly handwriting recognition	Voice calling, text and e–mail messaging, access to VAS, PIM features, data modem, www
Communicators	Pixel based, GUI features; QWERTY keypad	Voice calling, text and e–mail messaging, access to VAS, PIM features, data modem, www
PDAs with wireless connectivity	Pixel based GUI; possibly touchscreen; keypad ranges from no keys to QWERTY keypad, handwriting recognition	Text and e–mail messaging, PIM features, access to VAS, wireless data, www
Handheld PCs with wireless connectivity	Windows CE GUI, grayscale touchscreen; QWERTY keypad, handwriting recognition	Word processing, spreadsheet, text and e–mail messaging, PIM features, access to VAS, wireless data, www
Miniature PCs with wireless connectivity	Windows GUI, colour display, QWERTY keyboard (WIMP)	Standard desktop PC features and services, wireless data (and voice), www
PC card phones	Windows GUI	Voice calling, text and e–mail messaging, access to VAS, PIM features, data modem
GPS navigators	Character or pixel based; some keys	Global positioning and navigating, digital chart plotting; e.g. car navigation systems

Figure 23. Mobile communicating device segments (Kiljander 1997)

Prohm et. al. (2002) categorize mobile terminals into *basic phones*, *enhanced phones*, *smart phones*, and *wireless information devices*. The first three categories, as their name implies, represent voice-centric devices, whereas the wireless information devices are evolving from personal digital assistants being equipped with wireless communication and other digital technologies. Based on the actual and estimated sales volumes of the various mobile terminal segments illustrated in **Figure 24** we can assume that the voice-centric devices are likely to constitute the dominant wireless communication devices segment for some time to come.

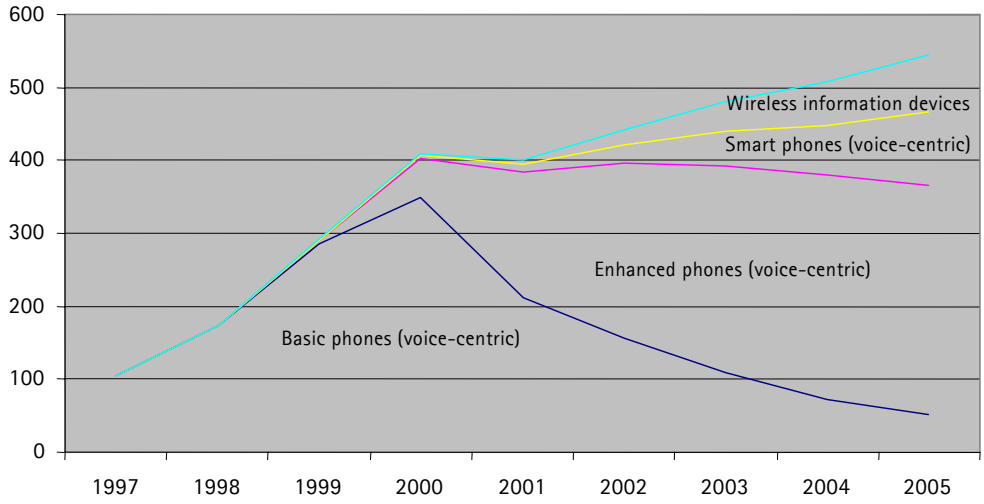

Figure 24. Worldwide mobile terminals sales to end users (in millions of units; Prohm et. al. 2002)

2.2.2 Mobile Phone Segmentation

After the review of contemporary mobile phone consumer segmentation approaches in the previous chapters it is obvious that the mobile phone manufacturers are targeting the different consumer segments with focused, segmented products. Product segmentation aims at solving the 'design for everyone' dilemma described by Donald Norman in (Bergman 2000): if you design something for everyone, there must be something for all of them, which leads to an ever-increasing number of features, an ever-increasing number of specific applications, and an ever-increasing complexity.

The handset manufacturers try to reach the different consumer segments by offering compelling, differentiated products that are focused on a specific subset of the broad consumer base:

> *"… with the segmentation of mobile phone markets, individuals are purchasing phones that suit their different lifestyles. … Understanding segmentation is a prerequisite for success. … As the market has become increasingly segmented, the ability to master various product categories has become crucially important. In a segmented consumer market with high volumes, critical success factors include comprehensive product portfolio, a strong and appealing brand as well as efficient global logistics."*[77]

Figure 25 below illustrates the development of mobile phone product segmentation in the industry. In the beginning, new mobile phones were always smaller, their batteries lasted longer, and they had more features than their predecessors. Around late 1990s the industry had matured to offer different products at different price points, and in the early 2000s the industry is creating highly focused product offerings for various consumer segments. Mastering the product segmentation strategy and implementation is crucial for successful business — Funk (2002) reports how Ericsson revamped its product segmentation model in 1998 to offer entry level, design intensive, and functional phones, but

[77] Nokia. ANNUAL REPORT 1998. [Cited 06-Jun-2002] Available from WWW: <http://www.nokia.com/investor/1998/pdf/nok98eng.pdf>.

ran into implementation problems and could not release any new phones between the end of 1997 and early 1999 and thus lost significant market share of the GSM market.

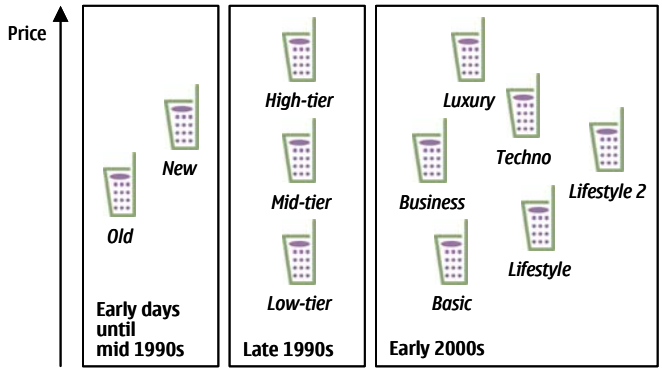

Figure 25. Evolution of product segmentation in mobile phone industry

Nokia's current product segmentation model is built around the dimensions of product style, and product applications (Helin 2002). The Nokia product portfolio consists of the following product styles:

- **Premium**: most elegant solution, design and fine materials.[78]
- **Fashion**: stylishly provocative and creatively trend-conscious image.
- **Classic**: a well-balanced, inspirational yet discrete image.
- **Active**: healthy active sports & leisure image.
- **Expression**: fun image.
- **Basic**: friendly and practical image.

The second dimension emphasizes the device functionality and applications:

- **Voice/Messaging**
- **Entertainment**
- **Imaging**
- **Media**
- **Business**

Motorola's product segments are illustrated in **Figure 14** and **Figure 32**. Its current mobile phone product categories (or sub-brands) are **Accompli**, **Timeport**, **Talkabout**, and **V**. The product segments of Sony Ericsson are the **A**, **R**, and **T** segments (Baffoy 2000, C&K Management 2002, Funk 2002):

- **A**: low-end phones
- **R**: high functionality
- **T**: exclusive design and high price

[78] Lindholm, C. SEGMENTATION WITHOUT FRAGMENTATION – HOW DO NOKIA UI SERIES AND PRODUCT SEGMENTS ALIGN. Presentation in Nokia Mobile Internet Conference, 06-Nov-2002. [Cited 10-Apr-2003] Available from WWW: <http://www.nokia.com/nmic2002/downloads/pdf/NMIC_Christian_Lindholm.pdf>.

2.2.3 Communicators and Other Gadgets for Mobile Telephony

This section will briefly outline the contemporary wireless communication device categories outside the mainstream, voice-centric, single-handedly usable mobile phones segment. This presentation is not meant to be a covering analysis of the state-of-the-art communication gadgets or to preview the future developments in corporate research labs but to give the reader an overview of what types of communication devices are in the marketplace. All devices presented in this section facilitate voice communication.

Nokia introduced the first Communicator in 1996 and the current 9300 Communicator represents the fifth product generation in the category (**Figure 22**). The communicator is an integrated digital mobile phone and a personal digital assistant. The Symbian operating system allows third party application developers to enhance the functionality of the device. The Nokia Communicator incorporates two user interfaces in the same product: the basic phone functionality is accessible via a conventional phone user interface on the front cover, whereas the PDA functionality with its larger display and a miniature Qwerty keyboard is available when the user opens the clamshell cover of the device.

A number of other Qwerty keyboard equipped voice and data communication devices is on the market; the RIM BlackBerry illustrated in **Figure 26** being one of these. Unlike the Nokia Communicator, most of these devices are designed around the concept of an integrated user interface meaning that the voice communication and personal information management functionality are accessed through the same display and keyboard.

RIM BlackBerry 5810 with headset for voice calling and Qwerty keyboard for email

Audiovox Thera with phone and PDA functionality

Nokia 5510 with Qwerty keyboard, FM radio and MP3 player

Ericsson wireless Bluetooth headset

Figure 26. Novel form factors for wireless voice communication devices

Voice communication functionality has recently been introduced in the dominant PDA platforms built around the Palm operating system and Microsoft PocketPC. The consumers' response has been somewhat mixed: many early adopters have been pleased to see these convergence devices finally becoming available as they have anxiously waited for them for years, but some of these early implementations like the Audiovox Thera presented in **Figure 26** suffer from

usability problems with the integration of the PDA and phone functionalities.[79] Simultaneously fulfilling the needs of the phone users and the PDA users is not a trivial task.

The immense success of text messaging has led to the introduction of hybrid mobile phones with built-in Qwerty keyboards, such as the Nokia 5510 shown in **Figure 26**. Some other device vendors have solved the text entry challenge by introducing miniature Qwerty keyboard accessories to be attached to the wireless devices.[80]

Wearability has long been a silver bullet in mobile computing but the commercial breakthrough of wearable devices is yet to happen. Samsung has been selling a wrist-mounted mobile phone in Korea, and several other manufacturers and mobile operators have conducted trials with wristwatch concept prototypes but no significant commercial success has taken place. Many vendors are currently offering wireless Bluetooth headsets to accompany their mobile phones — Ericsson's model is illustrated in **Figure 26**. With the Bluetooth headset the user is able to make phone calls via using voice commands to control the phone, and pick up incoming calls while the phone itself can be in a briefcase or tucked in a pocket without being physically connected to the headset.

2.3 Mobile Phone User Interface

User interface can be defined as:

> *"Those aspects of the system that the user comes in contact with."* (Moran 1981)

or e.g.

> *"The totality of surface aspects of a computer system, such as its input and output devices, the information presented to or elicited from the user, feedback presented to the user, the system's behaviour, its documentation and associated training programmes, and the user's actions with respect to these aspects."* (Preece et. al. 1994)

The mobile phone represents a new type of user interface domain that differs from the desktop computing environments (Jokela & Pirkola 1999a, Kiljander 1997, Kuutti 2000, Väänänen-Vainio-Mattila & Ruuska 2000, Weiss 2002, Ziefle 2002):

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[79] *"As a phone, the Audiovox Thera is downright clumsy. As a wireless data device, it's only fair. … it lacks a keyboard or physical phone keypad. This makes it almost impossible to use one-handed as a phone. … Also, unlike the (Handspring) Treo, it isn't designed as a flip phone, so you can't hold it up to your ear for a call without risking getting oils or makeup from your face on the screen. … Every time you want to connect to the Internet, you have to manually connect, just like on the old networks. … the built-in phone software isn't well integrated with the rest of the device. … there's a separate address book for phone use. If you go to the main Contacts program, you can't dial a number. And, if you try to call up a Web page, the Thera won't automatically connect to the Internet to do so. Verizon's Thera is unlikely to satisfy either the voice-oriented or the data-oriented user."* In: The Wall Street Journal Online. 09-May-2002. [Cited 05-Jun-2002] Available from WWW: <http://online.wsj.com>.

[80] Ericsson has introduced the miniature Qwerty Chatboard for mobile phones and several small keyboards exist for the Palm and PocketPC PDAs.

- The devices are small so the user interface only has a small physical footprint available.
- The input and output capabilities, and the processing power and available memory are limited.
- The mobile and social usage context, and the reasons for use pose new requirements and design challenges.
- Mobile phones are mechanical devices, and in order to give enough time for the industrial and mechanical design in the development process, control keys must be decided earlier in the process than when designing a desktop software system.

This section will illustrate the mobile context of use, describe the mobile phone user interface, and further analyze the differences between the mobile and desktop user interfaces. The concept of mobile phone user interface segmentation is illustrated; it builds on top of consumer and product segmentation. The section will briefly illustrate user interface customization and user interface branding in the mobile phone domain, and conclude by describing future mobile phone user interface conventions and technologies.

2.3.1 Mobile Context of Use

One of the fundamental differences between mobile telephones and the mainstream HCI environments is the context of use. The user of a desktop or a portable computer is most often stationary while using her computing equipment, the use of the equipment often takes place in the same, familiar location, and the social context stays usually quite the same. The mobile context of use leads to fundamental differences in the user interface conventions between the traditional computing environments and information appliances such as mobile telephones. Many of the UI design philosophies from the PC GUI or consumer electronics domains do not apply or cannot be used when developing information appliances (Mohageg & Wagner 2000). Within the mobile context, it is not possible to foresee where, when, and by whom the product will be used (Ketola 2002).

The **physical context** is associated with the physical constraints in the usage environment. The user may be physically located in a specific country where certain mobile services are available. The user may be located at home, in the office, commuting, or on a sailboat in Greece. Some of the surroundings may be noisy or unstable. It may be so dark or cold that using the device without a flashlight or gloves is not possible.

The **social context** introduces the people aspects into mobile device use. Mobile users need to communicate with others, and mobile communication can utilize only a narrow bandwidth of the total human communication. Mobile communication has special elements of privacy and discreteness incorporated as it can take place in public surroundings or other places where it may be inappropriate to communicate. Owners of mobile devices also want to express their individuality or conformity via their devices.

The **mental context** denotes the aspects of the user's understanding of the mobile handset usage model. The user may be conducting a single task with her device, or she may be carrying out several tasks simultaneously with the device, while

engaged in a phone call. The user may also be engaged with some non-device functionality such as carrying a bag, driving a car, or shopping for groceries.

The **mobile infrastructure context** has some similarities with the mainstream HCI when it comes to networking and connectivity. No or bad cellular network coverage and low communication bandwidth make communication or network service access inconveniently slow and unreliable, or completely impossible. The additional difficulties associated with lack of global roaming cause problems for seamless mobility.

All of these dimensions of the mobile use context affect the successful design of mobile handset user interfaces. **Figure 27** below lists some of the explicit differences along these dimensions in mobile telephones HCI compared to the desktop PC and consumer electronics (CE) domains.

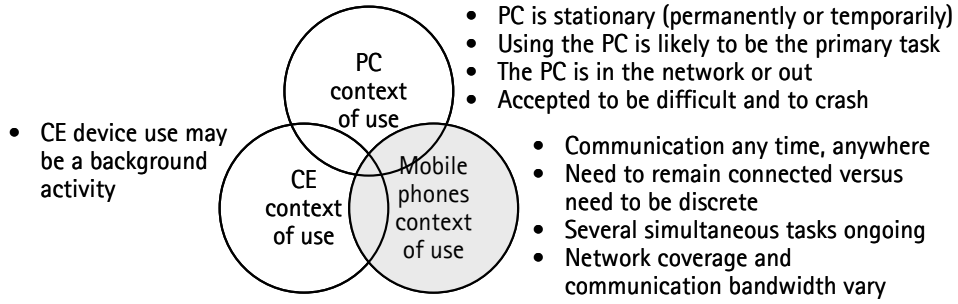

Figure 27. Differences in mobile context of use dimensions

Keinonen (2000) describes the use of cartoon scenarios to illustrate the context of use when designing new mobile device concepts. Cartoon scenarios convey the image of the product and its use in the physical and functional environment, but they also convey the atmosphere, assumptions, and expectations towards the product and its use.

2.3.2 Mobile Phone User Interface Elements

To define the elements of the mobile phone user interface we first focus on the tangible mobile phone artifact itself. A number of **physical user interface components** are incorporated into the handset as illustrated in **Figure 28**.

Some of the user interface components facilitate **user input**, such as:

- Numeric keypad for entering digits, letters, and special characters; in some devices there is a miniature Qwerty keyboard for enhanced text entry
- Control keys and devices for controlling the device; these include navigation keys, joysticks, rocker keys, rollers, wheels, softkeys, menu keys, backstepping keys, and other special keys
- Call-management keys for managing phone calls; in some phone models there are no dedicated call-management keys, and the call-management functionality is overloaded to other (control) keys
- Volume keys for quick access to control the audio volume; in some phone models this functionality is overloaded to other (control) keys
- Power key to switch the device on and off

- Special-purpose keys to access dedicated functionality, such as camera, Internet access, voice recorder, or keys for opening hinges, slides, or flip covers in the phone
- Microphone for audio input; both for speech transmission and uttering voice commands
- Digital camera
- Sensors; e.g. light, proximity, or fingerprint recognition sensor
- Touchpad or touchscreen for direct manipulation UI control or handwriting recognition; mobile communications devices equipped with touchscreens lie generally outside the scope of this study

Figure 28. Mobile phone user interface components

The other user interface components are **output devices** conveying information to the user:

- Flat-panel display or displays
- LED(s) to indicate the status of the device: low battery, incoming call, unread message(s), gaming effects, etc.
- Earpiece and possible hands-free loudspeaker for audio output
- Buzzer for playing ringing tones and other audio
- Vibration motor for tactile output in e.g. incoming call or message notification, and gaming effects
- Laser pointer, or flashlight

In addition to the tangible user interface components, several other user interface or product-related aspects affect the user experience of a mobile telephone.

- After the in-store purchasing experience with a sales person the consumer will usually familiarize herself with the new phone alone. This ***'out-of-box experience'*** is heavily dependent on the complete product, including the content and fit of the sales package. New phone models contain an increasing amount of features requiring a specific setup procedure — e.g. settings for Internet browsing, synchronization and data transfer — and

these are seldom mastered by the end users: "*A piece of advice for others: if you are not a born geek, don't leave the store before the gadget you just purchased is fully configured and you have tried out yourself that you can use the features.*"[81]

- A mobile phone needs to be designed to be both ***intuitive for first-time use*** and ***efficient in long-term use***. When a consumer starts to use a new phone, she has no previous experience with it. She may also have no experience with mobile phones in general, or she may have been a seasoned user of a mobile device functioning radically differently. To create a satisfying user experience the new phone and the features in it must be designed to be intuitive for all these user types. Later on, the user will gradually learn and explore more of the handset's functionality, and become an expert in using it. These users value efficiency more than intuitiveness, as they already know how to accomplish things, and they want to get this done as efficiently as possible.

- A key element affecting the user's satisfaction with a mobile phone is device ***ergonomics***. A pocketable device inherently leads to a physically small footprint available for the input and output devices. It may be that the mainstream mobile phone is close to reaching its minimum usable size[82] — however, the display's relative proportion to the phone's faceplate is continuously growing since there is urge to present more information to the user in an appealing manner. The industrial and mechanical designers have a challenging task in fitting the display, keys, and other UI components in an appealing, ergonomic, and durable package that is also of the right size, and still usable single-handedly.

- A major factor affecting the purchasing decision is the ***features*** in the device. Later on, the consumer may not actually use all the functionality, but she might not have purchased the handset without the features. In real use, the ***usability of the most frequently used features*** becomes more important. Mohageg & Wagner (2000) suggest that the designers should keep the 80/20 rule in their minds: identify and focus on the 20% of functions that will meet 80% of the users' task needs, and optimize the user interface of the product around the absolutely key features in that 20% of functions in the product. All contemporary phones have so many features that it is no longer possible to map each feature to a dedicated, physical key on the product; the convention all manufacturers are applying is to structure the features into *menus* and provide menu navigation and selection via a small set of control keys.

- ***Network services*** for voice and data communications are provided by the mobile operator or service provider. Studies have shown that end users do not fully understand the distinction between network services and

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[81] Conclusions from a month-long real-life test of mobile Internet phones arranged by Helsingin Sanomat, 25-Jun-2002. [Cited 29-Jun-2002] Available from WWW: <http://www.helsinginsanomat.fi/arkisto/juttu.asp?id=20020625ER3>.

[82] In his book Being Digital, Nicholas Negroponte argues that the credit card is about the smallest possible item a user will be able to carry with him without losing it. E.g. the Sony Ericsson T66 mobile phone is approaching this size with the dimensions of 92 × 41 × 18.5 millimeters.

handset features and in problem situations they do not necessarily know how and where to start solving the issue[83]. End users should not be burdened with technological details of services and features but the combination of these should be designed to be as intuitive and integrated as possible[84].

- Some of the phone features reside permanently in the handset, and some are downloaded over the air or accessed through a service interface such as a wireless Internet browser in the phone. The ***type and version of the browser*** dictates the ***content types*** — e.g. i-mode, MIDP Java, WAP, X-HTML, HTML — the handset is able to support. The popularity of the browser platform correlates with the amount of chargeable and free content available. Some types of content — e.g. ringing tones, operator logos, and picture messages — do not require a dedicated browser application but compatibility with de facto industry standard formats such as Nokia's Smart Messaging.

- Some of the high-end mainstream mobile phones are designed around a standardized and commercially available ***operating system and user interface platform***, such as Microsoft's Smartphone 2002, or the Symbian operating system and Nokia Series 60 user interface. Third party application developers can develop application content for these platforms using commercially available application development tools and counting on application development support from the operating system or phone vendors. With a popular operating system and user interface platform the application developer is able to reach the mass consumer markets and the users can benefit from a wide array of available applications.

- The available ***memory*** dictates how much content or applications the user can download or add to her device. The device feature structure and memory management may group all the user-added applications e.g. under one specific menu branch or applications can be added anywhere in the menu hierarchy. With some devices the memory can be increased via memory cards the user can install in the device.

- Mobile phones are used globally. The vendors make different ***language versions*** of the products and usually offer a product variant in a specific market area with support for all relevant languages incorporated. Supporting a language in a product includes having the display texts localized in the language, having the language-specific characters in the character set, supporting the local writing system — within the constraints of the small device with limited input and output capabilities — and ensuring that the display graphics, colors, sounds, and metaphors are culturally appropriate. Since the user population of mobile phones is extremely heterogeneous, the selection of appropriate terms is very demanding (Koivunen et. al. 1996).

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[83] E.g. are the voice mails stored in the phone? The incoming text messages are in the phone but usually the voice mails are not.

[84] E.g. an error message informing the user of an unsuccessful message sending could tell the user whether it's a network issue or a glitch on the handset side and suggest ways to overcome the problem unless the phone can resolve it by itself.

- The user interface in the handset is not the only user interface in the complete mobile phone product. Various ***accessories and add-ons*** are designed for mobile phones and they need to work seamlessly and intuitively together with the handset. Chargers, headsets, car kits, plug-in cameras, keyboards and music players, and replaceable phone covers must attach to the handset without excessive force, be durable, and have plastic and galvanic connectors standing thousands of attachments and detachments.

- Supporting ***cross-platform and cross-manufacturer services and technologies*** requires strict adherence to industry standards. Proprietary solutions can succeed only if the manufacturer has enough market share and wants to launch a solution without support from the competitors. However, the industry is to a large extent turning to cross-vendor standard development to ensure takeoff of new mobile technologies and services such as Bluetooth, MMS, or SyncML.

- A phone vendor's interest on the consumer should not end after the consumer has purchased the mobile phone. Obviously, the mobile operators offer customer support to their subscribers. This service is primarily offered to solve subscribers' problems and questions related to the wireless service but it usually needs to cater to handset-related issues too. The phone vendors are using telephone help lines and Internet for ***end-user support***. The end-user support channel is also one means to get end-user input to new product development.

We can construct a model of the mobile phone user interface elements as shown in **Figure 29** illustrating the relationships, interdependencies, and dimensions between the different user interface components.

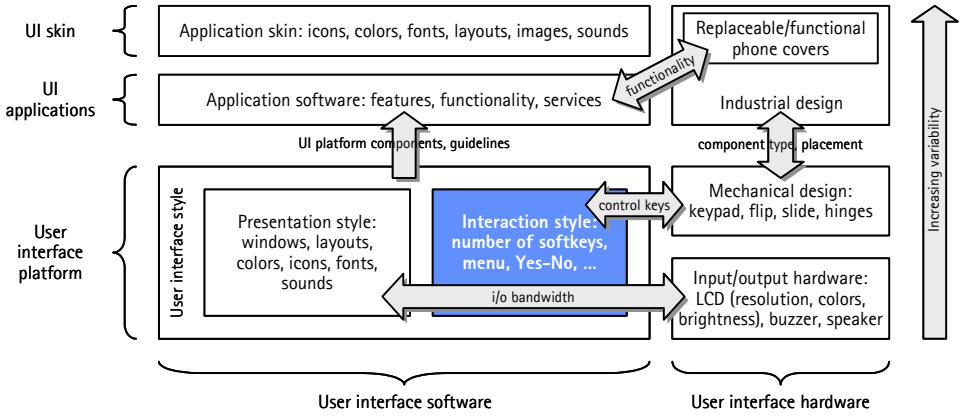


Figure 29. Mobile phone user interface elements

The user interacts with the mobile phone via the user interface that is implemented with user interface software and hardware elements. The **UI software** consists of UI software libraries with UI components, UI features and applications implemented with the libraries, and graphical and audible UI elements. The **UI hardware** includes the output devices such as displays, speakers, and vibration motors, as well as the input devices such as keypads and control devices. The industrial design dimension is sometimes considered part of the hardware user interface, or vice versa. More detailed analysis of the industrial design element is not within the scope of this study.

The user interface elements can also be categorized based on their reusability. The UI software libraries and components are usually referred to as the UI software **platform** that can be used to deploy a number or products, with varying UI applications and functionality. Likewise, the fundamental UI hardware components can be wrapped within different industrial design to deliver products in different shapes, materials, and colors.

Within the software UI platform, the **user interface style** is comprised of the **interaction style**, that being the topic in this study, and the **presentation style**. The interaction and presentation style together are often designed around a common metaphor, such as the desktop, or the menu. The interaction style describes the *interaction paradigm*, or the *user interface architecture*, while the presentation style can be described also as the stylistic *'look and feel'*, or the *interface design*. Interaction design advocate Alan Cooper talks about interface design and architecture in Anderson (2000a):

> *"Look and Feel stuff is Interface Design. It's all very stylistic. It's the color that you paint your walls. Interaction Design is about the Architecture. It's what kind of building are we building. What functions does it support. What are the shapes of the rooms and the walls and ceilings. What is the infrastructure. What kind of elevators. What kind of cooling and heating. That's Interaction Design. … What does it [the system] do? How does it communicate? How does it behave? These are the fundamental issues. Let's look at database queries. You issue a query to a database. It hands you back a solution set. This is a technology that's known. What we do is that we debate about how to have little dialog boxes to submit queries and display solution sets. That is interface design! People generally don't ask fundamental questions like "In a situation, where I have a particular User, who is trying to accomplish a task, who is trying to achieve a goal, what are the appropriate methods of information retrieval for that person?" Would it be a query and solution set as the way to solve the problem. That is an Interaction Design question. It's one that is not often asked. But is the type of question that we ask here [at Cooper Interaction Design]. It's a very very different approach than asking "What should the dialog box look like"."*

2.3.3 User Interface, External Interface, and Service Interface

Previous sections have illustrated the mobile telephone user interface. This user interface is a combination of hardware and software user interface elements and technologies. The notion of mobile phone user interface can also be broadened to cover some elements outside the physical handset, though. Ketola (2002) defines mobile phone **user interface**, **external interface**, and **service interface**, and illustrates their interdependencies as shown in **Figure 30**.

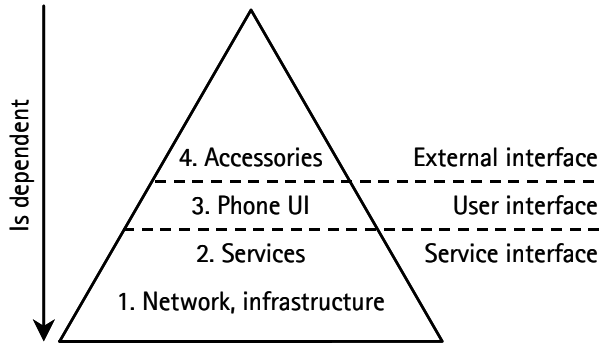


Figure 30. Interface hierarchy (Ketola 2002)

The external interface contains the user interface of the user support materials, devices, and software. These include mobile phone accessories, PC and Internet applications, and customer documentation. The service interface is *the user's view of the available mobile operator's or service provider's mobile services visible through the mobile phone user interface*. Ketola claims that the users sometimes find it difficult to understand which part of a service is phone functionality and which belongs to the service.

This definition of interface hierarchy by Ketola (2002) is somewhat limited as some accessories may be able to access the service interface without the mobile phone in-between. This is the case e.g. with a headset that supports dialing via a voice-control user interface. Likewise, some service applications utilize the cellular network just as a bit pipe and there is no visible service offered by a mobile operator. This is the case e.g. with a user watching a live surveillance video that is sent from a home surveillance camera over an Internet connection. From this perspective the interface interdependencies can also be illustrated as shown in **Figure 31**.

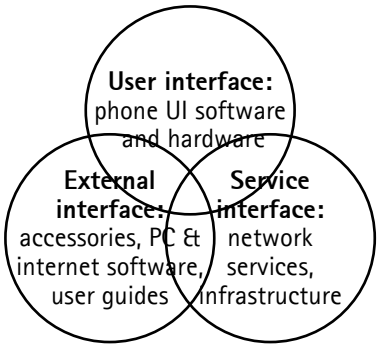


Figure 31. Interface interdependencies

2.3.4 User Interface Segmentation

Mobile phone manufacturers are creating focused product offerings for different consumer segments applying various consumer segmentation approaches and models as described earlier. Mobile handsets are increasingly developed based on common software and hardware platforms with maximum flexibility, modularity, and customizability. Customizability of the underlying hardware and software platforms allows the manufacturers to benefit from economies of scale while still being able to tailor the products to the appropriate customers and consumer segments.

The user interface of the mobile device is one applicable element in the customization and categorization of the vendor's product portfolio. User interface segmentation denotes a marketing strategy where a manufacturer is applying different user interfaces to support product differentiation. User interface segmentation can also be driven by user needs.

Figure 32 illustrates how Motorola has been targeting different consumer segments with different products and different user interfaces (Motorola 2002).. Nokia's Christian Lindholm illustrates the UI segmentation rationale at Nokia even more directly:

> *"User interface segmentation is the guiding star of Nokia device usability. Some people just want to make phone calls while others want to browse the Internet. We are creating differentiated terminals …"*[85]

[85] Lindholm, C. 2000. KEYS TO NATURAL MOBILITY. Nokia Link Magazine. Issue 2, 1st Quarter 2000. Pp. 12 – 13. ISSN 400964/2000.

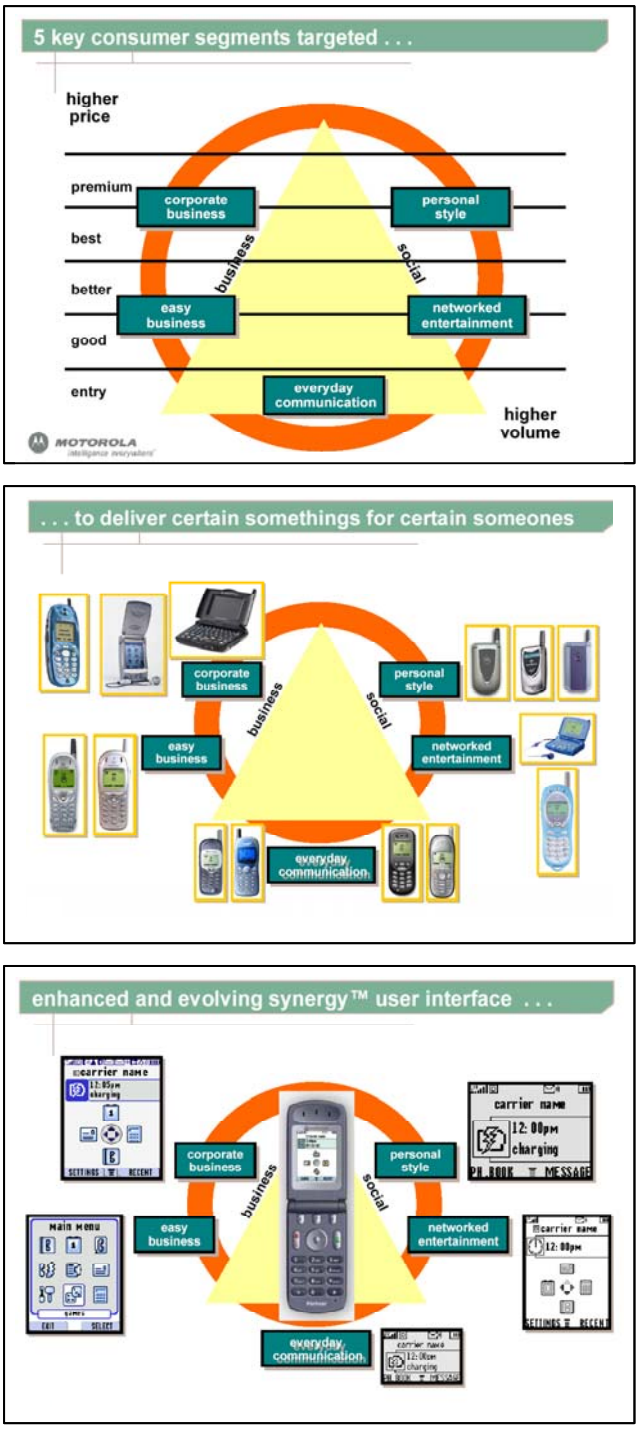


Figure 32. Consumer segments, products, and user interfaces of Motorola

However, besides the *usability knee* (Kiljander & Järnström 2003) described further in **Section 2.3.5**, there is no publicly available analysis of the linkage between UI segmentation and usability in mobile devices. From a consistency standpoint, one could even argue that UI segmentation is a *divergence* element, and thus harmful to usability, as will be discussed in **Section 3.6.2**.

The upcoming sections will analyze the contemporary user interfaces and interaction styles of the leading mobile phone vendors in detail. Motorola and Nokia have communicated their consumer segmentation models, and how they target different consumer segments with different products and different user interfaces. Motorola's consumer and product segmentation in 2002 was based

around the five segments shown in **Figure 14**: *personal style*, *networked entertainment*, *everyday communication*, *easy business*, and *corporate business*. According to Motorola's marketing communications material (Motorola 2002), the Synergy user interface platform is tailorable for these segments as illustrated in **Figure 33**.

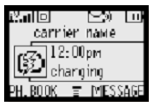
Consumer and product segment	Personal style	Networked entertainment	Everyday communication	Easy business	Corporate business
Synergy user interface (display images not to scale)					

Figure 33. Motorola's Synergy user interface for different consumer and product segments

Nokia's marketing communications material[86] illustrates the *Series 30*, *Series 40*, *Series 60*, and *Series 80* user interface categories that are applied in Nokia's handset portfolio as shown in **Figure 34** below.

Analyzing these two companies reveals some similarities and differences between their user interface segmentation approaches. Motorola basically has one user interface platform — Synergy — that is scalable across all the consumer and mobile phone segments in the company's portfolio. These established segmentation models drive the need to scale the user interface across different handsets. The more business or entertainment oriented the product segment is, the larger and more colorful is the products' display.

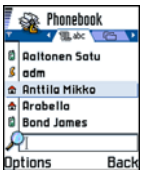
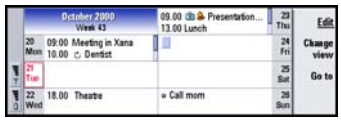
UI category	Series 30	Series 40	Series 60	Series 80
Key drivers	Cost-driven platform	Size-driven color platform	One-hand operated feature platform	Two-hand operated feature platform
Display image (images not to scale)				
Display resolution	96 x 65	128 x128	176 x 208	640 x 200
Supported application and content platforms	WAP/XHTML MIDP MMS	WAP/XHTML MIDP MMS	WAP/XHTML MIDP MMS Symbian OS	WEB browser MIDP, Personal Java MMS Symbian OS

Figure 34. Nokia's user interface categories

[86] Nokia. [Cited 21-Jun-2002] Available from WWW: <http://www.nokia.com/investor/roadshow/ceoroadshow.pdf>. In 2003 Nokia revised the Series 30 category name to denote the cost-driven platform based on a Nokia-proprietary operating system that does not support XHTML, MIDP, or MMS.

From Nokia's UI category definitions above we can see that the segmentation factors include usage handedness, display size and resolution, and supported application and content platforms. The user interface categories have explicitly distinct names[87], even though an analysis of the display examples reveals that the presentation and interaction styles are relatively similar between the Series 30, 40, and 60 user interface categories. This UI segmentation approach is not explicitly based on consumer or product segments. The highest sales volumes in the Nokia product portfolio have belonged to phones with the one-softkey Navi-key UI for several years; yet the Navi-key UI is not included in the abovementioned categorization as it does not support open content platforms like MIDP Java or MMS. Few years ago Nokia's user interface segments were more directly aligned with the product categories, such as the one-softkey Navi-key UI for the Basic and Expression phones (e.g. the 3100, 3200, 3300, and 5100 series), the two-softkey user interface for the Classic and Premium phones (e.g. the 6100 and 8800 series), and the Navi-roller user interface for the Media phones (the 7100 series). With the increasing number of phone segments and categories it is no longer possible or even necessary to have a dedicated user interface category for each product category and thus the user interface categories are now more dynamically matched with product categories.

A fundamental attribute in user interface segmentation is the display and its capabilities such as physical size, resolution, color depth, and image quality. Both Motorola and Nokia display examples in **Figure 33** and **Figure 34** indicate that many of the UI interaction and layout aspects remain the same between different UI categories and segments while the display is changing. Similarly, Volland (2000) describes the Siemens C35/M35 and S35 phone displays:

> *"Two display sizes – One look & feel. Main UI elements are the same in both variants. Bigger screen is used to add useful information in a title line or add one line for SMS view and WAP."*[88]

The Siemens UI scalability across the S25, C35/M35, and S35 phones is illustrated in **Figure 35**.

97x54 pixels on S25 phone | 101x54 pixels on C35/M35 phone | 101x80 pixels on S35 phone

Figure 35. Siemens user interface scalability

Based on the publicly available information from the abovementioned companies, apart from Nokia, it remains somewhat unclear whether UI segmentation is driven primarily by product differentiation drivers within the

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[87] The Series 30, Series 40, Series 60, and Series 80 UI category names were given for marketing communications purposes. See also **Figure 37**.
[88] The definition and usage of the term 'look and feel' is clearly ambiguous in the (mobile) HCI community.

companies' product portfolio, or whether real differences in user needs between consumer segments are influencing UI segmentation.

Section 3.3 will illustrate and categorize the contemporary interaction styles applied by the abovementioned companies in more detail.

2.3.5 Functionality versus Complexity, and The Usability Knee

In theory, it would be possible to implement any kind of a feature or application of any kind of complexity with (almost) any of the abovementioned UI categories. However, this would result in severe usability and other problems, as one could e.g. imagine designing a presentation graphics viewer application for a very small monochrome display. When more functionality is added to a product, the product often becomes more complex to use. The overall usability suffers when the project development team keeps on adding features even though the end user may not be requesting or going to use them. Mohageg & Wagner (2000) define the *functionality threshold* concept — illustrated in **Figure 36** — indicating that information appliances should limit the functionality to the essential few (the threshold) that provide a compelling product without leading to unmanageable complexity.

Mohageg & Wagner further suggest tackling the functionality versus complexity issue with the 80/20 rule: identify and focus on the 20% of functions that will meet 80% of the users' task needs. The user interface of the product should be optimized around the absolutely key features in that 20% of functions in the product.

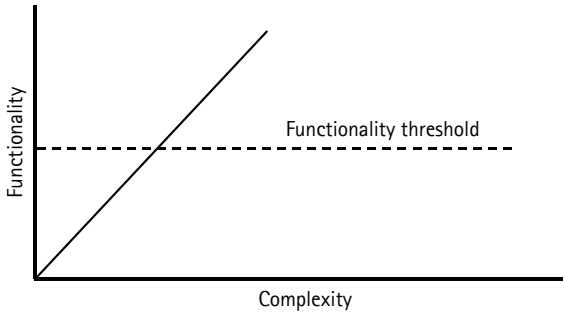

Figure 36. Functionality threshold[89]

User interface segmentation aims at easing the complexity versus functionality dilemma by matching the user needs with the 'right' user interface solution instead of offering the same user interface and functionality to every consumer. To illustrate this behavior and the general reasoning behind UI segmentation, Nokia uses an internally-developed concept named the *usability knee*[90] (Kiljander & Järnström 2003).

[89] The threshold figure of Mohageg & Wagner (2000) illustrates functionality as a function of complexity; it would be more natural to present complexity as a function of functionality.

[90] The term *knee* is related to the shape of the ease-of-use-versus-functionality curves.

The usability knee as shown in **Figure 37** illustrates how each of the UI categories has a breakpoint in the curves representing ease-of-use as a function of functionality. This breakpoint is reached when features get complex enough. Sometimes the breakpoints are easily recognizable already on designers' whiteboards, others are revealed by usability tests or trade customer feedback.

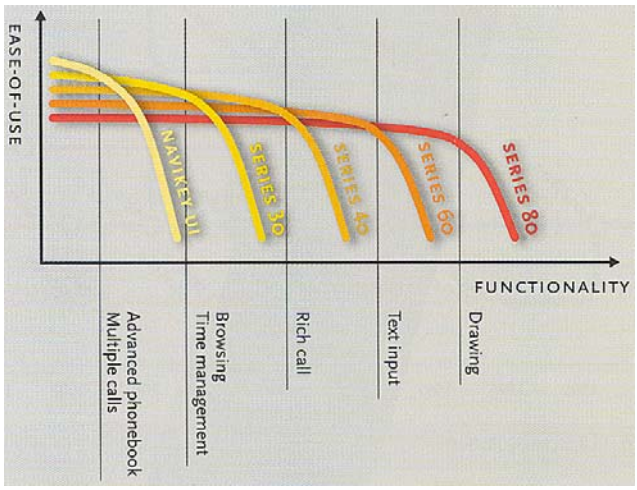

Figure 37. Mobile phone usability knee

We can very roughly recognize a continuum of usability critical features and order those on a complexity scale. Some of these breakpoints on the usability versus complexity curve include: *handling multiple phone calls*, *advanced phonebook*, *time management functionality*, *Internet browsing*, *rich call functionality*, *text input*, and *drawing applications*. With simpler features a simpler user interface category will suffice, and the platform capabilities must improve when more complex features need to be delivered to the user. A concrete example of a user need driving the development of a new UI is text messaging: one of the design drivers of the Nokia Series 60 user interface was to be able to show one complete text message consisting of 160 characters on the display. Before the Series 60 UI, there was no mobile phone UI from Nokia that was capable of displaying a full message; all the earlier user interfaces – Navi-key, Series 30, and Series 40 – were hit by the usability knee when it comes to text message displaying.

2.3.6 User Interface Customization and Personalization

Traditionally, mobile phones have been customized and personalized via hardware solutions such as replaceable color covers. Increasingly, the software user interface is becoming an important mechanism for customization and personalization. These provide a mechanism for a trade customer or a consumer to have a product that is specifically designed for them and takes their needs and desires into account. The definitions by Nielsen (1998) and Xin et. al. (2001) differentiate *customization* and *personalization* (in the WWW HCI domain) as:

- **Customization** is under (direct) user control: the user explicitly selects between certain options (a "portal" site with headlines from the New York Times or from the Wall St. Journal; enter ticker symbols for the stocks you want to track). The user is able to modify content and the look and feel of content offered on a site.

- **Personalization** is more technology and behavior driven. The site [computer server] controls what the user sees, based on information about the user's attributes and behaviors stored on the server. The computer tries to serve up individualized pages to the user based on some form of model of that user's needs.

In the mobile industry, customization and personalization are usually associated with the different roles of the different customers. In the context of this study we define the terms as:

- **User interface customization** denotes modifying the manufacturer's standard mobile phone user interface to cater for the needs of the mobile operator or service provider. User interface customization may be carried out by the handset manufacturer or by the mobile operator, and it includes elements like preloading the operator's Internet access point settings and brand-specific graphical images to the handset user interface.

- **User interface personalization** denotes the end user or consumer modifying his or her personal handset to make it look and feel more personal. User interface personalization may include downloading new ringing tones, games, or UI theme packages. According to Blom (2002), personalization and personification applied in user interfaces may have a positive impact on mental workload, engagement, trust, and emotional involvement.

Figure 38 below illustrates the relationship between user interface customization and personalization.

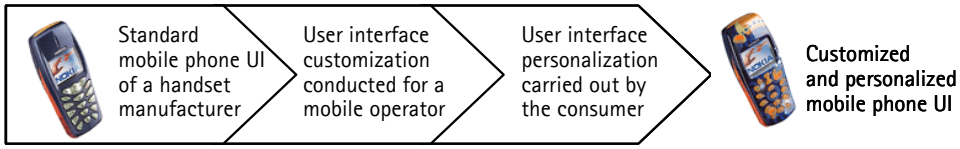

Figure 38. Mobile phone UI customization and personalization

User interface customization conducted by mobile phone manufacturers is *mass customization* (Pine 1993) as product and user interface variants are created for operators through flexibility and quick responsiveness. Of the four different approaches to mass customization defined by Gilmore & Pine (2000) — *transparent customization*, *collaborative customization*, *adaptive customization*, and *cosmetic customization* — the approach that is usually followed in the industry is a mixture of all methods.[91]

The interaction style of the mobile handset is usually left untouched by user interface customization and personalization. This is likely because customizing

[91] In *transparent customization* the company provides customers with products without letting the customers explicitly know that the products have been customized. *Collaborative customizers* engage in an ongoing dialogue with their customers to help them articulate their needs, and to create customized products for them. The customers are able to customize the *adaptively customizable* products themselves. *Cosmetic customization* is presenting a standard product differently to different customers. A mix of the approaches is often the best way to serve a particular set of customers. A mobile phone manufacturer needs to apply all of the customization approaches to serve its different customers with focused products. Methods like *contextual inquiry* are used to transparently customize products for specific user segments. An ongoing dialogue between a mobile telephone manufacturer and a mobile operator results in collaboratively customized products for that specific operator. With the adaptive customization approach the end users can adjust the mobile phone ringing tones, graphics, and shortcuts according to their needs and desires. Cosmetic customization is applied e.g. when a mobile operator requests its logo to be printed on the phone's cover, in the user guide, and in the sales package.

the fundamental interaction conventions and information architecture would be highly challenging from the software architecture point-of-view, and most probably it would not offer significant advantages. Changes to the interaction style would make it more difficult for users to use the device, and the benefits of user interface customization and personalization can be achieved by modifying other elements in the mobile device user interface. Of the user interface elements defined in **Figure 29**, we can see that the following layers are affected by user interface customization and personalization:

- Certain applications in the phone can be customized and personalized on an **application skin** level with new graphical elements such as wallpapers or sounds.
- The **application software** can be customized or personalized by pre-loading or downloading new applications such as games to the handset.
- The **presentation style** of the user interface can be changed by customization and personalization to support new colors, icons, fonts, and sounds.
- The **industrial design** of the handset can be affected: many contemporary handset models support replaceable covers and some handsets have been especially designed to support covers of different forms and shapes.

Wallpaper application skin | Application software | Presentation style | Industrial design

Figure 39. UI elements for customization and personalization

Many of the UI customization and personalization opportunities can be mixed in a specific product. An extreme example among contemporary products is the Wildseed platform that supports '*intelligent faceplates*' for mobile phones as shown in **Figure 40**. These faceplates make it possible to change the exterior design of the device together with the phone's user interface presentation layer and functionality of the handset, such as custom applications, ringing tones, media content, and Internet links.

Figure 40. Wildseed 'intelligent faceplates'[92]

Industry trends indicate that youngsters, teenagers, and young adults are the most avid customers to handset personalization services and content. Personalization as a 'show-off' element to express one's individuality may be less relevant for more mature user segments but they favor mobile services and functionality that is associated with and supports their personal or working lives[93].

Mobile phone user interface personalization has turned into a significant business of its own, as companies sell ringing tones, logos, and UI themes to consumers. Globally, mobile phone ringing tone sales reached $1 billion in the year 2002, according to the Mobile Music report from the Baskerville research group.[94]

2.3.7 Branding in The User Interface

Brands and *brand management* have become contemporary business buzzwords. A valued brand is something a company will build systematically over decades, its customers will love, and the hordes of financial analysts will scrutinize when estimating the future development of the company's share price.

Moon & Millison (2000) define a *brand* in terms of four interrelated elements:

- A brand represents the principal *satisfaction* that a customer expects and desires from the process of buying and using a product or service.
- A brand represents an ongoing *collaboration* between seller and buyer.
- This collaboration produces the buyer/seller *relationship*.
- The *story* gives meaning to the relationship and its evolution over time.

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[92] Wildseed. [Cited 06-Jul-2004] Available from WWW: <http://www.wildseed.com>.
[93] Fredrik Öijer. 18-Sep-2000. PERSONALIZATION. Presentation in Man Machine Interface for Mobile, 18th-19th September 2000, Rome, Italy.
[94] Dallas Morning News. SETTING THE TONE: CONSUMER DEMAND JUMPS OFF THE DIAL FOR CUSTOMIZED RINGING. 24-Mar-2003. [Cited 06-Jul-2004] Available from WWW: <http://www.jsonline.com/bym/tech/news/mar03/128039.asp>.

Strong brands have the power to increase sales and earnings. The brand consultancy Interbrand tries to figure how much boost each brand delivers, and how much those future earnings are worth today. The year 2004 list of world's 100 most valuable brands begins with the globally known Coca-Cola, Microsoft, and IBM, and includes wireless industry related brands like the ones listed in **Figure 41** (Interbrand 2004).

Rank		2004 brand value $ billions	Country of ownership	Description
1	Coca-Cola	67.394	U.S.	Little innovation beyond its flagship brand and poor management has caught up with Coke as consumers' thirst for cola has diminished.
2	Microsoft	61.372	U.S.	Its logo pops up on 400 million computer screens worldwide. But virus plagues and rival Linux took some luster off Gates & Co.
3	IBM	53.791	U.S.	A leader in defining e-business, with services making up more than half of Big Blue's sales.
8	Nokia	24.041	Finland	Tough times for the mobile-phone giant as its market share has slipped and younger buyers turn to rivals such as Samsung.
20	Sony	12.759	Japan	It was late to the LCD TV boom, and the PS2 video game console is slipping. Worse, rival Samsung is in Sony's face.
21	Samsung	12.553	South Korea	No longer just undercutting the prices of big Japanese brands, the Korean consumer-electronics dynamo is suddenly cool.
39	Siemens	7.470	Germany	The Munich conglomerate behind everything from phones to power plants is seeing a payoff from years of global image building.
65	Philips	4.378	Netherlands	The Dutch electronics giant has scored some hits, but it's still struggling to fend off Asian rivals.
76	Motorola	3.483	U.S.	Motorola is relevant again, with its clam-shell phones gaining in Europe and in new markets like China.
77	Panasonic	3.480	Japan	It boasts some of the best technology in must-have items like recordable DVDs and plasma-screen TVs.

Figure 41. The Global Brand Scoreboard (Interbrand 2004)

The look and feel of the mobile handset and the service content it can access are strategic brand-building elements in the global, multi-million Euro mobile communications business, as indicated by e.g. the following statements by the Ovum analyst and consulting company:

> *"There is also a nagging suspicion that the more powerful device manufacturers want to create a direct relationship with end-users, through brand dominance and premium content delivery. … Ovum forecasts that there will be over 410 million feature phones shipped in 2007, but it will no longer be the big device manufacturers who dictate what these devices look like and the platforms they support. The world's most powerful mobile operators are starting to specify their own phones, bearing their own brand and customised to underpin their service differentiation. This trend will continue, and in the process change the balance of power in the wireless devices market."*[95]

[95] "*Sendo's shock announcement proves operators are taking the driving seat says Ovum.*" Ovum. 07-Nov-2002. [Cited 06-Jul-2004] Available from WWW: <http://www.ovum.com/go/press/mediareleases/015991.htm>.

A Nokia-internal study[96] conducted in 2002 investigated the linkage between mobile phone user interfaces, usability, and consumers' brand preference. The qualitative study concludes that positive personal experiences with mobile phones from a certain brand have a strong impact on customers' brand loyalty. Consumers want to continue using the familiar brand that is felt easy and logical to use. Discontinuities to the familiar user experience are not wanted or tolerated. Some people mentioned that they are not willing to invest in a new phone and learn new usage conventions but they wish the new phone to improve the experience with new features and functionality. In general, consumers value similarity of user interfaces between different phone models of the same brand.

Contemporary mobile phones contain a number of user interface technology enablers that make the mobile UI a feasible brand promotion medium. These elements include the high-resolution color displays, sound circuits capable of playing polyphonic audio tunes, wireless Internet browsers capable of rendering content encoded in various markup languages, and e.g. the MMS services capable of transmitting multimedia objects almost as easily as conventional text messages can be sent. These elements can be utilized by the handset manufacturer, by the mobile operator or service provider, by the independent application developers, or by the content developer to promote their respective brands.

The usability consultancy User Interface Engineering (1999) describe two basic techniques for creating the emotional association in branding:

- Users attribute emotions directly with *direct-experience branding*. The direct experience from an automotive test drive or a restaurant dinner will influence the feelings of a person toward the vehicle or establishment.

- For most products and services it is impossible to give users a direct experience so an *indirect branding messaging* is applied. Manufacturers e.g. sponsor sporting events to associate their products with the fun and excitement of the sport[97].

There is no publicly available research to investigate the brand effects of user interfaces or usability in the domain of mobile phones. User Interface Engineering have analyzed numerous Internet sites to determine how WWW design affects branding (1999, 2002). Internet sites are interactive, not passive, so there is always a direct experience that can push the indirect message to the background. If an Internet site is designed on the basis of indirect branding message, the user is passive and may not even notice the message. Assuming that users visit web sites for a specific purpose, the better the site fulfills that purpose, the better the direct experience. Findings from the studies conducted by User Interface Engineering indicate that:

- Users consider a site "fun" if it lets them find what they are looking for. The strongest correlation with information finding success was the users' perception of how much fun the site was. (i.e. the more successful they

[96] Eight qualitative interviews were done in Finland and 18 in Italy. The interviews lasted around two hours.

[97] As an example example Nokia has sponsored Formula 1 car racing, American college football, and snowboarding.

were at finding information, the more likely the users would call the site "fun").

- There was no significant correlation between fun and any of the graphical variables such as number of images.

- Purchasing the products the shopper is seeking correlates very highly with brand strength.

- A high frequency of Search functionality usage correlates strongly with decreases in brand strength.

Internet users' direct experience with the site plays a greater role in shaping their impressions than the indirect branding message. User Interface Engineering compared e.g. the Internet sites of eBay[98] and Ford[99] and found that Ford's lavish use of logos and marketing slogans prevented users from finding the information they were seeking and prohibited the forming of a positive experience, whereas the most important aspect of eBay was that users consistently found interesting items quickly and easily, and the presentation of the information was far less important to user success. The direct experience branding works better, and any obstacles users face will directly and negatively affect how they perceive the brand.

Can we draw analogies from WWW sites' impacts on brands to the cellular mobile telephones domain? The similarities and differences between the mobile phone user interface and the WWW user interface will be elaborated in **Section 3.4**. The mobile phone is a smart product with most of its user-controllable functionality being operated through the user interface. The users spend a considerable time with the device's user interface — to store and retrieve names and numbers of their friends, to call their colleagues, to send text messages to beloved ones, to set a calendar alarm to remind of the children's soccer game, or to check the news headlines. Moon & Millison (2000) argue that the elegance, simplicity, and power of the user interface, more than any other resource, creates the most effective and memorable aspect of a digital brand — a *firebrand*[100]. The satisfactions that make up the firebrand in the consumer's mind derive from interactions with digital brand resources at the interface. Thus, this continuous, interactive, direct experience will either strengthen or weaken the brand image. When the mobile phone users accomplish their goals, a long-term positive effect on the brand is created. The indirect branding message conveyed with names, logos, tag lines, trademarks, and packaging may be less relevant to the users as they want to communicate with their important people.

Within this framework it is obvious that the mobile phone user interface is a considerable and powerful brand creation element. However, there are several players competing over the small footprint of the pocketable device's user interface: the handset manufacturer, the operating system software vendor, the mobile operator, the application developers, and the content providers.

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[98] eBay. [Cited 06-Jul-2004] Available from WWW: <www.ebay.com>.
[99] Ford Motor Company. [Cited 06-Jul-2004] Available from WWW: <www.ford.com>.
[100] Moon & Millison (2000) define a *firebrand* as: "*The satisfactions that consumers and other stakeholders experience as they interact with a producer's digital brand resources. These interactions create and maintain a trusted relationship between consumers (and other stakeholders) and producers.*"

In the WWW HCI domain, User Interface Engineering (1999) concluded that the graphical variables of a WWW site did not have significant correlation with the consumers' satisfaction. On the other hand, several other authors argue that the aesthetic attributes of a user interface correlate with its apparent usability, and they can have a key role in creating customer satisfaction: 'attractive things work better' (see e.g. Kurosu & Kashimura 1995, Tractinsky 1997, Norman 2002, Kallio 2003). A product or user interface designed to be used under stress — e.g. doors via an evacuation route of a building — has to maximize usability i.e. the designers should apply user-centered design principles in the design work. A design to be used in neutral or positive situations — e.g. watching a movie in a home theater — should also emphasize the pleasant and pleasurable aspects of the appearance or functioning of the design. In a relaxed context people are more tolerant of difficulties and can overlook lesser problems in the user interface (Norman 2002).

This is most probably true also with mobile telephones. During 2003 the sales of modern, color-screen and polyphonic-ringing-tones-equipped mobile phones surged as people were upgrading their older phone models. What seemed to be a key driver was the desire to improve the pleasurable aspects of mobile phone usage. This is different from the study of User Interface Engineering (1999) that focused on a highly rational task: gather product information to make an educated purchasing decision on the Internet. The vast amount of graphical imagery experienced by the web users was mostly content i.e. imagery that only has an indirect branding message effect. As discussed in **Section 2.3**, the mobile phone user interface, the software applications, and Internet content differ from their counterparts in the desktop computing environments, and thus we cannot directly argue that graphics imagery in the user interface has no link with consumer satisfaction, or that the interaction style would be more important than the presentation style. Also, mobile telephones do also possess the 'coolness factor'[101] that is still different between phones and computers, and this has an effect on the subjective product and brand preferences. In any case, it is obvious that excessive, brand-driven device user interface customization may pose usability risks, as e.g. Microsoft points out with its Smartphone platform:

> *"One of the things that attracts operators to the Smartphone is the possibility of customizing the UI, … We allow you to customize just about everything, … The exceptions are the parts that are necessary to ensure usability."*[102]

Further research would be needed around this topic to analyze the relative importance of the various user interface aspects of the mobile telephones from the branding viewpoint.

To conclude, Moon & Millison (2000) list three guiding principles for effective, brand-conscious user interface design:

- Good interfaces focus on specific outcomes and must give users meaningful results in the fewest possible mouse clicks.

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[101] For the *trendy* user segment, the phone must be new, cool, and represent the latest technology. The actual usage and content is of secondary importance. (Wilska 2002)
[102] Telecoms.com. MOBILE INTERNET. Issue 19, 18-Oct-2002. [Cited 28-Nov-2002] Available from WWW: <http://www.telecoms.com/NASApp/cs/ContentServer?pagename=telecomsportal/render&var_element=content/article_display&auth_pubcode=MI&var_article_id=1034682640887&var_seqnum=60&display_channel=home>.

- Successful interfaces feel personally relevant.
- Effective interfaces provide a multimodal relationship with the services and resources of the Web site.

Albeit these design rules are very general, and have been created in the WWW domain, they are applicable and relevant also to mobile phones and specifically to mobile Internet services accessed with mobile phones. More detailed design guidelines for mobile Internet services can be found e.g. from Kaikkonen & Williams (2000, 2001).

2.3.8 Future Mobile User Interfaces

Previous sections have illustrated the contemporary mobile phone user interface that has evolved from the early mobile telephones as shown in **Figure 2**. The early mobile telephone user interface was characterized by:

- No display, or only a small character-based display.
- Command-based interaction style; the user had to memorize the functions of the individual control keys (that were labeled with short acronyms) or a specific command language.
- No descriptive prompts on the display to assist the user.
- Small number of memory locations for storing telephone numbers. Names could not be stored in the memory.
- One pre-defined ringing tone with no volume control.
- Bulky devices with short talk and standby times.

Advancements in user interface technologies — such as color displays, multimedia messaging, predictive text input, embedded digital cameras, and MIDI tones, just to name a few — and the continuously growing number of features in mobile handsets have significantly changed the mobile phone user interface. The mobile telephone that was initially designed for wireless voice communication has turned into a handportable 'Swiss Army knife' for communication, entertainment, and information management. This 'featuritis' syndrome is obviously not only positive development as it leads to inherently more complex products.

Kiljander & Järnström (2003) argue that progress in the mobile phone user interface domain happens in evolutionary steps instead of via revolutionary discontinuities. With this in mind it should be possible to predict at least the short-term future in mobile phone user interface development with relative confidence. There are also market area specific differences in mobile device user interface conventions. The mobile, wireless Internet boom started in Japan a couple of years before the Western markets. User interface technologies such as color displays, polyphonic ringing tones, and built-in digital cameras were also commonplace on the Japanese market before they appeared on mobile phones elsewhere. It is often said that one can look at the Japanese marketplace to see what may be common elsewhere in two years time. This section will try, however, to look even a bit beyond what's happening in Japan in 2004.

The evolution of the future mobile phone user interface is driven by several factors that naturally will not take place separately, but will together contribute to the evolution of the mobile user interface:

1. Improvements in the mobile communication channel bandwidth.

2. Improvements and breakthroughs in handset user interface technologies.

3. Introduction on novel mobile communication device form factors and usage contexts.

The first factor is related to the improvements in wireless bandwidth. With the contemporary 2.5G cellular networks the maximum possible data transmission speed is 115.2 – 182.4 Kbps and in reality the speeds are much lower than that. The much-hyped third generation mobile networks provide full coverage and mobility for 144 Kbps, and limited coverage and mobility for 2 Mbps. With speeds like this it is possible — at least in theory — to e.g. transmit streaming video to and from mobile handsets, thus significantly enhancing the possible user experience. The improved data transmission speeds would make it possible to design the mobile handset to be a 'dumb terminal' and keep the user interface and application intelligence on the network, thus making it easier for the operator or service provider to upgrade the service, and in general have greater control and knowledge of the consumer. The mobile handset could in a case like this contain only a simple browser or application loader that would download and present the required services and applications to the end user. Obviously, this over-the-air functionality would be restricted to software, and all the device hardware would still have to be integrated into the device that the end user is carrying with her. Also, without network coverage or service access, the handset would probably be useless to the user, thus likely reducing consumers' interest in the concept.

The second factor is about technology improvements in mobile device software, hardware, and mechanics. The vision of Ojanperä & Prasad (2001) is:

> *"In order to capitalize on mass market, user interfaces of wireless devices must be developed far beyond today's standards. Applications have to be easy to use, non-technical, and understandable to a lay person. Voice recognition is one possible technique that can help with building user-friendly applications. Virtual reality is used to create a virtual environment for one user: a mobile user could imitate office conditions, for example, in a hotel room and could see the others in a realistic meeting environment. Interactive virtual reality opens new possibilities for developing more attractive games that can be played against other users over the wireless link."*

An example often presented is the change in mobile phone displays first from character displays to pixel displays, and later from monochrome displays to color displays. Novel user interface technologies currently on the horizon and applicable also in the mobile phone domain include e.g. the following:

- Various **context awareness** technologies (both software and hardware) let the phone adapt to the usage situation and location, and offer personalized services to the user in a considerate manner.[103]

- Research on **neural control** of computing systems aims at developing brain-control interfaces (BCI). Many research activities focus on disabled people such as people with locked-in syndrome being cognitively intact but unable to move or speak; e.g. Carroll et. al (2002) report on the development of a communication system for completely paralyzed people. Rudimentary neural control could also be used with wearable and mobile devices and usage contexts where the user's hands are occupied with other tasks.

- **Disposable and throwaway mobile phones** are targeted at the low-cost pre-paid mobile phone and calling card market but despite numerous product announcements there has been no commercial breakthrough yet with these devices[104]. Disposable phones usually include a simplified user interface with a small number of keys, no display, and reduced functionality so that e.g. with some models the consumer can only make calls, not receive them.

- Display technologies for mobile devices are continuously improving regarding their ergonomics, power consumption, manufacturability, durability, and cost. One of the fastest-evolving display technologies applicable to handportable devices currently is the organic light-emitting diode (**OLED**) display technology, that is considered to have superior brightness and color resolution performance, wider viewing angle, lower power consumption, thin aspect ratio, and better physical characteristics than the conventional flat panel display technologies (Cropper 2000).

- Various enabler technologies can be used to enhance the mobile telephone user interface: **over-the-air downloading** enables updating handset functionality of user interface look and feel by the consumer, **Java** and **BREW** enable creation of downloadable applications and games, **SyncML** facilitates device data synchronization with a server over the network, **Bluetooth** and **wireless LANs** enable short-distance wireless connectivity, different **positioning technologies** such as Cell ID, E-OTD, and A-GPS facilitate handset positioning and different location-aware services, new **input technologies** will make text and speech input easier, and **direct manipulation UI** technologies already established on the desktop computing environments are finding their way into the mobile handset domain.

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[103] The Context Aware Cell Phone Project at MIT Media Lab incorporates a GPS receiver, three-axis accelerometer, IR tag readers and IR active tags, and a context-modeling inference engine to a Java-equipped mobile phone to make the phone switch profiles when the user enters a restaurant, sits in the driver's seat of a car, etc. ([Cited 06-Jul-2004] Available from WWW: <http://www.media.mit.edu/wearables/mithril/phone.html>.)

[104] Disposable mobile phone manufacturers include e.g. Dieceland Technologies ([Cited 20-Jun-2002] Available from WWW: <http://www.dtcproducts.com/home.html>), Hop-On Communications ([Cited 20-Jun-2002] Available from WWW: <http://www.hop-on.com>) and New Horizons ([Cited 20-Jun-2002] Available from WWW: <http://www.cyclonephone.com>).

On a broader level Nielsen (1993b) describes twelve dimensions along which next-generation user interfaces may differ from conventional interfaces. The 1993 vision would obviously not be fully up-to-date in mainstream HCI but as the mobile phone HCI development is clearly behind the mainstream domain, we can apply relevant elements of Nielsen's vision. **Figure 42** amends Nielsen's comparison by presenting potential applications of the next-generation interfaces in the mobile phone user interface domain.

User interface dimension	Current interface generation	Next-generation interfaces	*Possible applications in next-generation mobile interfaces*
User focus	Controlling computer	Controlling task domain	*Any task*
Computer's role	Obeying orders literally	Interpreting user actions and doing what it deems appropriate	*Context-awareness technologies*
Interface control	By user (i.e. interface is explicitly made visible)	By computer (since user does not worry about the interface as such)	*Context-awareness technologies*
Syntax	Object-Action composites	None (no composites since single user token constitutes an interaction unit)	*Voice control*
Object visibility	Essential for the use of direct manipulation	Some objects may be implicit and hidden	*Power user shortcuts*
Interaction stream	Single device at a time	Parallel streams from multiple devices	*Context-awareness technologies, streaming media as both input and output*
Bandwidth	Low (keyboard) to fairly low (mouse)	High to very high (virtual realities)	*Streaming media between multiple parties*
Tracking feedback	Possible on lexical level	Needs deep knowledge of object semantics	*As in next-generation interfaces in general*
Turn-taking	Yes; user and computer wait for each other	No; user and computer both keep going	*Context-awareness technologies, streaming media*
Interface locus	Workstation screen, mouse, and keyboard	Embedded in user's environment, including entire room and building	*Wearable, embedded, and ubiquitous mobile communication devices*
User programming	Imperative and poorly structured macro languages	Programming-by-demonstration and non-imperative, graphical languages	*Software agent technologies; both in the terminal and on the network*
Software packaging	Monolithic applications	Plug-and-play modules	*Downloadable applications; e.g. Java*

Figure 42. Comparison between current and next generation user interfaces

The third factor in mobile phone user interface evolution — introduction of novel form factors and usage contexts — is facilitated by the abovementioned technology factors. As an example, mobile device component miniaturization and improvements in micro-display technologies can result in workable and usable wearable communication devices.

A workshop in the CHI2000 conference focusing on future mobile device user interfaces created four scenarios with representative, fictitious characters, and

further envisioned respective communication devices applicable to these users (Ruuska-Kalliokulju et. al. 2001). The resulting concept prototypes — three of them are shown in **Figure 43** — were fairly similar with common themes like wearability, non-intrusiveness, social acceptability, fashionability and coolness, multimodality, context awareness, and modularity.

The third generation of mobile communication (3G) is the evolutionary successor to the contemporary 2G (2.5G) networks, services, and handsets. The success of 3G multimedia services will to a large extent depend on the attractiveness and usability of both the services and mobile handsets. The UMTS Forum market analysis group conducted a study analyzing four different market scenarios for the mobile multimedia market (Ojanperä & Prasad 2001). The scenarios differ in the approach to spectrum pricing and liberalization, emergence of global radio and traffic delivery standards, and the ease of use of terminals. The *commoditized mass-market* scenario is developed through cheap spectrum, and simple and cheap mobile multimedia terminals. Liberalization and adoption of global standards have resulted in economies of scale. The users come from both business and consumer segments. The scenarios presented clearly show the importance of offering easy-to-use handsets and services to the mass markets in order for the mobile multimedia business to take off.

Figure 43. Future mobile device user interfaces (Ruuska-Kalliokulju et. al. 2001)

Scenario	Mobile users by 2005 (penetration)	Multimedia users by 2005
Slow evolution	82 M (22%)	7.5 M
Business centric	82 M (22%)	9 M
Sophisticated mass market	123 M (35%)	19 M
Commoditized mass market	140 M (40%)	27 M

Figure 44. Number of mobile and multimedia users in Europe by 2005 (Ojanperä & Prasad 2001)

A short glimpse of the near term future is visible via the first commercially available 3G W-CDMA handsets from the major handset manufacturers. From the user interface viewpoint these devices look a bit conservative, as there are no major UI technology or interaction style breakthroughs. As an example, Motorola's A820 3G phone has a relatively large high-resolution color display, it can download video clips and send multimedia messages but the interaction style is the one the company is using in the contemporary 2-2.5G handsets. The device itself is considerably larger and heavier than the sleek contemporary 2G or 2.5G handsets. Likewise, Nokia's first 3G handset, the Nokia 6650 shown in **Figure 71**, is somewhat bulkier than Nokia's other contemporary handsets, incorporates an external antenna in an era of internal antennas, and contains no radically novel user interface or interaction technologies.

Figure 45. Motorola A820

3. MOBILE PHONE INTERACTION STYLES

Mobile phone interaction style is the fundamental construct under study in this research work. In the context of this work we apply the following definition:

> Mobile phone interaction style is the framework consisting of
> the physical interaction objects, the abstract interaction elements,
> and the associated behavior or interaction conventions
> that are applied throughout the core functionality of the mobile phone.
> Within the context of this study, the interaction style definition excludes
> the stylistic appearance elements of the user interface,
> that are often referred to as the 'look' of the user interface.

Figure 46. Definition of mobile phone interaction style

As an example, the interaction style applied in the Siemens MT50 phone shown in **Figure 73**, includes two softkeys (*physical interaction objects*), with the rightmost softkey accessing the Menu and submenus, and inside the menus the rightmost softkey performs the Select function (*behavior*). The leftmost softkey contains a context-sensitive function, or when the rightmost softkey performs Select, the leftmost softkey performs submenu activation (behavior). The red handset key (*physical interaction object*) is used to navigate back one level in the menu structure (*behavior*). The up and down keys (*physical interaction objects*) are used to navigate back and forth in the menu structure (*behavior*). The green and red handset keys (*physical interaction objects*) work to initiate and terminate a phone call (*behavior*). The menu and its submenus are arranged in a tree structure that is presented as a vertical list of items (*abstract interaction elements*). The stylistic, appearance-related attributes of the user interface, such as the black-and-white display resolution of 101x64 pixels and the amount of three or four rows of textual content on the display, are not part of the interaction style. The manufacturer is using the same interaction style in other mobile phones that have different user interface presentation layer attributes, but the underlying interaction style remains similar. **Figure 93** illustrates representative Motorola, Nokia, Siemens, and Sony Ericsson mobile phone models with their interaction styles that are studied in the empirical part of this research work.

As described in **Section 2.3.2**, the term *interaction style* denotes a subset of the *user interface style* in the context of this work. The *user interface style* includes both the *interaction style* and the *presentation style* that denotes the stylistic, 'look and feel' attributes of the user interface. The interaction style implements the *user interface architecture* (see e.g. Anderson 2000a).

Interaction styles applied in contemporary mobile telephones are variations and combinations of the interaction styles commonly defined in mainstream HCI. All contemporary, mainstream cellular mobile telephones apply various forms of menu interaction style, that is complemented with other interaction styles whenever appropriate and applicable.

This section will begin by reviewing interaction style definitions and categorizations from mainstream HCI literature. The interaction styles in the mobile phone domain are then investigated through an analysis of contemporary, mass-market mobile phones from the major phone vendors: **Motorola**, **Nokia**, **Samsung**, **Siemens**, and **Sony Ericsson**.[105] The **Microsoft** Windows Powered Smartphone user interface platform is also included in the analysis as it is a user interface platform for some newly emerged smart phones. The analysis is based on the Orange SPV Smartphone, as that is the first commercially available handset using the user interface platform.

It must be noted that the analysis focuses solely on the *interaction styles* applied in the handsets — not on analyzing or comparing the (usability of) individual applications or specific features of the products.

Mobile phone interaction styles are based on the menu interaction paradigm. The menus in different vendors' handsets are structured differently, the menu navigation and selection mechanisms vary, and the menu items are presented using various visualization conventions. An interesting observation based on the analysis of these commercially available mobile phone interaction styles is that one of the actively promoted aspects in contemporary mobile communications — mobile Internet — is designed and implemented across the majority of the analyzed handsets in an inconsistent manner compared to the basic interaction style of the device.

3.1 Interaction Styles in Mainstream HCI

From mainstream HCI sources we can find the following definitions for user interface or interaction styles:

Source	Definition for user interface or interaction style(s)
Draper (1996)	*"Interaction style means a constellation of standard solutions to the problem of doing input and output – the "look and feel" of an interface."*
Gould et. al. (1997)	*"A user-interface style includes what the screen looks like, the human-computer interaction techniques, and the interaction devices (e.g., mouse, touch screen)."*
Hix & Hartson (1993)	*"Interaction styles are a collection of interface objects and associated techniques from which an interaction designer can choose when designing the user interaction component of an interface. Interaction style includes the look (appearance) and feel (behavior) of interaction objects and associated interaction techniques, from a behavioral (user's) view."*
Preece et. al. (1994)	*"Interaction styles is a generic term to include all the ways that users communicate or interact with computer systems."*

Figure 47. Interaction style definitions in mainstream HCI

The sole reference to user interface styles from the mobile HCI domain would be broad enough to be applied also in the more generic HCI field:

[105] The five mobile phone vendors with the largest worldwide market shares in 2003 were selected to the analysis: Motorola, Nokia, Samsung, Siemens, and Sony Ericsson (in alphabetical order). Their global market shares and product sales volumes are presented in **Figure 21**.

Kiljander & Järnström (2003)	*"The user interface style is a combination of the user interaction conventions, audio-visual-tactile appearance, and user interface hardware."*

Figure 48. User interface style definition from mobile HCI

These definitions do not explicitly differentiate between the terms "user interface style" and "interaction style". Within the context of this study, however, these terms are not interchangeable, as described in **Section 2.3.2**. The focus in the study is on the *interaction styles* in mobile telephones. The *interaction style* implements the *user interface architecture* (see e.g. Anderson 2000a), whereas the *user interface style* is a broader construct comprising also the *presentation style* (also: *look and feel*, or *interface design*) of the user interface.

Despite the differences between mobile telephones and desktop computing hardware user interface platforms, the mobile phone user interfaces apply elements from the desktop computing interaction styles. Interaction styles are not mutually exclusive — it is commonplace for products, systems, and applications to apply several interaction styles in combination such as voice commands and menus in a mobile phone. **Figure 49** summarizes interaction styles from several mainstream HCI sources.

Interaction style	Shneiderman (1992)	Hix & Hartson (1993)	Nielsen (1993a)	Preece et. al. (1994)	Draper (1996)
Batch			☒		
Question and answer			☒	☒	
(Typed) command languages	☒	☒	☒	☒	☒
Menus	☒	☒	☒	☒	☒
Push-buttons, function keys			☒		☒
Forms	☒	☒	☒	☒	☒
Direct manipulation	☒		☒	☒	☒
Graphical interfaces		☒			
Non-command			☒		
Natural language	☒	☒	☒	☒	
Windows		☒			☒
Boxes		☒			
Speech synthesis		☒			
Touchscreen		☒			

Figure 49. Interaction style categorization

Nielsen (1993a) categorizes a **batch system** as a distinct interaction style, and calls it *zero-dimensional interface*, as the human-computer interaction element is restricted to a single point in time: the submission of the batch computing job. Actually, the batch jobs are designed, implemented, submitted, the results reviewed, processed, and maybe re-submitted, so the complete task is interactive (albeit possibly very slow), and one could categorize these systems also as

command languages with a possibly very expressive syntax. Batch jobs have the advantage of being able to run without user supervision or intervention, and they are highly applicable to situations where the same computing tasks need to be performed routinely, such as e.g. a monthly billing system.

In typical **question and answer systems** the computer is in charge of the human-computer interaction session. A rudimentary menu system with the computer stating questions and presenting the available choices to the user, and waiting for the user to reply, can also be considered a question and answer system. These kind of systems are suitable for casual use and for novice users as there is no possibility to navigate wrongly[106], but they can be frustrating for experienced users who would not want to respond to all possibly irrelevant questions before they get to the relevant one.

Command languages usually apply alphanumeric strings to represent commands, parameters and options typed in by the user to control a computing system. Commands can be given to the system also via other channels such as voice control. Command languages are usually expressive, terse, and support a rapid communication style between the system and the user, so they often appeal to experienced users but are tedious to learn when the user is still a novice with the system.

Menus consolidate a list of available commands and present those to the user for selection. Menus reduce the need to memorize the available options, as the options are visible. They also reduce the amount of errors related to inputting the selection as the user simply chooses the desired option from the list of available options. Menus, on the other hand, require an area on the display, and they can easily become confusing if they are nested without an intuitive hierarchical structure. Draper (1996) sees menus as a *universal intermediate style*, as part of a range of facilities for displaying subsets of the available commands in response to user choices expressed from mouse or keyboard.

A **push-button** or **function key** based interface presents all available commands to the user via dedicated buttons or keys. A function key packages a complete command into a single lexical user operation (Nielsen 1993a).[107] Function keys are appealing in some applications since they provide fast interaction and there are so few of them that the users may start to learn them by heart and become highly efficient with the system.

Forms offer a convenient way for the user to enter multiple fields of information in an analogous manner with the real world. On the other hand, forms can become cluttered and cumbersome to navigate, and entering information via typing is always error-prone. Visual design of electronic forms should apply the guidelines and principles of paper forms design, whenever appropriate within the development constraints such as constraints for appearance, tools, libraries and templates, prototyping, and personalizability (Marcus 1992). Preece et. al. (1994)

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[106] The user can still get the wrong result, though.

[107] If we follow the Nielsen definition with *complete commands*, then many keyboard shortcuts for menu items often found in PC applications — e.g. Ctrl+F for Find — are not *function keys* but just keyboard shortcuts for menu items as they usually lead to the system asking further input from the user. An example of a *function key* would be e.g. Fn+PgUp in the author's PC to toggle the keyboard light on and off without involving any further question and answer dialogue or other user interaction.

present *spreadsheets* as special forms electronically mimicking a familiar paper predecessor.

Shneiderman (1992) defines **direct manipulation systems** to have the following characteristics: 1) visual representation (metaphor) of the world of action: objects and actions are shown, analogical reasoning is tapped; 2) rapid, incremental, and reversible actions; 3) typing replaced by pointing and selecting; 4) results of actions visible immediately. Sometimes the term *graphical user interface* (GUI) is used almost interchangeable with *direct manipulation system*. Direct manipulation systems do not necessarily require a graphical environment although the contemporary computing environments implement direct manipulation on a bitmapped desktop environment.

Graphical interfaces are different from the widespread notion of GUI. A GUI is usually identified by its UI widgets — windows, buttons, boxes, icons, etc. — and the application of direct manipulation principles. Hix & Hartson (1993) present graphical interfaces as interfaces for applications that use visual representations, rather than textual of numeric representations, to communicate with the user. They describe the following applications for graphical interfaces: 1) data and scientific visualization; 2) visual databases; 3) animation; 4) video (and audio); 5) multimedia/hypermedia; 6) virtual reality.

Unlike the interaction styles presented above, **non-command UIs** do not involve the user in an explicit dialogue to order specific actions from the computing system. In non-command systems the computer takes over the responsibility for the interaction by observing the user and adapting its actions accordingly. Technologies like active badges, eye tracking, gesture recognition, analysis of the user's actions, proximity sensors, semi-intelligent agents, and embedded help can be used to probe and assist the user in a discrete manner.

Natural language interaction allows unconstrained input to handle frequently changing problems. The user can interact with a natural language system via e.g. a textual command language or speech recognition technology.

Windows and **boxes** are not interaction styles as such but distinct screen areas used to separate processes or organize work by tasks (Draper 1996; Hix & Hartson 1993). *Boxes* as presented by Hix & Hartson (1993) are basically *secondary windows*. Windows and boxes may or may not share or combine interaction styles.

Furthermore, Hix & Hartson (1993) briefly describe some popular and feasible interaction styles: **touchscreens** can be used as input technology to various menu, push-button, and direct manipulation interfaces, and **speech synthesis** is an output technology applicable as redundant output channel or desirable for visually and physically disabled users.

Nielsen (1993b) anticipates the upcoming generation of user interfaces to move beyond the standard WIMP paradigm to involve elements like virtual realities, head-mounted displays, sound and speech, pen and gesture recognition, animation and multimedia, limited artificial intelligence, and highly portable computers with cellular or other wireless communication capabilities. We can obviously see that some of these developments have indeed happened during the late 1990s and early 2000s. Smart products like mobile phones and personal digital assistants together outnumber the conventional personal computing environments. Pen-based devices are widely used, animation and multimedia is

commonplace in entertainment, edutainment, and Internet applications, users can communicate wirelessly and globally with their mobile devices, and the devices support rudimentary speech interaction.

Many — if not all — real-world computing systems use a combination of some of the abovementioned interaction styles instead of implementing the complete user interaction with one specific interaction style. An automatic teller machine (ATM) for example, first asks the PIN code from the user via a question and answer dialogue, and then continues via a menu or function key interaction style and at some point may apply form filling for the user to enter the amount of money to withdraw. Similarly, a mobile phone user interface is an aggregate of several different interaction styles.

3.2 Indirect Manipulation Menu

Interaction styles applied in contemporary, commercially available cellular mobile telephones are variants and combinations of interaction styles defined and discussed in mainstream HCI sources (see **Figure 49**). The *mobile context of use* and *the device form factor* are the primary underlying reasons for the differences between the interaction styles of mobile, handportable devices and the desktop computing environments.[108]

The user applies push buttons, other physical controls, or speech commands to give explicit input to the device. The system gives feedback to the user by textual and graphical elements on the phone display(s), through tactile feedback, by abstract sounds, tones, or synthetic speech. The contemporary mobile phones have so large feature sets that mapping all functions to separate control keys is no longer possible. The trade-offs between the large number of features and the small physical footprint of the device leads to the application of indirect manipulation in the overall user interface of a mobile device. *Menus* have been devised to solve the mapping dilemma, but they require the user to understand the interface mechanism to some extent. The user must develop an appropriate mental model of the interface in order to be able to use it effectively.

Some features and functionality are better designed using a specific interaction style, and in some other features it may be appropriate to use another style as the users may have earlier experience from another domain in using a similar feature. Some examples of different interaction styles to design and implement different functionality in mobile phones include:

- **Command language** user interfaces are no longer used in contemporary mobile phones, with some notable exceptions such as entering a phone number to initiate a phone call. Entering digits in the phone's idle state is fundamentally a command language operation. There are no prompts to instruct the user, no menus to choose from, no special keys to be pressed; the user simply has to know that the digits must be entered first. Usually there is

[108] The mobile context of use is the primary reason for the device form factor, too. The mobile context of use and its implications to the user interface are discussed in Section **2.3**.

also some hidden functionality that may be accessible only via a command language.[109]

- Contemporary mobile phones possess so many features that it is no longer possible to map the individual features to specific keys on the handset's keypad. However, some of the phone functionality is usually available via dedicated **push-buttons** or **function keys**. Numeric keypads are found from all mainstream mobile phones, the handsets often incorporate green and red call management keys to make call handling more intuitive and efficient; and a dedicated power key, volume control keys, and scrolling keys are almost a norm.

- Practically all contemporary mobile phone user interfaces are designed around the **menu** interaction style. The phone displays the available functions and objects via a menu, and the user navigates this menu structure to make a selection. The menus in different vendors' handsets are structured differently, the menu navigation and selection mechanisms vary, and the menu items are presented using various visualization conventions. The upcoming sections will discuss the menu UI in detail.

- **Form**-type user interfaces are used in several mobile phone applications such as calendar and phonebook, where memory entries are being stored or edited. The form lets the user to edit or enter all data elements in the same context without moving back and forth between separate displays. Not losing the context eases the cognitive load on the user due to the small screen limitations.

- **Non-command UIs** are applied in mobile handsets in some specific cases like automatic backlight control, or proximity sensors are used to control the handsfree audio volume.[110] The user does not have to control this functionality via explicit commands but the usage context or the user's gestures and movements act as the input.

- Rudimentary **speech recognition** is applied for speech dialing, and command shortcuts. Most mobile phones utilize speaker-dependent speech recognition so the user must train the recognition system before it can be used, albeit speaker-independent solutions are gaining ground.[111]

- Synchronization of handset memory contents with a PC software or a network service is usually designed around a **batch system** approach. The execution of the synchronization task may take a considerable amount of time and it is not preferable to tie the user to the task as she probably has other things to do. A batch system also makes it possible to automate the synchronization task to run at a designated time.

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[109] Nokia handsets display their software version number when the user keys in *#0000# in the idle state of the phone. The average user may never need this functionality but it is a convenient way for the service personnel to check the version of the embedded software.

[110] Both features can be found e.g. in the Nokia 7650 handset.

[111] Samsung SPH-A600 supports speaker-independent digit dialing, name dialing, and some spoken commands.

- **Touchscreen**-based user interfaces are slightly outside the scope of this study as the research focus is defined to be single-handedly used handsets. Touchscreen UIs are being applied in some mobile devices that are usually somewhat bulkier and more expensive than the mainstream mobile phones discussed in this study.

Contemporary mobile phone user interfaces apply a hybrid interaction style; a large proportion of the functions and components is designed around the menu interaction style, some functions apply the command language style, some utilize forms, and in some elements we can recognize attributes of direct manipulation style. To categorize this hybrid interaction style, we have chosen the name **indirect manipulation menu** interaction style to be used in the context of this thesis.

> The term *indirect manipulation* is sometimes used in HCI within the context of next-generation user interfaces — Morse & Reynolds (1993) write "*This is indirect manipulation, in which you are directly manipulating an abstraction that controls the behavior or appearance of the actual object. A common example is the paragraph formats or style sheets seen in document preparation systems.*" — or with graphical applications such as animation toolkits — Davies & Thomas (2001) state "*The deletion is an indirect manipulation operation. The user first selects the object for deletion and then uses a pushbutton on a dialog box to initiate the operation.*" No explicit definitions for indirect manipulation are presented, but it is implicitly used to describe an interface that has direct manipulation elements associated with indirect behavior. This study takes a similar approach when applying the term.

The backbone of the user interface in contemporary mobile phones is a **menu** tree that contains an immense number of features: in the comparative usability study that was conducted at Nokia in the summer of 2002 on contemporary mobile telephone handsets, it was found that several voice-centric mobile phone models[112] contain 25–30 main features[113] and 600–700 menu items[114] in total. Designing a **direct manipulation** interface to support this amount of functionality within the constraints of the mobile phone physical user interface would be extremely difficult if not impossible — e.g. Shneiderman (1992) suggests that direct manipulation is likely to be most applicable in cases where the task is confined to a small number of objects and simple actions.

Shneiderman's short definition for direct manipulation is:

1. *Continuous representation of the objects and actions of interest*
2. *Physical actions or presses of labeled buttons instead of complex syntax*
3. *Rapid incremental reversible operations whose effect on the object of interest is immediately visible*

Control keys in mobile phones — both dedicated keys like "Clear" or scrolling keys, and dynamic softkeys — do fulfill claims 1 and 2 of the above definition: they are presses of labeled buttons, and they represent the actions of interest

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[112] E.g. Nokia 7210, Siemens SL45i, and Sony Ericsson T68i.
[113] With a *feature* we mean a set of functionalities related to a certain usage purpose; e.g. *alarm clock*, *browser*, *multimedia messaging*, and *phonebook* are distinct features.
[114] A *menu item* is a distinctly selectable function in the phone's menu structure.

continuously. However, in mobile phone user interfaces, these actions are not always reversible; there is no universal "Undo" in mobile phones. These control keys follow the **menu** interaction style, with softkeys displaying the (usually dynamic) name of the menu item on the display, as illustrated in **Figure 50**. The hierarchical menu structure — that is described in more detail in **Section 3.2.1**. — and the various objects in the mobile phone user interface, such as contact names and numbers, ringing tones, or games, are accessed via **indirect manipulation**, since the physical user interface constraints make it impossible to represent all available objects and actions continuously, and the operations are not always reversible.

We chose to call the mobile phone interaction style **indirect manipulation menu** since most of the contemporary mobile phone functionality is designed around a menu interface. Even the prevailing softkey paradigm is in essence a menu UI. The number of features designed with a command language style, with forms, or with non-command UIs, is quite limited in contemporary phones. The interaction style is not direct manipulation due to the constraints originated from the mobile phone physical user interface, and due to the lack of generally reversible operations.

Figure 50. Motorola Timeport 280 menu element explanation in the user guide

Most of the handset manufacturers apply somewhat inconsistent UI design conventions even in the basic functionality of the mobile device. The user interaction for voice call handling is roughly similar across manufacturers and handsets — you enter the digits with the numeric keys, and then press the call-initiating key — but not exactly the same, however: first the user may have to switch on the device or unlock the keypad, perhaps enter a PIN code, in case the number to be called is abroad she may have to know how the enter the international dialing prefix, if she makes typing errors she needs to erase the wrong digits, and eventually know which key is used to initiate the call after all digits have been entered.[115] All this functionality often differs among different manufacturers; some de facto standards are starting to emerge, though.[116]

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[115] With a device like the earlier Nokia Communicator the user also needs to know how to hold the handset when talking as the earpiece and microphone are on the 'wrong' side of the phone.

[116] E.g. both Motorola and Nokia use the keypad sequence Menu-* (Star) to activate and deactivate the keypad. One can argue that Menu-* may not be the most intuitive design solution but as more and more people become replacement customers they already know how to operate a certain feature, and a common standard will make it easier for them to

3.2.1 Menu Presentation and Interaction

All contemporary, mainstream cellular mobile telephones are designed around a menu user interface paradigm. Ziefle (2002) regards mobile phones as typical representations of electronic information retrieval systems having a hierarchical menu structure. The phone functions are located in a menu that is usually arranged into a tree structure that occasionally wraps around leading to a circular or cyclic menu navigation experience. The menu structure contains the majority of the phone features usually grouped according to functional similarity, so that e.g. a Messages menu item contains the incoming text, multimedia, and email messages, with functions to listen to voice messages, create, and send new messages, and manipulate the folders where messages can be stored. **Figure 51** shows the main menu tree of the Motorola Timeport 280 phone, and the circular main menu of the Motorola Talkabout 192 phone, as illustrated in the user guides of the phones.

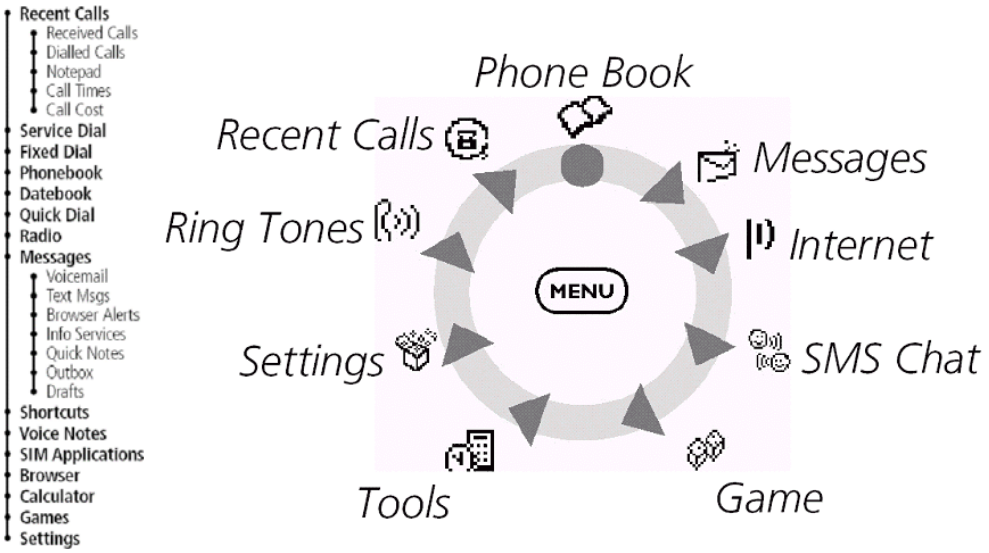

Figure 51. Motorola Timeport 280 main menu tree (left), and Motorola Talkabout 192 rotary menu (right) as illustrated in the phones' user guides

Menu systems incorporated in mobile telephones are designed around indirect manipulation, since the physical user interface constraints make it impossible to represent all available objects and actions continuously. Scrolling keys are used to navigate in the menu structure to locate the desired functionality, selection key is applied to select the desired function, and then various submenus, wizards, forms, or question-and-answer dialogs are used to complete the task, and these UI elements may often differ from the menu interaction style.

Based on the presentation and interaction styles of the contemporary mobile phone menu structures, we can categorize them as shown in **Figure 52**. As already discussed in **Section 3.2**, the actual mobile phones usually apply a number of different interaction styles in the whole product user interface.

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switch between mobile phone vendors if they for some reason want to do that. **Section 3.6.1** will discuss mobile phone UI standardization in more detail.

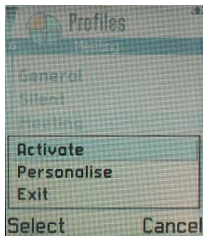
Menu presentation style	Menu interaction style	Examples (not to scale)	
One menu item shown per time. Usually an indicator is used to denote the current location in the menu.	Vertical scrolling and selection with up/down keys, rocker device, or a miniature joystick.	 Nokia 6610	 Samsung SGH-N620
Vertical lists of textual and/or iconic menu items. Usually not all items fit on the display, and a scrolling indicator is used to indicate the current location in the menu.	Vertical scrolling and selection with up/down keys, rocker device, or a miniature joystick.	 Motorola V60	 Siemens MT50
Pop-up menus are often applied in sub-menus that are context-sensitive. By showing the main display state on the background the phone makes it easier for the user to maintain context.	The user interacts with pop-up menus like with the conventional, vertically scrolling menus.	 Nokia 7650	 Siemens S45
Horizontal, sometimes tabbed, list of usually iconic menu items. Usually all items fit on the display.	Horizontal scrolling and selection with left/right keys, rocker device, or a miniature joystick.	 Ericsson R600	 Samsung SGH-T100
Round grouping of textual and/or iconic menu items. All items may or may not fit on the display.	Rotating or up/down (left/right) scrolling of circular menu.	 Motorola Talkabout 192	 Philips Fisio 820
2-dimensional matrix of iconic menu items. All menu items may or may not fit on the display simultaneously.	2-dimensional navigation and selection with separate directional keys, rocker device, or a miniature joystick.	 Panasonic P504i	 Sony Ericsson T68i

Figure 52. Menu presentation and interaction styles

Most of the reviewed mobile phone menus follow the **extended menu** interaction style as defined by Shneiderman (1992). An extended menu contains too many menu items to fit on one screen, and may continue for many screens. Unlike extended menus, the horizontal menus in **Figure 52** and quite often also the 2-dimensional icon grid menus fit on one display. A trend in mobile handset user interfaces is that menu trees keep on getting longer and deeper since the

functionality is increasing constantly. From the usability perspective the menus should be manageable: e.g. the Nokia Series 60 UI design team tries to limit the length of function lists to seven plus or minus two[117], and the Nokia Series 40 UI design team tries to limit the length of the main menu to nine items so that they can fit on one three-by-three icon display.

Some of the menu presentation and interaction styles move the focus within the menu items, and some keep the focus location static while moving the items. Full-screen menus like the Nokia 6610 and Samsung SGH-N620 in **Figure 52** do not need to present an explicit focus pointer, as there is only one active item on the display. Likewise, the rotating menus of Motorola Talkabout 192 and Philips Fisio 820 always keep the menu item under focus in the middle of the display, and when the user scrolls the menu, the items move one step clockwise or counter-clockwise. On the other hand, the one-dimensional list menus (e.g. Motorola V60 and Siemens MT50) or the two-dimensional grid menus (e.g. Panasonic P504i and Sony Ericsson T68i) keep the menu items static and move only the focus — unless the focus would move out of the display area, and the hidden menu items need to be brought visible.

The association between menu presentation, interaction, and the physical control devices can either improve or weaken the total usability. A well-designed example is the placement and functionality of the 'jog wheel' device in the Sony CMD-Z7 handset shown in **Figure 53**. The jog wheel is placed on the side of the device, and the wheel rotation is instantaneously mapped to the rotation of the 3D circular menu.

Figure 53. Sony CMD-Z7 jog wheel and rotating main menu

Figure 54. Amoisonic A8+ vertical menu with horizontal scrollbar

A more questionable mix between the menu presentation and navigation elements is illustrated on the screen of the Amoisonic A8+ handset shown in **Figure 54**. The submenus are scrolled *vertically* with the up and down arrow keys, like the up and down arrow symbols indicate on the bottom of the display. In submenus there is a *horizontal* scrollbar shown below the submenu header text. This scrollbar indicates the location of the highlighted submenu item in the overall submenu item list. The mixing of vertical scrolling interaction and horizontal location status presentation complicates the user experience unnecessarily.

Dedicated function keys are a version of menu style that provides access to special functionality. The usage frequency or criticality of certain features is high enough for the designers to incorporate designated control keys or pushbuttons in the handset. These features include e.g. volume control, text erasing, silent mode activation, mobile Internet access, phonebook, messaging, voice

[117] Miller (1956) introduced the *span of absolute judgement* concept and suggested that for unidimensional judgments this span is usually somewhere in the neighborhood of seven.

commands, or the power button. In some handsets the user can assign a personal favorite function to a user-configurable quick access key.

Some mobile phone applications utilize menus of **screen buttons**, much like the pushbuttons found in desktop GUI environments. Screen buttons offer a familiar user interface that is especially applicable when the button labels are symbolic or very short, since the available screen space is limited, and usually there is also some other information to be shown. Screen buttons make a large number of functions available (almost) instantaneously (e.g. play, pause, record, rewind, forward in a music player). Some screen buttons are used by navigating the focus to the desired button (e.g. the Nokia 7650 recorder in **Figure 55**) whereas some screen buttons are directly mapped with keys in the phone keypad so no navigation is needed (e.g. the Sony CMD Z28 calculator in **Figure 55**).

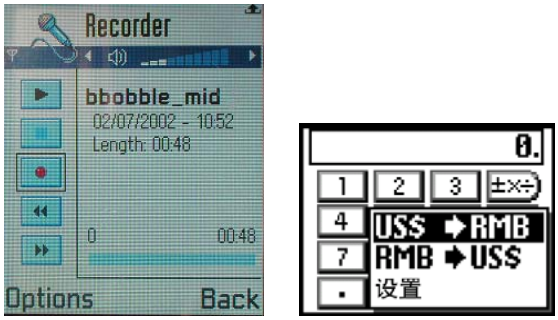


Figure 55. Screen buttons in Nokia 7650 recorder, and in Sony CMD Z28 calculator[118]

Menu presentation and interaction style is one element to be considered when designing a mobile phone user interface for replacement customers. The designers always have to find the appropriate balance between novel and possibly more radical solutions, and sticking with the heritage that may be more comfortable for users of previous-generation handsets:

> *"When you enter the 6100's menu system you immediately note the new color graphics. ... I had been hoping for a switch in menu structures, though. … This is not the case. The 6100 sticks to the same basic classic Nokia menu system that has been in all of their phones for years, … This will probably please longtime Nokia users, even though I was not happy with it."*[119]

3.2.2 Navigation Devices

The user moves around in the menu structure with a physical navigation device. The navigation device is usually a cluster of conventional keys or some other micro-mechanical device having a small-enough footprint but still offering good-enough ergonomics for reliably moving the navigation focus on the display. Contemporary mobile phones incorporate various types of navigation devices, as illustrated in **Figure 56** below:

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[118] The Sony calculator screen buttons are partially hidden in the picture by a pop-up menu allowing the user to select a currency conversion function.

[119] Oryl, M. NOKIA'S COLORFUL BABY, THE 6100. 29-Nov-2002. [Cited 06-Jul-2003] Available from WWW: <http://mobile.burn.com/review.jsp?Page=2&Id=167>.

Navigation device	Examples (not to scale)	
Separate up and down (or left and right) directional navigation keys were the first means to navigate in mobile phone user interfaces. In some handsets all four directions are implemented as separate keys. The keys can be implemented using various dome technologies.	 Ericsson T66	 Fujitsu F504i
Directional keys are frequently integrated into one **paddle-type element** to improve ergonomics in applications like games. Sometimes the paddle contains also the selection function in the middle. In some phone models the directional keys are combined with the numeric keypad keys, like in the Philips Fisio 820 phone. Paddles can be implemented with separate or packaged dome technologies.	 Nokia 6650	 Philips Fisio 820
Miniature digital joysticks are often applied in contemporary mobile phones supporting Internet navigation or gaming functionality. Some devices facilitate navigation in two dimensions only (4-way or 8-way), whereas some also include the selection function through pressing the joystick element.	 Motorola Timeport 280	 Sony Ericsson T68i
Rocker, roller, and rotating wheel devices are usually very intuitive when scrolling one-dimensional lists but may fall short when two-dimensional navigation is required. The roller wheels can usually be pressed for selection, and in some devices there are additional directions of movement for special functionality, such as in the Sony CMD-Z7 phone, where the jog wheel can also be pushed and pulled.	 Nokia 7110	 Sony CMD-Z7

Figure 56. Mobile phone navigation devices

3.2.3 Item Selection and Canceling

The navigation devices described in the previous chapter let the user move around in the menu structure and between other UI elements. Similar navigation conventions are applied in name list scrolling, text entry, game playing, Internet browsing, calendar navigation, and accessing other functionality of the handset. When the desired menu item, phone number, data storage folder, pop-up list item, Internet hyperlink, or any other object of interest is under focus, the user may select it using a specific selection key in the device user interface. There are three types of selection keys in contemporary mobile phones:

- Select softkey: a key prompting the user with an on-screen label like "Select"
- Select hardkey: a key with a printed label like "OK", or "Yes"
- Select integrated in a special navigation device like a joystick, roller key, or some other micro-mechanical device that usually has no specific label to indicate the available selection functionality

Occasionally the user will navigate to a wrong menu branch or decide that she doesn't want to complete the intended task after all. Practically every phone user interface offers a means to backstep or cancel the operation with a specific cancel key. Various types of cancel keys are applied in contemporary mobile phones:

- Cancel softkey: a key prompting the user with an on-screen label like "Cancel", "Back", or "Exit"
- Cancel hardkey: a key with a printed label like "C"
- Cancel integrated in a special micro-mechanical device like a jog wheel that usually has no label to indicate the available cancel functionality

There are no established mobile phone UI standards or even conventions when it comes to selection and canceling functionality and key mapping, but the Select–Cancel two-softkey approach is becoming popular among several manufacturers. **Section 3.3** in the thesis will review some contemporary, mainstream mobile phone user interfaces from the major phone manufacturers, and **Figure 57** below will map these mobile phone user interfaces across the Select and Cancel variant dimensions. **Section 4.1** will explicate in detail how the Select, Cancel, and menu access functions are designed in the Three-softkey interaction style.

	Select softkey	**Select hardkey**	**Select in special key**
Cancel softkey	Motorola V60 and Timeport 280, Nokia 6610 and 6650, Samsung SGH-N620 and SGH-T100, Ericsson T60d		Nokia 7650
Cancel hardkey	Nokia 3330, Siemens MT50 and S45	Motorola Talkabout 192, Ericsson T65, Sony Ericsson T68i	Orange SPV
Cancel in special key			Sony CMD-Z7

Figure 57. Item selection and canceling styles

In reality, the abovementioned categorization is an approximation. Many of the reviewed phones follow their base UI conventions quite rigorously throughout the UI but there are special cases where exceptions take place, as the following examples illustrate:

- Motorola's Talkabout 192 has a Select 'semi-softkey' as the "OK" hardkey has an on-screen label, albeit the label is formulated as a question. However, in the browser application the softkeys behave inconsistently as sometimes the "OK" hardkey also backsteps (and has the "Back" label), and the "Edit" function can occasionally be found from either the "Menu" semi-softkey or "OK" semi-softkey depending on the context.
- Nokia's Select softkey approach is complemented by a Select hardkey in the browser application in the 3330, and 6610 phones[120]. This way the Select function can be offered to the user via one key press — instead of forcing the user to first press the "Options" softkey and then select the "Select" function from the function list.

[120] In the 3330 phone the Select function is overloaded to the 1 and 3 keys, and in the 6610 phone it is overloaded to the green handset key.

- Samsung phones have Cancel available usually in a softkey, and the functionality is duplicated in a specific "C" hardkey, except in text input states where "C" is used for backspacing, and the dedicated End key is used for backstepping.

- Sony's CMD-Z7 has Cancel available both as a jog dial pull function, and in a dedicated "C" hardkey.

Even though many handset manufacturers are currently applying variants of the Select–Cancel softkey approach, there are no mutually accepted conventions to define e.g. the labeling or ordering of these softkeys, as illustrated in **Figure 58** below.

Nokia 6610 Samsung SGH-N620 Sony Ericsson T62u Motorola V60 Sagem MY X-5

Figure 58. Select–Cancel softkey labels and ordering

3.2.4 Softkeys

Despite the differences in their menu structures or in their Select–Cancel logic, most contemporary mobile phones utilize a softkey-based user interface. A softkey is a context-sensitive function key that comprises of a physical key and an attached changeable label on the display. The physical key is usually placed close to the phone display to strengthen the association with the label. When the key is pressed, the phone performs the function indicated by the label. If no label is shown, pressing the key usually performs no function.

Without softkeys (Mobira Cityman)	With softkeys (Nokia 7110)
1. Press the M button.	1. Press Names (right softkey).
2. Press the ABC button.	2. Scroll to Add entry.
3. Key in the name.	3. Press Select (left softkey).
4. Press the ABC button.	4. Key in the name.
5. Key in the phone number.	5. Press OK (left softkey).
6. Press the M button again.	6. Key in the phone number.
	7. Press OK (left softkey).

Figure 59. Saving a name and number into memory
with Mobira Cityman (no softkeys) and a Nokia 7110 (with softkeys)

Figure 59 illustrates the usability improvements brought by the softkeys when compared to the early mobile phones[121] equipped with designated memory control keys only (Väänänen-Vainio-Mattila & Ruuska 2000). The number of key presses has actually increased, but the discoverability and intuitiveness of the

[121] The example phones are the Mobira Cityman from the 1980s (the third phone in **Figure 2**) and the Nokia 7110 from late 1990s.

interaction sequence have improved significantly. It must be noted, however, that these improvements are not only due to the introduction of softkeys but at the same time the mobile phone displays have become larger, and capable of presenting information in a more informative manner.

The number of softkeys varies between phone manufacturers and interaction styles as can be seen from the examples in **Figure 60** below.

	Examples not to scale		
1 softkey			
	Motorola Talkabout 192	Nokia 3330	Siemens A36
2 softkeys			
	Orange SPV	Samsung SGH-N620	Siemens S45
3 softkeys			
	Motorola A820	Nokia 6650	Panasonic P504i
4 softkeys[122]			
	Siemens C 35[123]	Siemens M 35	

Figure 60. Mobile phone user interface softkeys

[122] Four horizontally arranged softkey labels seems to be the practical maximum on the small displays in mobile phones. On a wider screen it is possible to display more labels, such as the six softkey labels in some scientific calculators (e.g. the Hewlett-Packard 49G+). Likewise, some music synthesizers (e.g. the Yamaha PSR-1100) apply vertically arranged softkeys on both sides of the display.

[123] The user interface in the Siemens C 35 and M 35 phones utilizes 1 to 4 softkeys depending on the context.

An interesting notification illustrated in **Figure 61** is that Sony Ericsson remapped Ericsson's conventional Yes–No hardkey UI to a Select–Back softkey UI for all their new phones in 2003 for the U.S. market. In these phone models the interaction logic of these two UI variants is very similar, with the exception of the Select–Back UI offering somewhat richer and more flexible functionality in some interaction sequences like checkbox status toggling. The T600 phone series introduced in Spring 2003 incorporates a two-softkey user interface, described by Sony Ericsson with "*Soft keys make applications easier and faster to use.*" The UI in the 600 series also includes a new backstepping key so now the rightmost softkey can be used for other functions. A brief analysis of the Sony Ericsson product portfolio in mid-2004 indicates that the Yes–No style is gradually being replaced by the two-softkey style in the manufacturer's new products.

Figure 61. Sony Ericsson T200, T62u, and T610 softkey evolution

Softkey labels are usually textual but in cases where three labels cannot easily fit on the display, iconic labels are used. E.g. Motorola's Menu softkey label is iconic (see the Motorola A820 in **Figure 60**), and the three-softkey phones in Japan frequently utilize iconic softkey labels.

A rather strange and contradictory application of the handset user interface is seen by some retailer advertisements as illustrated in **Figure 62**. Imagery for advertisements or marketing communications purposes is often skillfully manipulated but in these cases the images show non-existing combinations of the hardware and software user interface: the two-softkey phone shows a one-softkey phone display, and the one-softkey phone shows a two-softkey phone display.

Figure 62. Contradictory user interface image manipulation around softkeys[124]

[124] Helsingin Sanomat. 19-Dec-2002. Nokia 5210 advertised by Päämies, and Nokia 3310 advertised by Stockmann.

3.2.5 Voice Call Handling

Even though text messaging[125], mobile services browsing, game playing, or e.g. digital imaging have emerged as ways to utilize mobile telephones, the traditional use of handsets for voice communication still prevails in general. Therefore, intuitive and efficient voice calling functionality has been and remains a key goal in mobile phone UI design. A calling situation can have high stress factor, since the user needs to be able to master the needed handset functionality while continuing a conversation with a calling party without dropping the call, and possibly juggling between a number of simultaneous calls.

The various call handling conventions in different mobile phone interaction styles are illustrated in **Figure 63** below.

Call handling style	Green key initiates a phone call, and red key ends the call.[126]	Combined green/red key initiates a phone call, and when a call is active, pressing the same key will end the call.	Call handling with two context-sensitive softkeys.	Call handling with one context-sensitive softkey.	In some phones with a folding or sliding form factor, the opening or extending of the phone will automatically answer an incoming call, and closing the phone will end the call.
Example	 Motorola Talkabout 2288R	 Alcatel One Touch 311	 Sony Ericsson T61z	 Nokia 3330[127]	 Motorola V60

Figure 63. Call handling conventions in mobile phone user interfaces

The widely applied solution to call handling user interface is to have control keys marked with green and red handset symbols for call manipulation. An exception to this convention is e.g. Nokia's Navi-key style that has no keys marked with these symbols, but call handling is done with the single softkey.

To facilitate in-call functionality such as conference calling, muting, and putting the active call on hold, the phones normally support an in-call menu via a specific Menu hardkey or softkey. The functionality of this menu usually follows the basic interaction conventions applied in the phone UI.

Section 3.2.7 will describe how the call-handling user interface is utilized as a product category differentiator in Motorola's and Nokia's product portfolio.

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[125] Nokia-internal user research indicates that especially in the teenager segment in the most developed mobile phone markets like Denmark, many people communicate mostly without traditional phone calls but use text messaging instead and extensively.
[126] Often the keys are labeled with receiver symbols, "Yes"/"No", or e.g. "OK"/"C".
[127] The "C" key offers a hidden shortcut to end a call in the Navi-key interaction style.

3.2.6 Menu Interaction Style Usability Issues

The inherent constraints in the mobile telephone physical user interface affect the usability of the menu interaction style. No matter how well the interaction is designed, the indirect manipulation menu interface will not be completely free from usability deficiencies. Väänänen-Vainio-Mattila & Ruuska (2000) claim that the challenges in mobile phone HCI are caused especially by the constraints of indirect manipulation.

The psychological theory and performance evaluation of menu-based user interfaces for conventional HCI environments have been researched extensively (see e.g. Norman 1991). However, many of the guidelines in the conventional computing environments are not fully applicable in handportable communication products due to the differences in the domains, as outlined in **Section 2.3**.

When used consistently, the menu paradigm makes the mobile phone functionality straightforward and uncomplicated to access. However, usability research in the mobile phone domain indicates several issues associated with the indirect manipulation of a rich and large set of functionality via a small display. Keinonen et. al. (1996), Koivunen et. al. (1996), Kiljander (1997), Väänänen-Vainio-Mattila & Ruuska (2000), and Helle et. al (2003), describe these usability problems with mobile handsets — these are frequently encountered in the daily usability engineering work at Nokia.

- The increasing amount of phone features leads to long menus and submenus, and creates deep menu structures. This makes the sequential interaction sequences long and slow, and it also makes it difficult for the user to guess where to go when searching for a new function. Norman (1991) suggests that the optimum breadth is near eight menu items and the optimum depth is near two menu hierarchy levels. As an example, the Sony Ericsson T68i has ten menus on the main level, and the number of submenus in these menus ranges from 5 to 14. Many of these submenus have further submenus.

- There may be no clear visual indication of the user's location in the menu structure. This may make it difficult for the user to form a mental model of the phone's states; especially if she is not very technology-oriented. The visual presentation may lack differentiating indication between menu categories and menu operations, and the beginning and end of menu markings may also be missing or incomprehensible.

- The creation of an appropriate mental model is also difficult since the display is too small to accommodate all available menu items at the same time.

- Menu browsing becomes tedious, as all menu items need to be read and understood when looking for a specific menu item. One of the most frequently observed errors in usability testing situations is actually that the user scrolls past the desired menu item, and must scroll back one menu item. This was the reason why the upwards-scrolling key was added to the Nokia Navi-key UI (Lindholm 2003).

- On a small display the menu wordings affect the applicable graphical display layouts, and the wordings are language-dependent, so localization is one of the key drivers when it comes to visual design of mobile phone displays. Terminology issues in general are one of the most frequently encountered

usability problems in mobile phones. Many novel mobile phone features introduce terminology that is previously unknown to the users. Some terminology may be inherited from the personal computing or Internet domains, but it needs to be remembered that mobile phones are consumer products and the users may not have earlier computer or Internet experience. Obviously the users will learn even difficult terminology over time, but it may well be so that due to incomprehensible terminology, certain functionality will not be used.

- Poor or incomprehensible feedback is often causing usability problems. Feedback is needed both from performing menu operations and from the current location in the menu. A frequently noticed usability problem is caused by inconsistent application behavior after an operation is performed; some applications may leave the menu altogether, some may return one level back in the menu structure, and some may remain on the last menu level.

- Some usability challenges with indirect menu manipulation can be resolved by assigning frequently needed key functionality to dedicated control keys and buttons. In a relatively small product like a mobile phone, there cannot be enough direct buttons for all device functionality, so a major part of the functionality has to reside in the menu. The menu navigation buttons must therefore be well designed. Koivunen et. al. (1996) suggest at least the following buttons to be present: menu forward and backward scrolling buttons, select button, button to go back one level, button to jump to the beginning of the menu. Sometimes the menu navigation buttons are overloaded or marked with non-standard or incomprehensible abbreviations.

It is interesting to note that much like mobile phones, the newly introduced smart products like digital cameras, or the digital versatile disc (DVD) medium and equipment have introduced new HCI domains that are not fully consistent with the earlier, more established applications of menu user interfaces. As an example, Norman (2001) complains about DVD menu design:

> *"Designers of DVDs have failed to profit from the lessons of previous media: Computer Software, Internet web pages, and even WAP phones. As a result, the DVD menu structure is getting more and more baroque, less and less usable, less pleasurable, less effective. It is time to take DVD design as seriously as we do web design. The field needs some discipline some attention to the User Experience, concern about accessibility for those with less than perfect sight and hearing, and some standardization of control and display formats."*

3.2.7 Non-Menu Interaction Styles

Not all of the mobile phone functionality is designed around the indirect manipulation menu. **Section 3.2.5** discussed voice call handling, and there is other, specific functionality that is often designed around a different interaction style.

Forms are often applied solution in mobile phone user interfaces whenever the user needs to interact with an information structure consisting of several elements. By consolidating all relevant data fields on the same form display, the user is saved from tedious navigation between separate displays and menus. **Figure 64** below illustrates forms applied to interact with a phonebook entry in the Nokia 7650 phone, and to interact with a calendar entry in the Siemens S45 phone. The user navigates between the data fields on the form with the

navigation device, selects a field, and enters or edits the correct information via the phone keypad.

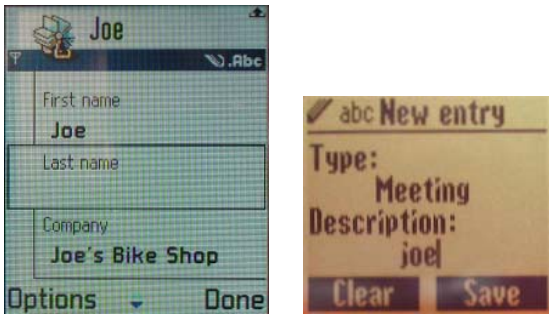

Figure 64. Forms in Nokia 7650 phonebook, and in Siemens S45 calendar

Voice control has long been seen as a solution in creating next-generation user interaction styles. This has not taken place yet, and the applications of voice interfaces on mobile telephones are also quite limited. The more reliable systems are usually speaker-dependent which means that the user has to train the system before it can be used. Auditory commands can be used for placing a phone call from the phonebook, or by assigning voice shortcuts to menu functions. These voice commands complement the menu-based interface, and become useful in situations where the conventional user interface is not appropriate for some reason, such as with disabled users, or in eyes-busy and hands-busy situations (Nielsen 2003). Continuous speech recognition in the background is still not possible due to performance reasons. Speech can also provide an interface to network-based services. Automatic conversion of text messages to speech is being provided by some mobile operators, and services like voice Internet browsing are available. In the handset-based speech UI solutions, there is usually a voice command button in the handset or e.g. in the headset to activate voice recognition.

3.2.8 Direct Manipulation Interaction Styles

Handheld communicating devices that have their roots in the PDA product categories often apply a direct manipulation interface with a touchscreen as the input device. As defined, these devices are outside the scope of this study. The direct manipulation user interface paradigm is not widely used in mainstream mobile telephones. However, some Asian mobile phone manufacturers have introduced direct manipulation as a complementary interaction mechanism in their recent phone models. The NEC N2051 W-CDMA phone from NTT DoCoMo in Japan is introducing a 'mouse' pointer controlled GUI. The user selects and activates on-screen button and navigates on the screens with a 'mouse' pointer, that is controlled with a 360 degree joystick named 'Neuropointer'. **Figure 65** illustrates some UI screens of the phone. The user is still able to navigate between the UI controls with the directional keys, so the pointer control is only a complementary control mechanism. Using the mouse pointer UI over a short period of time gave the author the impression that the ergonomics of the joystick may still need to be improved — besides, a freely moving pointer may not be the optimal UI control mechanism in a mobile context where there is no stable support for the user's hand controlling the navigation device like there is in a desktop or laptop PC usage context.

Figure 65. 360 degree 'Neuropointer' UI in NEC N2051

The Panda EMOL98 GSM phone from the Chinese manufacturer introduces a pen-operated touchscreen UI in a standard mobile phone clamshell form factor. The user can still operate the phone menus and softkeys via the navigational keys and the softkey buttons, but there is also the possibility to directly select and activate screen objects with a tiny stylus. The pen-based UI is obviously very convenient in entering Chinese Kanji handwriting into the phone, as illustrated in **Figure 66** below.

Figure 66. Touchscreen UI in Panda EMOL98

The joystick-controlled mouse pointer and the touchscreen UI both represent possible and likely directions in mobile phone UI evolution. In the abovementioned products they complement the indirect menu manipulation UI operated via button presses. The touchscreen UI approach is especially convenient in oriental text input applications where the standard 3-by-4 phone keypad has obvious limitations. However, it also requires the user to use both hands to operate the phone, and this may be an obstacle in some mobile usage contexts.

3.2.9 Simplified Interaction Styles

Of the analyzed phone manufacturers and their handsets, Motorola and Nokia are applying a relatively similar approach in using the interaction style as a differentiator between their entry-level handsets and the mid-range and high-end products.[128] The mid-range and high-end products incorporate dedicated green and red receiver keys for call handling, and have a number of other fixed control keys and softkeys. The entry-level handsets are reusing roughly the similar menu structure and a subset of the menu features from their higher-end siblings but they are designed around a reduced set of softkeys and modified fixed control keys as described in **Figure 67** below. The comparison is done between both vendor's handsets having a display with the same resolution and colors: from Motorola the V60 and Talkabout 192 models illustrated in **Figure 70**, and from Nokia the representative models are e.g. the 3360 and 3330 models illustrated in **Figure 93**.

	Motorola		Nokia	
	'Standard' UI: Motorola V60	Simplified UI: Motorola Talkabout 192	'Standard' UI: Nokia 3360	Simplified UI: Nokia 3330
Menu	Vertically scrolling list of menu items	Vertically scrolling list of animated menu items; also graphical grid menu	Vertically scrolling list of animated menu items	Vertically scrolling list of animated menu items
Softkeys	Left and right softkey; Exit–Select	OK softkey	Left and right softkey; Select–Back	Navi softkey
Control keys	Menu key	Menu key, C key	-	C key
Navigation keys	Up and down keys	Up and down keys	Up and down keys	Up and down keys
Call handling keys	Send, End keys	-	Send, End keys	-

Figure 67. Standard and simplified Motorola and Nokia interaction styles

Both Motorola and Nokia are mapping the functionality of the two softkeys onto one softkey and a C(lear) key in their simplified UIs: Motorola maps the right softkey to the single OK softkey[129], and Nokia maps the left softkey to the single Navi softkey. Motorola's left and Nokia's right softkey are mapped to the C key. The simplified UIs of both vendors implement call handling with the single softkey and the C key, as there are no dedicated control keys for this purpose.

[128] '*Entry-level*', '*mid-range*', and '*high-end*' are ill-defined terms. In the context of mobile phones, one could define entry-level as the most inexpensive products (e.g. Motorola Talkabout 192 or Nokia 3310), high-end as the most expensive, often design-driven handsets (e.g. Motorola V70 or Nokia 8910), and the mid-range between these two extremes (e.g. Motorola Timeport 280 or Nokia 6310). From the functionality point-of-view a somewhat similar categorization would be division into '*phone*', '*browser phone*', and '*smart phone*'.

[129] Motorola's one-softkey approach no longer remains consistent in the mobile Internet browser application as the Menu key is occasionally also used like a softkey.

With user interface segmentation like this the companies can target different user segments with products having visibly different look and feel but still retaining an underlying similarity between device functionality and feature sets.

3.3 Contemporary Mobile Phone Analysis

In this study we analyzed commercially available mobile phones and their interaction styles from the following manufacturers: Motorola, Nokia, Samsung, Siemens, and Sony Ericsson. These five vendors had the largest worldwide market share in 2003 (Gartner 2004). A Microsoft Smartphone handset was also selected to the analysis as it represents a commercially available UI platform for contemporary smart phones; the initial interaction style analysis was conducted based on the UI emulator available with the Microsoft PocketPC software development kit (SDK), and later we evaluated the Orange SPV phone as it became commercially available.

Within the scope of this work it was practically impossible to cover all mobile phone models and variants from each of the selected manufacturers. The analyzed handsets were selected based on the following criteria:

- The handsets must lie within the scope of this research work — the focus of the study is on the interaction styles of *mainstream, high-volume, voice-centric cellular mobile telephones*. We did not evaluate low-volume, PDA-type devices.
- The selected handsets from a manufacturer should represent the manufacturer's contemporary[130] (and near future) UI portfolio as broadly as possibly. No discontinued models were selected to the analysis.
- The selected handsets had to be physically available i.e. no analysis was to be done without an empirical hands-on experience and evaluation.[131]
- The handsets should work in European GSM cellular networks.[132]

It is not possible to reliably estimate how widely used certain interaction styles are, as this would require access to individual products' sales volumes, and the manufacturers do not usually disclose the sales volumes per individual products.

It must be noted that the analysis focuses solely on the *interaction styles* applied in the handsets — not on comparing the number or usability of individual applications or features of the products.

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[130] The analysis was done in mid-2002.

[131] An exception to this was the Microsoft Windows Powered Smartphone reference UI, that was initially evaluated based on a software UI emulator. The Orange SPV phone was evaluated later, when it became commercially available.

[132] European GSM compatibility was required to facilitate evaluation of the entire phone functionality. One analyzed handset, the Ericsson T60d, is a U.S. TDMA device. There are no commercial TDMA networks in Finland; however, the handset was chosen to the analysis as it incorporates a new interaction style in a Sony Ericsson product. Call handling was evaluated based on information in the user guide. The author could not find a mobile Internet browser from the phone although the user guide extremely briefly hinted that there should be one.

3.3.1 Mobile Phone Analysis Method

The mobile phone analysis reported in this thesis was conducted during the summer of 2002 as part of a larger, comparative usability study on contemporary mobile handsets. A team of Nokia usability experts selected the handsets for review and conducted the analysis.[133] The analysis consisted of two parts:

1. A usability analysis of representative tasks conducted on the products. This analysis looked at the usability problems and difficulties when executing the tasks.

2. An analysis of interaction style elements for the products.

The analysis part 1 was based on a representative set of test tasks that was devised based on earlier field research on feature usage, and some other studies conducted in different markets. The defined tasks were either high-frequency ones, or they were tasks that are often tried out in the early phase of the product ownership, but then not used any longer. These tasks might have high usage potential if the usability and other deficiencies could be improved. The task set is summarized in **Figure 68** below. The feature-specific findings of the analysis part 1 are outside the scope of this study.

Make a call from the phonebook. (Voice calls are the most common use of the phone in the field study.)
Save a number to the phonebook. (Save to SIM was in the top ten most widely used features in the field study.)
Send an SMS. (SMS send and receive were second only to voice calls in frequency and access in the field study.)
Receive an SMS. (Reasoning was the same as for Send SMS.)
Set alarm clock. (This task showed long-term continued use in field study.)
Set a meeting appointment. (Frequency of use decreased after users gained experience, possibly suggesting problems in the area.)
Find free meeting times next week. (The task tests how well the UI presents complex information to the user.)
Start the browser and use Google to check Helsinki weather. (Frequency of use decreased after users gained experience, so there may be usability or other problems in the browser.)

Figure 68. Task set in mobile phone usability analysis

The interaction style analysis part was conducted in parallel with the task analysis. In the interaction style analysis, following aspects and elements of the phone UI were analyzed:

[133] John Rieman was in charge of the evaluation project and defined the methodology, while Dana McKay and the author were assisting. An expert review was chosen as the method since there was not enough time to conduct large, empirical usability studies with a big-enough sample set of test users.

Phone UI element	Method or reasoning
Targeted user or product segment	Manufacturer's marketing communications information; is there correlation between UI solutions and user or product segment
UI platform	Manufacturer's marketing communications information; indicates whether the product UI belongs to a more widely used platform
Presentation style: display rows and fonts	Indicates the amount of information or content that can be shown on the display; indicates scalability issues
Presentation style: sounds	Indicates interaction style-related sound UI elements
Main menu	What is the menu presentation style, how is the menu accessed and navigated (interaction style)
Submenus	What is the submenu presentation style, how are the submenus accessed and navigated (interaction style)
Option lists[134]	What is the option list presentation style, how are the lists accessed and navigated (interaction style)
Select-Cancel	What are the control key mappings for Select and Cancel functionality
Global exit	Is there a mechanism to quickly and intuitively revert to the basic state of the UI
Navigation	What are the control key mappings to move back and forth among the UI elements
Softkeys	What is the applied softkey paradigm and key conventions, if any
Call management	What are the dedicated keys and UI conventions for call management
Other dedicated keys	What are the dedicated keys for volume control, mobile Internet browser access, voice commands, and other functionality
Help system	What kind of help system and conventions are incorporated in the handset
Personalizability	What presentation or interaction style modifications can be made by the user
Display	What is the display(s) resolution and color depth
Audio	What is the tone quality (monophonic or polyphonic) and is there speakerphone functionality
Keys and other input devices	What are the keys and other input devices in the phone

Figure 69. UI elements investigated in the interaction style analysis

Sections 3.3.2 to **3.3.7** present the detailed findings from the interaction style analysis.

[134] Many of the analyzed products included context-sensitive function lists; these are called 'option lists' in this study. Unlike option lists, the analyzed submenus were most often not context-sensitive.

3.3.2 Motorola

Three Motorola phone models available in the 2nd half of 2002 were selected to the interaction style analysis to represent the Motorola product and UI portfolio. The **Talkabout 192** is targeted at Motorola's 'Everyday communication' consumer segment: "*a fully featured, friendly phone for personal connectors who seek the peace of mind that comes from staying in touch with friends and family. … Talkabout 192 phone has an easy to use format.*"[135] The **V60** model contains "*… intuitive technology that's easy to use … combined with sophisticated design … a stylish reflection of your personality*"[136] and is targeted at Motorola's 'Personal style' segment. The interaction style of the V60 is utilized also in the V70 and V66 models (V66 has additional left and right navigation keys). The **Timeport 280** for business users in the 'Easy business' segment is "*the mobile phone that makes you more effective … brings you all the tools you need to manage a hectic schedule.*"[137]

The V60 is a dual display clamshell phone with the small external display being used for time display and incoming call indication while the phone is closed. This analysis will focus on interaction via the larger, internal display, as that is the main UI display in the handset.

All the analyzed phones include 'New Interface Software' defined on Motorola's Internet pages[138] as:

> "*A feature of Motorola mobile phones that lets you to navigate your phone's menus faster than ever. The new software reduces the time spent scrolling through menus, because it displays more feature options per screen. You'll get to spend more time using your phone's features and less time trying to locate them.*"

This 'New Interface Software' refers to the Synergy UI platform illustrated in **Figure 33**.[139]

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[135] Motorola. MOTOROLA TALKABOUT® 192 PHONE. [Cited 12-Oct-2004] Available from WWW: <http://www.motorola.com/mot/documents/0,1028,134,00.doc>.
[136] Motorola. MOTOROLA V60 PRODUCT INFORMATION. [Cited 06-Jul-2004] Available from WWW: <http://www.motorola.co.uk/>.
[137] Motorola. MOTOROLA TIMEPORT 280 PRODUCT INFORMATION. [Cited 06-Jul-2004] Available from WWW: <http://www.motorola.co.uk/>.
[138] Motorola. MOTOROLA TALKABOUT 192, V60, AND TIMEPORT 280 KEY FEATURES. [Cited 11-Jul-2002] Available from WWW: <http://www.motorola.co.uk>.
[139] Strictly speaking, the Synergy presentations in (Motorola 2002) do not include the interaction style applied in the Talkabout 192 phone. However, the interaction style analysis conducted by the author reveals a close resemblance between the two-softkeys-and-Menu interaction style used in the V60 and Timeport 280 models and the one-softkey interaction style in the Talkabout 192. The menu structure and ordering is also basically the same between the handsets, so at least from the end-user viewpoint we can conclude that the Talkabout 192 interaction style is a relatively close variant of the Synergy UI.

Phone model			Motorola Talkabout 192	Motorola V60	Motorola Timeport 280
					
Segment			Everyday communication	Personal style	Easy business
Product information			http://www.motorola.co.uk	http://www.motorola.co.uk	http://www.motorola.co.uk
UI platform/style			Synergy variant	Synergy	Synergy
Software UI platform	Presentation style	Display layouts: rows	Indicator row, 3 content rows, softkey label row	Indicator row, 3 or 2 content rows depending on the Zoom factor, softkey label row	Indicator row, 6 or 4 content rows depending on the Zoom factor, softkey label row
		Fonts	Idle number entry and incall right softkey label in large font, elsewhere in normal font	Huge, large, and normal bold for number entry in idle, everything else in normal font	Large font for number entry in idle. Everything else in normal or small font depending on Zoom factor.
		Sounds	-	Ascending and descending keypad tones for Send and End keys, respectively	Like V60
	Interaction style	Menu: key mapping	"MENU" key	"MENU" middle softkey	"M" middle softkey
		Menu: Main menu presentation	Circular menu. Name and animation shown for item in focus, previous and next items with icons only. No end-of-menu markers nor scrollbar.	A vertical list of two or three main menu items (depends on Zoom factor) with icons (no animations) visible at a time. No elevator in scrollbar.	Like V60 (four or six items visible)
		Menu: Main menu navigation	Vertical wrap-around, pressing MENU will scroll menu one step down. Up+Down duplicated in * (left) and # (right).	Vertical wrap-around (or non-wrapping)	Like V60
		Menu: Submenu presentation	End-of-menu markers, no elevator in scrollbar. Menu items longer than the display width auto-scroll horizontally after a timeout.	Like Talkabout 192	End-of-menu markers, no elevator in scrollbar
		Menu: Submenu navigation	Like main menu navigation	Like main menu navigation. * (left) and # (right) keys toggle between settings values on the bottom level of the menu.	Like main menu navigation. Left and right on the joystick toggle between settings values on the bottom level of the menu.
		Menu: Options list presentation	Like submenu presentation	Like submenu presentation	Like submenu presentation
		Menu: Options list navigation	Like main menu navigation	Like main menu navigation	Like main menu navigation
		Select: key mapping	Green OK key	Right softkey	Like V60
		Cancel: key mapping	Red C key	Left softkey	Like V60
		Cancel: functionality	Backsteps to the previous display	Backsteps to the previous display	Like V60
		Global exit (to idle): key mapping	Long press of C key	End key	Like V60
		Navigation: key mapping	Up+Down key, Left+Right overloaded to * and # keys	Like Talkabout 192	Up+Down+Left+Right in 4-way joystick. Left and Right duplicated to * and # keys, respectively.
		Softkeys	Usually no softkeys, except somewhat inconsistently working three softkeys in Browser settings and Browser: C sometimes no longer backsteps but does Global Exit, sometimes "Back" is in OK key. RSK OK label sometimes "OK?", sometimes "OK". Edit sometimes in MSK, sometimes in RSK.	LSK (Backward: Exit/Cancel/Back/Delete), MSK (MENU), RSK (Forward: Select/View/Change/Browse/OK)	Like V60
		Dedicated key mapping: Call management	Overloaded to Green OK and Red C	Send, End.	Like V60
		Dedicated key mapping: Volume control	Overload to Up+Down	Volume Up+Down	Like V60

		Dedicated key mapping: Browser	-	-	-
		Dedicated key mapping: Voice command	Overloaded to Green OK	Voice key	Like V60
		Dedicated key mapping: other	-	Smart key (user-configurable)	-
		Voice control functionality	Name dialing	Name dialing, voice commands	Like V60
		Help system	-	None; New Shortcut function displays a help text	Like V60
	Personalizability	Menu	-	Main menu items can be reordered. Wrap-around or non-wrapping scrolling for lists.	Like V60
		Softkeys in idle state	-	Any main menu item to left softkey and right softkey.	Like V60
		Shortcuts to features	Graphical user-configurable Quick Access Menu available via Menu-long from Idle	Any main menu item to Smart key; user-configurable shortcuts list in Main Menu	User-configurable shortcuts list in Main Menu.
		Layouts, fonts, graphics	According to product information on Motorola Internet there should be zoomable fonts (like V60?) but these were not found from the menu.	Content area Zoom In (large font, 2 rows) or Zoom out (normal font, 3 rows)	Content area Zoom In (large font, 4 rows) or Zoom out (normal font, 6 rows)
HW UI platform	I/O hw	Display resolution and colors	96x64, black and white	96x64, black and white	128x100, black and white
		Sounds and speaker	Monophonic tones, no speakerphone	Monophonic tones, no speakerphone	Monophonic tones, no speakerphone
	Mechanical & industrial design: keys and other input devices		Power, 123456789*0#, MENU, Green OK, Red C, Up+Down	Power, 123456789*0#, MENU, LSK, RSK, Up+Down, Send, End, Volume Up+Down, Smart, Voice	Power, 123456789*0#, MENU, LSK, RSK, 4-way joystick, Send, End, Volume Up+Down, Voice

Figure 70. Motorola mobile phone interaction styles

The Motorola V60 and Timeport 280 phones follow the same interaction style, with the exception of the slightly taller display and the four-way joystick in the Timeport 280 model. The four-way joystick, however, is under-utilized in all other applications than the mobile Internet browser, where it can be used to select links (right) and backstep (left). The user navigates through the vertically-oriented menu, makes selections with the right softkey, and returns to previous levels in the menu with the left softkey. The Menu (soft)key provides access to the main menu from the idle state and to a dynamic list of available options everywhere else. The End key is used as a 'panic button' taking the user back to the idle state. The Talkabout 192 interaction style is designed around a similar menu structure and other UI elements. However, the menu structure is presented to the user as a round menu — forward and backward navigation is still done with the up and down arrow keys — and instead of interacting with the displays via two labeled softkeys, the UI applies a question-and-OK dialog with the user: the system formulates the available function as a question (e.g. "Select?") and the user accepts the function with the OK key or rejects it with the C key. The user can modify the order of main menu applications, and also the softkey shortcuts in the idle state of the V60 and Timeport 280 models. A graphical user-configurable main menu is available to the user via a long press of the MENU key in the Talkabout 192 phone.

In this study we do not directly assess the usability of the (Motorola) interaction styles nor the usability of the phones' features. The interaction style analysis conducted by the author reveals a consistent, professionally-designed interaction style in the V60 and Timeport 280 phones. The interaction style in the Talkabout 192 model suffers from design compromises obviously being made between the simple look of the device and the more complex interaction of the UI platform: the phone is designed to work with one softkey only (the OK key) but on several

displays the Menu and C keys are labeled as softkeys and the mapping of functions to softkeys is not consistent across the UI.

3.3.3 Nokia

Four Nokia phone models available in the second half of 2002 were selected to the interaction style analysis. The *expression*-category **Nokia 3330** is *"a highly appealing, yet affordable WAP phone to the broader audience."*[140] The 3330 phone incorporates Nokia's Navi-key user interface that is also used in the contemporary Nokia 3310, 3315, 3390, 3395, and 5510 phones. The **6610** model belongs to the *classic* phone category and is targeted at mobile professionals *"to help them balance their personal and work lives. … 6610 phone provides compact usability with a powerful set of technology features, including a high-quality color display, Java™ technology for downloadable applications and MMS (Multimedia Messaging Service)."*[141] Variants of the Series 40 user interface used in the 6610 phone are used e.g. in the 3285, 3350, 3360, 3410, 3510, 3610, 5210, 6210, 6250, 6310, 6340, 6360, 6370, 6500, 6510, 7210, 8210, 8250, 8260, 8265, 8270, 8290, 8310, 8390, 8850, 8860, 8855, 8890, and 8910 phones, and 9210 and 9290 communicators. The **Nokia 6650** is the first 3G W-CDMA mobile phone from Nokia, incorporating the new **Three-softkey** interaction style. The **Nokia 7650** belonging to the *imaging* category combines digital camera and multimedia messaging functionality, and is *"ideally suited for people who want to capture and share moments spontaneously. Advanced business features also make it a value-adding tool for the work environment. … The advanced graphical user interface and joystick with 5-way navigation add ease and speed to the use of this new device."*[142]

Phone model			Nokia 3330	Nokia 6610	Nokia 6650	Nokia 7650
						
Segment			Expression	Classic	Imaging	Imaging
Product information			http://www.nokia.com/phones/3330	http://www.nokia.com/phones/6610	http://www.nokia.com/phones/6650/	http://www.nokia.com/phones/7650
UI platform/style			Navi-key	Two-softkey Series 40	Three-softkey Series 40	Series 60
Software UI platform	Presentation style	Display layouts: rows	Indicator row, 3 content rows, softkey label row	Indicator/header row, 5-8 content rows depending on font size in message editor, softkey label row	Indicator/header row, 6-10 content rows depending on font size in message editor, softkey label row	Header area, 6-8 content rows, softkey label row
		Fonts	Large and normal font for phonebook scrolling and number entry from idle, main menu items in large, everything else in normal font	Normal and small in message editor; number entry in idle with large, elsewhere normal	Normal and small in message editor; number entry in idle with large, elsewhere normal	Large and normal in number entry in idle, elsewhere normal

[140] Nokia. PRESS RELEASE. 21-Mar-2001. [Cited 06-Jul-2004] Available from WWW: <http://press.nokia.com/PR/200103/813139_5.html>.
[141] Nokia. PRESS RELEASE. 17-Jun-2002. [Cited 06-Jul-2004] Available from WWW: <http://press.nokia.com/PR/200206/863478_5.html>.
[142] Nokia. PRESS RELEASE. 19-Nov-2001. [Cited 06-Jul-2004] Available from WWW: <http://press.nokia.com/PR/200111/840889_5.html>.

		Sounds	-	-	-	-
	Interaction style	Menu: key mapping	MSK "Menu/Options"	LSK "Menu/Options"	MSK "Menu", LSK "Options"	Menu key
		Menu: Main menu presentation	Full-screen main menu items: animation and item name. Vertical scrollbar, no end-of-menu markers.	Full-screen main menu items: icon and item name. Vertical scrollbar. No end-of-menu markers.	Vertical list of item icon + name combinations. No end-of-menu markers. Vertical scrollbar.	Application icon grid of 3x3 icons with textual labels. Small up/down indicators tell if part of the application grid is above or below the visible area.
		Menu: Main menu navigation	Vertical wrap-around	Vertical wrap-around	Vertical wrap-around	2-D navigation with joystick, joystick press launches application
		Menu: Submenu presentation	Vertical list of items. Vertical scrollbar.	Vertical list of items. Vertical scrollbar.	Vertical list of items. Vertical scrollbar.	Some submenus are vertical lists of item's icon and name; some submenus apply the 3x3 icon grid layout. Some vertical lists group items under horizontal tabs
		Menu: Submenu navigation	Vertical wrap-around	Vertical wrap-around	Vertical wrap-around	Non-wrapping. Tab navigation with joystick left and right (non wrapping).
		Menu: Options list presentation	Like main menu presentation	Like main menu presentation	Like submenu presentation	Vertical textual list of items. Small arrow indicator tells a sub options list is available.
		Menu: Options list navigation	Vertical wrap-around	Vertical wrap-around	Vertical wrap-around	Vertical non- wrapping. Joystick right, press or "Select" LSK will show a pop-up sub-options list when a small arrow indicator tells one is available.
		Select: key mapping	Middle softkey	Left softkey	Middle softkey in the middle of the 4/5-way rocker key	Joystick press. In Options lists also LSK.
		Cancel: key mapping	C key	Right softkey	Right softkey	RSK "Back/Exit"
		Cancel: functionality	Backsteps to the previous display, backspaces, ends call	Backsteps to the previous display, backspaces	Backsteps to the previous display, backspaces	Backsteps to the previous display. When the previous display is idle or main menu, RSK shows "Exit", otherwise "Back".
		Global exit (to idle): key mapping	Long press of C key	End key	End key	End key
		Navigation: key mapping	Up+Down keys	4-way rocker key	4-way rocker key	Joystick, joystick press does selection
		Softkeys	MSK: Menu/Options/-Select/OK	LSK (Forward: Menu/-Options/Select/Details/OK/...), RSK (Backward: Exit/Back/Cancel)	LSK (Options), MSK (Menu/Forward: Select/...), RSK (Backward: Exit/-Back/Cancel)	LSK (Forward: Options/Select), RSK (Backward: Exit/Back/Cancel)
		Dedicated key mapping: Call management	-	Send, End keys	Send, End keys	Send, End keys
		Dedicated key mapping: Volume control	Overloaded to Up+Down	Volume Up+Down	Volume Up+Down	Overload to joystick left and right during a call
		Dedicated key mapping: Browser	-	-	-	-
		Dedicated key mapping: Voice command	-	-	Voice key	Voice key
		Dedicated key mapping: other	-	-	-	-
		Voice control functionality	Name dialing	-	Name dialing	Name dialing
		Help system	-	Context-sensitive help shown after some idle time in the menu	Context-sensitive help shown after some idle time in the menu	-
	Personalizability	Menu	-	-	-	Menu items can be rearranged
		Softkeys in idle state	-	-	?	Left softkey, right softkey
		Shortcuts to features	-	-	"Go to" shortcuts menu	"Favorites" shortcuts menu

		Layouts, fonts, graphics	Large (1 name) or normal font (1 name+number or 3 names) in phonebook view	Message editor normal (5 rows) or small (8 rows) font	Message editor normal (6 rows) or small (9 rows) font	Grid menu views also as list views. Blue, Green, and Purple color palettes. Browser has Large and Normal font.
HW UI platform	I/O hw	Display resolution and colors	84x48, black and white	128x128, 4096 colors	128x160, 4096 colors	176x208, 4096 colors
		Sounds and speaker	Monophonic tones, no speakerphone	Polyphonic tones, speakerphone & FM radio	Polyphonic tones, speakerphone	Monophonic tones, digital audio files, speakerphone
	Mechanical & industrial design: keys and other input devices		Power, 123456789*0#, MSK, Cancel, Up+Down	Power, 123456789*0#, LSK, RSK, 4-way rocker, Send, End, Volume Up+Down	Power, 123456789*0#, LSK, RSK, 4-way+MSK rocker, Send, End, Volume Up+Down, Voice	Power, 123456789*0#, LSK, RSK, 5-way joystick, Send, End, ABC, Backspace, Menu, Voice

Figure 71. Nokia mobile phone interaction styles

All four contemporary Nokia interaction styles presented above are based on softkey interaction. The Series 40 UI in the 6610 model is a variant of the *two-softkey* interaction style family that is a descendant of Nokia's first softkey UI — the 2110 UI originally introduced in 1994 (Kiljander & Järnström 2003). The user navigates the menu structure with the 4-way rocker key (in some variants there are four separate keys, or up and down keys only), selects items with the left softkey, and moves back in the menu structure with the right softkey. Phone calls are initiated and terminated with the Send and End keys. The *Navi-key* interaction style in the Nokia 3330 model is a more distant variant of the original Two-softkey UI: the display layouts were almost identical in the phones with the same resolution display modules, and the two softkeys in the Two-softkey UI are mapped to one softkey (the Navi-key) and a dedicated C key in the Navi-key UI. The dedicated call-handling Send and End keys were omitted from the Navi-key interaction style in order to simplify the perceived usability of the handsets, and to differentiate the Navi-key phones from other phones.

The *Three-softkey* interaction style in the 6650 model is based on the Navi-roller interaction style introduced in the 7100 series phones. It follows the basic interaction style of the two-softkey UI family with the addition of a separate Select softkey — the middle press of the 4/5-way rocker key — to shorten the key press sequences by promoting the main function in each state to the user via a visible, labeled softkey. The *Series 60* interaction style in the 7650 model resembles the Three-softkey interaction style — Options-Back softkeys and the Select function in the joystick press — but the presentation style in the phone running the Symbian operating system is more graphical due to the larger, high-resolution color display. Together with the Microsoft Smartphone, the 7650 is the only analyzed phone with multitasking applications: the user can freely switch between applications and leave them 'open' in the background. This gives more flexibility to the user — one can be typing a text message or an email and quickly jump into the calendar application to check a meeting time, and then return to the messaging application to continue with the message — but it may also confuse users as they e.g. may have quit an application by pressing the 'panic' button (the End key) so the application has remained 'open' and when they later select the application from the main menu, they end up in the state they were when they left the application.

3.3.4 Samsung

Samsung N620 and T100 mobile phones were selected to the analysis from the Korean manufacturer. Samsung does not disclose the targeted user segments in the sales package, marketing materials, or on the Internet. Instead, the new

technologies introduced with the phones are being used as the main selling arguments:

- **Samsung N620**: *"The first phone in the market to support 16 poly ringtone"*[143]

- **Samsung T100**: *"The first GSM mobile phone to be built with a TFT color display. … users can also enjoy 16-poly ring tone melodies to express their unique individuality."*[144]

The folding-type T100 phone has two displays. The small, external display on the front cover shows time, date, signal and battery level, and also the caller ID. This analysis focuses on the larger, internal display, since that is the main display of the handset.

Phone model			Samsung N620	Samsung T100
				
Segment			?	?
Product information			http://www.samsungelectronics.com/mobile_phone/wireless_terminals/gsm/sgh_n620_features.html	http://www.samsungelectronics.com/mobile_phone/wireless_terminals/gsm/sgh_t100_features.html
UI platform/style			?	?
Software UI platform	Presentation style	Display layouts: rows, etc.	Header row, 3 content rows, softkey label row. Iconic Back and Backspace softkey labels.	6 content rows, softkey label row
		Fonts	Large, normal and small fonts in number entry in idle; normal font elsewhere.	Very large and large fonts in number entry in idle; normal font elsewhere.
		Sounds	-	-
	Interaction style	Menu: key mapping	Left softkey is "Menu/Options"	Like N620
		Menu: Main menu presentation	Full-screen main menu items with animations. No scrollbar but main menu indicator visible.	Menu top level arranged horizontally as 8 tabs.
		Menu: Main menu navigation	Vertical wrap-around, number shortcuts	Horizontal wrap-around
		Menu: Submenu presentation	Full-screen menu items with number shortcuts. No scrollbar.	Vertical, no scrollbar, nor end-of-menu markers but inversion bar jumps to the top or the bottom when menu wraps. Menu items longer than the display width auto-scroll horizontally.
		Menu: Submenu navigation	Like menus.	Like N620
		Menu: Options list presentation	Three list items shown per display. No scrollbar nor end-of-menu marker but item numbers shown.	Like submenus
		Menu: Options list navigation	Like submenus.	Like submenus
		Select: key mapping	Left softkey. Select function duplicated to Send key.	Left softkey
		Cancel: key mapping	Right (iconic) softkey, Browser/C key.	C key, often also right softkey (also backspace duplicated to C key and RSK). Only End key backsteps from text entry states.

[143] Samsung. PRODUCT INFORMATION. [Cited 11-Jul-2002] Available from WWW: <http://www.samsungelectronics.com.my/mobile_phone/sgh_n620_features.html>.
[144] Samsung. PRODUCT INFORMATION. [Cited 11-Jul-2002] Available from WWW: <http://www.samsungelectronics.com.my/mobile_phone/sgh_t100_features.html>.

		Cancel: functionality	Right softkey backsteps to the previous display when Back icon is shown. Function duplicated in the Browser/C key.	Backsteps to the previous display.
		Global exit (to idle): key mapping	End key exits to idle except when Browser/C key does backspace; then End key backsteps to previous display.	Sometimes End does global exit, sometimes it backsteps. Sometimes C does global exit, sometimes it backsteps.
		Navigation: key mapping	Up+Down keys	Up+Down+Left+Right keys
		Softkeys	LSK (Forward: Select/Options/View/OK/Find), RSK (Backward: Cancel/Backspace; Input mode toggle)	LSK (Forward: Select/View/OK/Find), RSK (Backward: Cancel; Input mode toggle)
		Dedicated key mapping: Call management	Send, End	Send, End
		Dedicated key mapping: Volume control	Volume Up+Down	Volume Up+Down
		Dedicated key mapping: Browser	Browser/C key	Browser key
		Dedicated key mapping: Voice command	-	-
		Dedicated key mapping: other	-	-
		Voice control functionality	Name dialing, voice commands	Name dialing, voice commands
		Help system	-	-
	Personaliza-bility	Menu	-	-
		Softkeys in idle state	-	-
		Shortcuts to features	-	-
		Layouts, fonts, graphics	-	-
HW UI platform	I/O hw	Display resolution and colors	128x64, 4 grayscales	128x160, 4096 colors
		Sounds and speaker	Polyphonic tones, no speakerphone	Polyphonic tones, no speakerphone
	Mechanical & industrial design: keys and other input devices		123456789*0#, LSK, RSK, Up+Down, Browser/C, Send, End/Power, Volume Up+Down	123456789*0#, LSK, RSK, 4-way rocker, C, Send, End/Power, Volume Up+Down, Browser

Figure 72. Samsung mobile phone interaction styles

Both the N620 and T100 share the same basic interaction style. The T100 adds a larger color display, left and right navigation keys, and separate C and Browser keys, but the basic interaction conventions remain the same. The menu follows a conventional tree structure, and in the T100 model the main menu is visualized as horizontal tabs that the user can scroll with the left and right navigation keys. Submenus, option lists, and in the N620 also the main menu, are scrolled with the up and down keys. The left softkey performs selection and the right softkey performs backstepping. When the right softkey is used for other functions — text input mode toggle, or backspacing — the End key performs backstepping. Otherwise, the End key is used to jump back to the idle state.

The Samsung interaction style is relatively close to Nokia's Two-softkey style: Samsung has added a separate C key that is explicitly needed only in text entry situations. From the feature point-of-view, the menu structure in the Samsung N620 model quite closely resembles e.g. the Nokia 6310 menu structure regarding applications and their ordering. The N620 sales package advertises "Nokia compatible" ringtones, logos, and picture messaging. The industrial design and key placement resemble more European phones than Korean ones, so Samsung rightfully states "European style look" in the N620 marketing material.[143]

No feature shortcuts, menu or layout personalizability is provided by these two Samsung phones.

3.3.5 Siemens

The MT50 and S45 mobile phones from Siemens were selected to the analysis. The **MT50** is an operator variant of the M50 phone — "*a distinctive mobile phone with a clear focus on design and entertainment … for popular people with an active social life*."[145] The **S45** is "*an innovative mobile business tool with high-speed data transfer, flexible speech and data memory, and integrated hands-free facility*."[146] The MT50 and M50 share their interaction style with the CL50, C45, S35i, M35, and C35i models. The interaction style of the S45 phone is used also in the SL45, SL42, S45i, and ME45 models. These two interaction styles cover the contemporary product portfolio of Siemens. The A segment phones (e.g. the A35, A36, and A40) targeted at first-time buyers used to have a simplified user interface and a restricted set of features. However, the newest phone in the A segment, the A50 model ("*a modern mobile phone focused on uncomplicated communication*"[147]), shares the interaction style with the MT50 so there are basically two interaction styles in the Siemens product portfolio. Variants of these styles obviously exist, such as the UI in the new C55 phone: the shortcut key to access the phonebook has been removed.

Phone model			Siemens MT50	Siemens S45
				
Segment			Youth	Business
Product information			http://www.my-siemens.com	http://www.my-siemens.com
UI platform/style			?	?
Software UI platform	Presentation style	Display layouts: rows	3-4 content rows, one row for softkey labels.	Like MT50 with the addition of a header row.
		Fonts	Large, normal	Like MT50
		Sounds	-	-
	Interaction style	Menu: key mapping	RSK "Menu/Options". "Options" is in LSK when RSK contains "Select".	Like MT50
		Menu: Main menu presentation	The menu item in focus stays on the middle row, is presented with bold font, and shows animation. The other items have no graphics. Vertical scrollbar.	Like MT50
		Menu: Main menu navigation	Vertical wrap-around	Like MT50 with the addition of the Left key performing Cancel and the Right key performing Select.
		Menu: Submenu presentation	Vertical submenus have end-of-menu markers. In some lists (e.g. SMS templates) items longer than the display width auto-scroll horizontally after a timeout.	Like MT50
		Menu: Submenu navigation	Vertical wrap-around. The individual (toggle-type) settings at the bottom of the menu tree are editable without selecting the setting: you just press RSK to change the value.	Like MT50 with the addition of the Left key performing Cancel and the Right key performing Select and changing the value of a (toggle-type) setting.

[145] Siemens. PRESS RELEASE. 12-Mar-2002. [Cited 07-Jul-2002] Available from WWW: <http://www.siemens.dk/siemens/presse/02-03-12-m50-e.html>.
[146] Siemens. PRESS RELEASE. 21-Mar-2001. [Cited 07-Jul-2002] Available from WWW: <http://www.siemens.com>.
[147] Siemens. PRESS RELEASE. 17-Jun-2002. [Cited 07-Jul-2002] Available from WWW: <http://www.siemens.com>.

		Menu: Options list presentation	Context-sensitive options lists have end-of-menu markers and are shown in a small pop-up box floating on top of the parent display state	Like MT50
		Menu: Options list navigation	Like submenus	Like submenus
		Select: key mapping	RSK "Select/Set/OK". LSK has primary function (e.g. "Activate") when RSK has "Options"	Like MT50 with the addition of the Right key performing Select.
		Cancel: key mapping	End	Like MT50
		Cancel: functionality	Backsteps to the previous display	Like MT50
		Global exit (to idle): key mapping	Long press of End key	Like MT50
		Navigation: key mapping	Up+Down key	Up+Down+Left+Right key
		Softkeys	LSK (empty/function), RSK (Menu/Options/Select)	Like MT50
		Dedicated key mapping: Call management	Send, End	Like MT50
		Dedicated key mapping: Volume control	Overloaded to Up+Down keys	Volume Up+Down. Volume Up+Down controls profiles in idle mode.
		Dedicated key mapping: Browser	-	-
		Dedicated key mapping: Voice command	-	-
		Dedicated key mapping: other	Phonebook	Dictaphone
		Voice control functionality	-	Name dialing
		Help system	Help submenu in Main Menu contains short instructions for key features. In text editing LSK contains "T9 info".	Like MT50
	Personalizability	Menu	"My menu" in Main Menu can contain any feature from a pre-defined list.	"My menu" works like in MT50 but is called "Favourites" in S45.
		Softkeys in idle state	Left softkey is user-configurable "Fast key".	Like MT50
		Shortcuts to features	Left softkey in idle and the number keys (a.k.a. "Magic buttons") can be configured to launch any application.	Like MT50
		Layouts, fonts, graphics	Large and normal font for almost the whole UI – some low-level options lists only have the normal font.	Like MT50. Long press of # key in browser zooms view in and out.
HW UI platform	I/O hw	Display resolution and colors	101x64, black and white	101x80, black and white
		Sounds and speaker	Monophonic tones, no speakerphone	Monophonic tones, speakerphone
	Mechanical & industrial design: keys and other input devices		123456789*0#, LSK, RSK, Up+Down, Send, End/Power, Phonebook	123456789*0#, LSK, RSK, 4-way rocker, Send, End/Power, Volume Up+Down, Dictaphone

Figure 73. Siemens mobile phone interaction styles

The evaluated MT50 and S45 phones share the same scalable Siemens UI platform. Both the presentation style and the interaction style have been upgraded from the MT50 to the S45. The S45 presentation style adds the header row to the display, as the display is 16 pixels taller. The interaction style of the MT50 contains a vertically navigated menu structure, backstepping function in the End key, and two softkeys with any state-specific function mapped to the left softkey, and Menu/Options/Select function mapped to the right softkey. Call handling is done via the dedicated Send and End keys. The S45 amends this interaction style by adding the Left and Right keys to the navigation device and utilizing these in menu navigation: the menu is now navigable in full two dimensions as the user can move deeper in the menu structure with the Right key and backstep to the previous (higher) level with the Left key. Other than that, the interaction styles are the same, like Siemens' Volland (2000) describes: "*two display sizes – one look & feel.*"

3.3.6 Sony Ericsson

Four contemporary Sony Ericsson phones branded as Ericsson, Sony, and Sony Ericsson were selected to the analysis in mid-2002. The **Ericsson T65** incorporates a Yes–No dialog user interface that Ericsson has been using in its phones for several years. The T65 is "*a powerful WAP phone with a*

contemporary design built to offer young people a fast and easy connection with the Mobile Internet."[148] The **T68i** with a color display was the first multimedia message (MMS) sending and receiving capable phone in the market with a focus on imaging, as pictures can be taken with the accessory digital camera, stored in the phone's photo album, uploaded onto the Internet, or sent as multimedia messages to other MMS phones.[149] The TDMA phone **T60d** is the only non-GSM handset evaluated in this study. The model was chosen for evaluation as it incorporates the first softkey-based interaction style in an Ericsson mobile phone. The T60d is aimed at "*people with active lifestyles looking for a full-featured phone that is easy to operate.*"[150] The **Sony CMD-Z7** represents Sony design and engineering from the pre Sony Ericsson period, and is targeted at the fashion-oriented consumers and business people alike, as "*it hides a powerful personal management tool with new features behind its cutting-edge appearance.*"[151]. It is the only phone in the analysis incorporating an input device other than the conventional keys or the micro-joysticks that have become common during the last couple of years: the 'Sony 5D Advanced Jog Dial'.

Phone model			Ericsson T65	Sony Ericsson T68i	Ericsson T60d	Sony CMD-Z7
						
Segment			Young people	Imaging	People with active lifestyles	Fashion-oriented consumers / business people
Product information			http://www.sonyericsson.com/uk/	http://www.sonyericsson.com/uk/	http://www.sonyericsson.com/us/	http://www.sonyericsson.com/uk/
UI platform/style			?	?	?	?
Software UI platform	Presentation style	Display layouts: rows	Header row + 3/4/5 content rows depending on font size	Header row + 4/5/7 content rows depending on font size	Like T65 with the addition of softkey label row	Header row, 4-5 rows of content
		Fonts	Small and Large on number entry. Elsewhere Small, Medium, Large.	Small, Medium, Large	Like T68i	Normal font
		Sounds	-	-	-	Audio and vibra error tones (e.g. when text input field is full)
	Interaction style	Menu: key mapping	Left/Right show main menu from idle state, Internet shows book-marks list, C-long shows Standby menu. In phonebook/message list/picture list/browser etc.: Internet shows context-sensitive list of available functions.	Left/Right/joystick press show main menu from idle state, C-long shows Standby menu. Options key shows a context-sensitive options list throughout the UI.	Pressing the right softkey ("Menu") or moving the joystick to the left or right shows main menu from idle state, CLR-long shows Standby menu. Options key shows a context-sensitive options list throughout the UI.	Jog Dial press presents the main menu from idle. Context-sensitive option lists (a.k.a. 'pop-up menus') are accessed via Jog Dial push.

[148] Ericsson. PRESS RELEASE. 04-Sep-2001. [Cited 11-Jul-2002] Available from WWW: <http://www.ericsson.com/press/20010904-0932.html>.
[149] Sony Ericsson. PRESS RELEASE. 05-Mar-2002. [Cited 2002 July 11] Available from WWW: <http://www.sonyericsson.com/>.
[150] Ericsson. PRESS RELEASE. 04-Sep-2001. [Cited 07-Jul-2002] Available from WWW: <http://www.ericsson.com/press/20010904-0910.html>.
[151] Sony. PRESS RELEASE. 10-Sep-2001. [Cited 11-Jul-2002]. Available from WWW: <http://www.sonyericsson.com/>.

		Menu: Main menu presentation	7 main menu items arranged horizontally as tabs. Active tab shows an animation.	9 iconic main menu items arranged in 3x3 grid. Header row shows the name of the item in focus.	Like T65	10 main menu items arranged in a horizontally rotating, animated 3-D circle of spheres. Header row shows the name of the item in focus. Number shortcuts (not shown).
		Menu: Main menu navigation	Horizontal wrap-around — wraps through idle. Number shortcuts.	2-D grid navigation. Numeric shortcuts (numbers not visible on the grid display, though).	Like T65	Horizontal wrap around by rotating the Jog Dial up or down. Also Jog Dial push rotates the spheres to the next menu item. Jog Dial press selects a main menu item and zooms into the submenu.
		Menu: Submenu presentation	Vertical list with end-of-menu marker. Small blinking arrows indicate menu items outside visible area. No scrollbar. Inactive items shown in gray.	Like T65. Some lists (e.g. Inbox) auto-scroll items longer than the display width.	Like T65	Vertical list with end-of-menu marker (that is also a backstep function when selected from the submenu). Vertical scrollbar with a hard-to-notice elevator. Small up/down arrows indicate menu items outside visible area. Inactive items shown in gray.
		Menu: Submenu navigation	Vertical no wrapping. Number shortcuts. Pressing Up on the 1st item will backstep to previous menu level.	Vertical wrap-around. Number shortcuts.	Like T65	Vertical no wrapping. Some submenus mixed with content: e.g. Phonebook menu in phonebook name list
		Menu: Options list presentation	Like submenu presenta-tion. Sometimes the options list is presented as a pop-up dialog, sometimes it occupies the whole display area. Sometimes the options list is accessed via the Internet key; sometimes "Options" is an item in a menu.	Like T65. The 'Internet' key in T65 is a general-purpose Options key in T68i.	Like T68i	Like submenu presentation
		Menu: Options list navigation	Vertical no wrapping. Number shortcuts.	Like submenu navigation	Like submenu navigation	Like submenu navigation
		Select: key mapping	Yes/Send	Yes/Send	Left softkey "Select". The function is duplicated to joystick press.	Jog Dial press
		Cancel: key mapping	No/End	No/End	Right softkey "Back/Exit"	Jog Dial pull, or C key
		Cancel: functionality	Backsteps to previous menu level or answers 'no' to a dialog.	Like T65	Backsteps to previous menu level	Backsteps to previous menu level
		Global exit (to idle): key mapping	Long press of No/End	Like T65	Long press of the right softkey	End key, or flip close
		Navigation: key mapping	4-way rocker	5-way joystick; joystick press duplicates the Yes/Send key function	Like T68i	5-D Jog Dial: scroll up, scroll down, pull, push, press
		Softkeys	-	-	LSK (Forward: Select/-Edit/OK/Yes), RSK (Back-ward: Back/Exit/No/-Cancel)	-
		Dedicated key mapping: Call management	Yes/Send, No/End	Yes/Send, No/End	-	-
		Dedicated key mapping: Volume control	Volume Up+Down	Volume Up+Down	Volume Up+Down	Jog dial scroll up+down
		Dedicated key mapping: Browser	Internet	-	-	-
		Dedicated key mapping: Voice command	Overloaded to Yes/Send	Like T65	Overloaded to volume Up+Down keys	Overloaded to Jog Dial press
		Dedicated key mapping: other	-	-	-	Voice memo
		Voice control functionality	Name dialing, voice commands	Name dialing, voice commands	Name dialing, voice commands	Name dialing

		Help system	Context-sensitive help in the menu with a pop-up dialog after a timeout. The user can switch help off.	Like T65. Help also sometimes available as the last item in option lists.	Like T65	Whenever a phone state has a context-sensitive options list, a help text "Menu" is shown on the bottom row after a timeout if there is no user input
	Personalizability	Menu	-	-	-	-
		Softkeys in idle state	-	-	-	-
		Shortcuts to features	Features and URLs can be added to My Shortcuts list in Main Menu	Like T65	Like T65	-
		Layouts, fonts, graphics	Small, Medium, Large font	Like T65	Like T65	-
HW UI platform	I/O hw	Display resolution and colors	101x67, 4 grayscales	101x80, 256 colors	101x80, black and white	96x92, 4 grayscales
		Sounds and speaker	Monophonic tones, no handsfree speaker	Monophonic tones, no handsfree speaker	Monophonic tones, no handsfree speaker	Polyphonic tones, handsfree speaker
	Mechanical & industrial design: keys and other input devices		123456789*0#, Yes/-Send, No/End/Power, 4-way rocker, C, Volume Up+Down, Internet	123456789*0#, Yes/-Send, No/End/Power, 5-way joystick, C, Volume Up+Down, Options	123456789*0#, LSK, RSK, 5-way joystick, CLR, Volume Up+Down, Options, Power	123456789*0#, Send, End/Power, MEMO, C, Jog dial (rotate up+down, pull, push, press)

Figure 74. Sony Ericsson mobile phone interaction styles

The Ericsson T65, T60d, and Sony Ericsson T68i all incorporate variants of Ericsson's classic Yes–No dialog user interface. The T65 is the entry-level variant of the interaction style. The user scrolls through the horizontally arranged main menu with left and right keys, and navigates the vertically arranged submenus and option lists with the up and down keys. Menu items are selected with the Yes key, backstepping is done with the No key, and the Internet/Options key occasionally contains a list of context-sensitive functions. The CLR key is used in text entry backspacing. The T68i and T60d evolve the interaction style in different directions. The T68i replaces the four-way rocker key of the T65 with a five-way joystick; the joystick press simply duplicates the functionality of the Yes key. The color display is slightly taller than in T65 so the main menu is represented as 3 × 3 grid of application icons. The T60d is a phone for the Americas' TDMA markets. The display resolution is the same with the T68i but instead of using the additional pixels to display one more content row, Ericsson has opted for a very Motorola/Nokia/Siemens/Samsung-like Select–Back softkey interaction style. The softkeys basically just label the old Yes–No keys with descriptive labels so the user interface logic is not fundamentally different from the Yes–No dialog UI. The two–softkey UI is now used in several new Sony Ericsson phones for the Americas: T61z, T61g, T62u, and T206[152]. The Z1010, Sony Ericsson's first W–CDMA phone, and the T600 series phones introduced in 2003, have a softkey-based user interface. New phone models in the Sony Ericsson product portfolio increasingly apply the softkey interaction style over the older Yes–No UI.

The Sony CMD-Z7 stands out from the other analyzed phones. Instead of navigating the user interface with up and down arrow keys, a four-way rocker key, or a micro joystick, the user moves back and forth in the menus and applications with a rotating wheel device — the 'Sony 5D Advanced Jog Dial' — that can be scrolled up and down, pulled upwards, pushed downwards, and

[152] "*Designed to be easy and fun to use, the T206 … is navigated with a four-way navigation button and soft keys.*" In: Sony Ericsson press release. 05-Mar-2002. [Cited 14-Jul-2002] Available from WWW: <http://www.sonyericsson.com/>.

pressed inwards. The main menu is illustrated as an animated three-dimensionally rendered horizontal circle of spheres each containing a menu item. Submenus and context-sensitive option lists are shown more conventionally as textual lists. The user selects menu items and display elements by pressing the Jog Dial and backsteps by pulling the Jog Dial upwards. The phone UI is quite ergonomically controlled with the Jog Dial device — although users with disabilities are likely to face difficulties as holding the device and scrolling or pressing the wheel in different directions requires well-coordinated senso-motoric skills. Jog Dial's future as a mobile phone control device may be difficult to estimate; the dominant design in handset control devices is currently a four-way navigation device — a rocker key, or a micro joystick — since many increasingly popular applications require two-dimensional movement: games, text and multimedia content editing, or even navigating in calendar views.

3.3.7 Microsoft Smartphone

The interaction style analysis in this study covers also Microsoft's Windows Powered Smartphone user interface for smart phones. Microsoft does not make cellular mobile telephones but dominates the PC operating system market with the Windows product family. Microsoft's Pocket PC operating system is gaining popularity among PDA manufacturers and consumers, and Microsoft is trying to duplicate this success in the highly lucrative, high-volume mobile phone market:

> *"One of the most important competitive battlegrounds for our platform as we face the next five or 10 years is the embedded space. There's a new world emerging of smart devices. That is the future of computing."* (Steve Ballmer, President and CEO of Microsoft, in Ricadela 2001).

The Windows Powered Smartphone operating system and user interface platform was announced in 2001:

> *"Stinger is designed to be a great phone, but what makes it a true smart phone is its ability to keep people connected to a plethora of personal and business information, single-handedly. Microsoft brings its expertise in software to smart phones by developing a core experience that includes the following: An intuitive interface designed for one-handed operation, which means users are never more than a few clicks away from the information they want …"*[153, 154]

The interaction style analysis conducted in this study focuses solely on the Smartphone user interface platform, and not on the Microsoft Pocket PC or Handheld PC platforms for PDA devices. These platforms are designed around a larger display, direct manipulation with a touchscreen, and an application set familiar from the desktop Windows environment. These user interfaces lie outside the scope of this research work.

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[153] The Microsoft Windows Powered Smartphone user interface platform is also known with the name "Stinger".

[154] Microsoft. MICROSOFT'S SMART PHONE UNLOCKS POTENTIAL OF 2.5G AND 3G WIRELESS NETWORKS. 19-Feb-2001. [Cited 06-Jul-2004] Available from WWW: <http://www.microsoft.com/presspass/press/2001/Feb01/02-19StingerHardwarePR.asp>.

Figure 75 below will illustrate the interaction style of the Smartphone. The sample phone is the Orange SPV[155].

Phone model			Orange SPV
			
Segment			Anyone who uses both a mobile phone and some sort of system to organize their personal information - Outlook, electronic organizer or PDA.[156]
Product information			http://www.microsoft.com/mobile/smartphone/default.asp
UI platform/style			Microsoft Windows Powered Smartphone
Software UI platform	Presentation style	Display layouts: rows	Header/indicator row, 9 content rows (depends on font size), softkey label row
		Fonts	Normal, Large
		Sounds	-
	Interaction style	Menu: key mapping	Left softkey ("Programs") from idle state shows program list. Right softkey often contains context-sensitive menu ("Menu").
		Menu: Main menu presentation	Vertical list of program icon and program name combinations. No scrollbar.
		Menu: Main menu navigation	Vertical wrap-around, number shortcuts
		Menu: Submenu presentation	Like main menu
		Menu: Submenu navigation	Like main menu
		Menu: Options list presentation	Pop-up function list.
		Menu: Options list navigation	Vertical wrap-around.
		Select: key mapping	Joystick press
		Cancel: key mapping	Back key
		Cancel: functionality	Return to previously visited display. Microsoft says: "Like on a browser."
		Global exit (to idle): key mapping	Home key
		Navigation: key mapping	5-way joystick (up+down+left+right and press-to-select)
		Softkeys	LSK (Forward: Programs/Home/Accept/Send/Hold/Reply/New/Stop/Agenda/-Month/Playlist/...), RSK (Contacts/Menu/Reject)
		Dedicated key mapping: Call management	Send, End keys
		Dedicated key mapping: Volume control	Volume Up+Down
		Dedicated key mapping: Browser	-
		Dedicated key mapping: Voice command	-
		Dedicated key mapping: other	-
		Voice control functionality	Voice tags for contacts and programs.
		Help system	Some content lists show <Help> as the first menu list item.
	Personalizability	Menu	-
		Softkeys in idle state	-
		Shortcuts to features	Iconic application shortcuts in idle state; scrollable with left and right keys. End user definable shortcut keys (2-9) to programs.
		Layouts, fonts, graphics	Normal font, large font.
HW UI platform	I/O hw	Display resolution and colors	176x220, 65000 colors
		Sounds and speaker	Polyphonic tones, speakerphone
	Mechanical & industrial design: keys and other input devices		123456789*0#, Left softkey, Right softkey, Send, End, Home, Back, 5-way joystick, C, Volume Up+Down (some keys can be device manufacturer specific)

Figure 75. Microsoft Windows Powered Smartphone 2002 interaction style

[155] SPV stands for *Sound*, *Pictures*, *Video*.
[156] Microsoft. SMARTPHONE FREQUENTLY ASKED QUESTIONS. [Cited 06-Jul-2004] Available from WWW: <http://www.microsoft.com/mobile/smartphone/getstarted/faq.asp>.

The Windows-ism of the Smartphone devices has been emphasized – knowing the Windows UI on a PC should give the user a kick-start in using the Smartphone:

> *"The Windows environment you are used to: If you have used Microsoft Windows before, then you will be very familiar with the new Smartphone 2002. You will recognize the interface and programs, and the Smartphone extends the reach of the PC experience by allowing you to access the same applications, information and services and use the same profiles and login accounts you have setup on your home or work PC."*[157]

However, the Windows environments on a PC and on the Smartphone do have significant differences. There is no mouse pointer in the Smartphone, but a joystick and two softkeys instead. There is no "Start" button and no taskbar. The individual applications cover the whole display. Resemblance to the desktop Windows GUI environment has been created via familiar application names (Internet Explorer, ActiveSync, etc.), application icons, home screen resembling the active desktop, and the Windows color scheme, as illustrated in **Figure 76** below.

> *"Knowing Windows won't help much--Smartphone 2002 may be an offshoot of Windows, but there's there's no "start" button, no taskbar and no pointer. What you do get is the phone keypad, a "home" key, a "back" key (which is also a delete key) and a joystick, plus two "soft programmable" menu keys that can be configured to do different things by whatever software you're running. Even so, it doesn't take long to learn the new user interface. But the advantage of running a variant of Windows doesn't lie in usability: rather, it's the bonus of extra software availability."*[158]

Figure 76. Microsoft Smartphone displays

3.4 Mobile Internet Breaking the Interaction Style Consistency

Analyzing the contemporary mobile phones revealed a number of well-designed interaction styles. Obviously, there are differences in the conventions applied between different manufacturers, but within a single vendor's product portfolio and specifically within specific products, the interaction styles are rather coherent, without any core features breaking the underlying interaction conventions. It is evident that the manufacturers are applying HCI guidelines and internal UI style guides in their product development.

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[157] Microsoft. SMARTPHONE TOUR. [Cited 06-Jul-2004] Available from WWW: <http://www.microsoft.com/mobile/smartphone/tour/familiar.asp>.
[158] ZDNet Reviews. ORANGE SPV REVIEW. 30-Oct-2002. [Cited 06-Jul-2004] Available from WWW: <http://reviews.zdnet.co.uk/review/15/1/2142.html>.

However, despite the HCI expertise and user-centered design approach in the manufacturers' product development organizations, the analyzed phones include two distinctive exceptions to the compliance with the defined interaction styles:

- Factory-installed or downloaded **games** do not necessarily follow the established interaction style conventions. The phone UI may e.g. be designed around a softkey interaction style but a game may utilize the whole display area so there is no room for softkey labels, but the phone keypad is used for gaming control. Games often introduce a number of control keys e.g. for controlling the movements of a game figure or firing the photon torpedoes of a spaceship. Sometimes the controls for different games in the same phone are inconsistent.[159] For games this is not a severe problem, and it may actually be the optimal approach; gaming ergonomics, and the overall gaming experience are not about following established rules but to exhilarate and surprise the player instead.

- The much-touted **mobile Internet** may be a more severe issue. In most of the analyzed mobile phones the mobile Internet browser and the mobile Internet applications are breaking the interaction style conventions followed throughout the other parts of the phone UI. E.g. the phone may usually display the available menu when the user presses a softkey labeled "Menu" or "Options" but when the user is browsing Internet, the menu is available only by pressing the * (Star) key in the numeric keypad — and there is no indication on the keypad or on the display that the menu is accessible only this way. [160]

There are several reasons to the mobile Internet browsers' non-conformance to the mobile phone interaction style. Firstly, many mobile phone manufacturers do not design and develop the browser themselves but use an industry standard browser, such as the Openwave WAP browser or Microsoft Mobile Explorer. The mobile phone product development project team may just integrate a browser software package designed, developed, and delivered by an external company. The browser developers have not necessarily designed the browser with a specific mobile phone (user interface) in their minds but have created a generic browsing application that needs to be ported on and integrated with the mobile phone manufacturer's user interface software and hardware platform. It may be the case that the UI platform lacks some specific keys, or that the display is too narrow, or that the phone manufacturer's interaction style dictates a different use for the softkeys than what the browser developers have envisioned. However, having a third-party browser does not necessarily indicate that the browsing experience deviates significantly from the rest of the phone. Of the analyzed phones, the Openwave browser in the Motorola V60 phone works almost identically to the phone UI, although it is developed by a third party. Nokia, on the other hand, is using its own browser in the 3330 and 7210 phones, and their interaction styles do not directly support an intuitive and efficient hyperlink selection, so the Select shortcuts are breaking the basic interaction style of the phones — also, these shortcuts between these two Nokia phones are

[159] E.g. In Nokia's 5510 phone the snake in Snake II moves downwards when the user hits the J or F key, and the spaceship in Space Impact moves upwards when these keys are hit.
[160] The mobile Internet browser menu in the Samsung N620 and T100 phones is accessed this way.

different.[161] Nokia's more recent interaction styles in the 6650 and 7650 phones support mobile Internet browsing better as they have a dedicated select key for hyperlink selection. In general, the interaction styles applied by mobile phone manufacturers in their handset models have not been initially designed to support effective Internet browsing. Many of the analyzed phones utilize interaction styles that have their origins in an era before the mobile Internet became a common feature in mobile phones. The conventional mobile phone user interfaces have been designed around a *menu navigation and item selection* interaction style instead of a *content page navigation and hyperlink selection* interface.

In the mobile phone interaction style analysis we investigated also the interaction style differences between the mobile Internet browser and the other phone features. **Figure** 77 summarizes the findings from the analyzed phones and estimates the likely effects of the interaction style inconsistencies between the browsing and general user experience.

Phone model	Browsing interaction non-conformance with general phone interaction	Likely effect on user experience
Microsoft Smartphone	Bookmarks and Internet content pages can be scrolled horizontally if the content does not fit on the display. Horizontal scrolling indicators and interaction is consistent with vertical scrolling.	Minor
Motorola Talkabout 192	On the browser displays there is a strange indicator above the C key; this indicator is not explained in the user guide. All the other display indicators are located on the header row. Internet content pages show the "Back" function only when the user scrolls above the first link or below the last link; the "Back" is shown on the right softkey. You press-and-hold the Menu key to access the browser menu whereas the normal phone menus are accessed via a short press. The browser menu does not wrap around. The browser menu and its functions apply two softkeys, unlike the one-softkey interaction in the rest of the UI. The browser menu "Back" softkey is in the middle softkey — not on the right like on the Internet content pages or on the C key like the other features in the phone have. Browser error messages show abbreviated softkey labels: "Dtls" (Details) and "Cncl" (Cancel).	Users familiar with softkeys may press the C key to see what the strange indicator will do (the key will backstep). The browser menu may be left unnoticed unless people find the long press of Menu key by accident or hear this from a more knowledgeable user.
Motorola V60	Browser menu does not wrap around but otherwise works like other menus.	Minor
Motorola Timeport T280	In the browser links can be selected with the joystick's right direction and backstepping can be done with the left direction. Browser menu does not wrap around but otherwise works like other menus.	The joystick makes browser navigation faster but may confuse the users who may be used to left and right navigation on the content page.
Nokia 3330	The browser menu works like any other phone menu. Selecting a hyperlink on a WAP page is done by pressing the softkey labeled "Options" (to access the browser menu) and then selecting "Select" by pressing the softkey labeled "Select". As a shortcut, a hyperlink can also be selected by pressing keys 1 or 3.	The 'double-select' (you move the cursor in a function list to "Select" and then press a softkey labeled "Select") is confusing users: it does not exist in the phone's other features. People are used to point-and-click interaction with the Internet and with the 3330 you have to point – go to "Options" list – go to "Select" – press "Select". Internal research indicates that the 1 and 3 shortcuts are not generally known by the phone

[161] Nokia is using the Openwave browser in the CDMA phones; these browsers work differently from the GSM phone browsers as e.g. the browser menu is mapped to a short press of the Power key, the Select function to the left softkey, and the Back function to the End key.

		owners.
Nokia 7210	Like the Nokia 3330 with the exception of the Select shortcut being the Send key instead of the 1 and 3 keys.	Like the Nokia 3330.
Nokia 6650	Browser interaction closely follows the Three-softkey interaction style with the Options, Select, and Back softkeys. The scrollbar shows the current location in the whole page, not on the downloaded partial page.	Minor
Nokia 7650	Browser interaction closely follows the Series 60 interaction style with the Options, Select, and Back softkeys. Occasionally the right softkey shows "History" instead of "Back". Downloaded function keys are added to a "Service options" sublist in the Options list.	Users may search for the Back function before they realize the History list can be used for backstepping; a real Back would be faster, though.
Samsung N620	The browser shows 5 content rows versus the 3 rows in the normal phone UI and the browser softkey labels are in very small font. The browser command "Back" is visible in the left softkey only when the user scrolls past the first or the last link on the content page; when links are selectable, the left softkey contains "Link". The browser menu is accessed via the * (Star) key and this is not indicated anywhere in the UI. The browser settings submenu left softkey is "Ok" unlike the "Select" elsewhere in the phone UI. Browser settings change character case via the right softkey ("Case") — in normal text entry the case is changed with the * (Star) key that has a 'Shift' indicator on it. In browser settings text entry the cursor is moved with the * and # keys unlike the normal text entry cursor movement with the Up and Down keys.	The browser menu may be left unnoticed unless people find it from the * key by accident or hear this from a more knowledgeable user. Editing the browser settings may be difficult if people already know how the change case and move the cursor with the phone as these functions work differently on the browser side.
Samsung T100	The browser menu is accessed via the * (Star) key that has no indication of this functionality. The browser menu does not wrap around like the other phone menus do.	The browser menu may be left unnoticed unless people find it from the * key by accident or hear this from a more knowledgeable user.
Siemens MT50	The browser menu is accessed by scrolling to the browser display header row that has a menu indicator; this type of menu access is not used elsewhere in the phone UI. The browser menu does not wrap around. The Phonebook key displays browser bookmarks list.	Users are likely to have difficulties finding the non-standard browser menu the first time; the menu indicator on the header row does give a visual clue, though.
Siemens S45	Like the MT50. In the browser the Left and Right keys do not perform Cancel-Select like in the rest of the UI but jump to the previous and next links.	Like the MT50. If the user has learned to navigate in the phone menu with Up-Down-Left-Right keys and not use the softkeys, then she may have difficulties learning to use the softkeys instead of the Left and Right key.
Siemens SL45i	Like the S45. Also the phone help system has been implemented with the browser engine.	Exiting from the menu system may be difficult, as backstepping does not work like it works in the rest of the UI.
(Sony) Ericsson T65	Browser UI works like the phone UI. Downloaded function keys are shown in the browser menu.	-
Sony Ericsson T68i	Browser UI works like the phone UI. Downloaded function keys are shown in the browser menu.	-
(Sony) Ericsson T60d	*Mobile Internet browser not tested due to no TDMA network available.*	-
Sony (Ericsson) CMD-Z7	Browser displays show 6 lines of content and a status row. Browser menu is accessed via pressing the Send key or via a Jog Dial push *before* the user has scrolled the Internet page. Downloaded function keys are shown on the Internet page.	Users are likely to have difficulties finding the non-standard browser menu the first time.

Figure 77. Mobile Internet interaction style non-conformance with mobile phone interaction style

The Microsoft Smartphone, Motorola V60, Nokia 6650, and the (Sony) Ericsson T65 and T68i have mobile Internet (WAP) browsers that most consistently follow the overall phone interaction style. In contrast to this, the mobile Internet browser in the Motorola Talkabout 192 works quite differently from the rest of the phone UI. The browser designers have evidently tried to make a compromise

between not breaking the Dialog-OK interaction style of the phone and also not breaking the mobile Internet browser conventions. The browsing experience would have been more consistent with the rest of the phone if the design had utilized the handset control keys more flexibly: mapping the browser menu to a *short* press of the Menu key, and mapping the browser Back function to the C key. Now the C key performs backstepping (and there is a strange indicator on the display next to the key), sometimes the Menu key shows the "Back" label and backsteps, and sometimes the Ok key shows the "Back" label and backsteps.

Some of the analyzed phones have their navigation control implemented with a 4-way (or 5-way) joystick or rocker key. There is no de facto UI standard yet to define how two-dimensional navigation should work in mobile phones. Motorola's Timeport 280, for example, is basically not using the left and right directions of the joystick in menu navigation, but moving the joystick in these directions in the browser, however, performs backstepping and link selection, respectively. The Siemens S45 does utilize left and right in the 4-way rocker key for backstepping and submenu selection in menu navigation, but does not function similarly in the browser, where left and right simply duplicate the functions of the up and down key presses.

Designing a usable mobile Internet phone user interface is not overly complicated. The Microsoft Smartphone, Motorola V60, Nokia 6650, and Ericsson T65 demonstrate that if the underlying interaction style has the right elements, then the mobile Internet browsing user experience — at least from the device point-of-view — is consistent and predictable. The fundamental requirement is to have the following three core functions intuitively and consistently mapped and easily available in the user interface:

1. *hyperlink selection* function
2. *backstepping* function; Weiss (2002) argues that the 'Back' button is the most popular control in Web browsing, but only a small fraction of the dozens of Internet-enabled handsets has one.
3. *menu* containing the other available functions

Nokia designed this kind of interaction style already in 1999 for the world's first WAP phone — the Nokia 7110 — and this UI later evolved into the Three-softkey UI in Nokia's first W-CDMA phone, the 6650 (Kiljander & Järnström 2003). The Navi-roller UI in the 7110 was suffering from certain usability problems; a major design goal with the new Three-softkey UI was to resolve these deficiencies. Kiili (2002) conducted a usability study focusing on WAP user experience with the 7110 handset; he concludes that the WAP interface in the 7110 is hard to learn as the interface does not offer as clear cues to WAP services as to basic functions. The cues of the WAP user interface did not direct subjects (n=40) to the right path and most of the subjects were confused because they did not have a clue what they should do. Other WAP-related problems were lack of feedback and difficulties with exiting services.

If the user has learned how to operate the basic functionality — initiating and receiving phone calls, sending and reading text messages, or e.g. using the alarm

clock[162] — of a phone with confidence, she may face difficulties when learning to use the mobile Internet with her phone if the mobile Internet user experience differs significantly from the other phone usage. Another factor distracting the user from successfully performing her task is the network and server response time: with the phone UI the user usually gets an immediate system response to her actions but a browser UI may provide no immediate or timely feedback. Well-designed indicators like on-screen progress bars may obviously help to convey a message to the user that the system is actually working. A multitasking software architecture will let the user to carry on something else with the handset while a lengthy server operation is being completed.

Could the non-conformance with the established mobile phone interaction styles be one possible reason to the slow take-off of the mobile Internet WAP services?[163] After all, user interface *consistency* is one of the most often suggested, fundamental UI design guidelines (e.g. Shneiderman 1992, Nielsen 2002a, Weiss 2002).

Mobile Internet i-mode services have been a success in Japan. To gain further insight into the interaction style conformance issue, the first i-mode handset available in Europe and outside Japan, the NEC N21i — shown in **Figure 78** — was also very briefly evaluated to see whether its Internet browsing experience follows the interaction conventions applied in the other key applications of the phone.

In the brief interaction style analysis of the NEC N21i phone we could not connect to any live i-mode Internet sites with SIM cards from Finnish operators. Nevertheless, the handset delivers two somewhat different user experiences. The phone functionality and offline features are designed around a flamboyant main menu with color icons, but the sub-menus contain very few graphical elements at all. The control key interaction is inconsistent — e.g. sometimes the interaction sequence to get away from an empty list is to press OK, and sometimes to press Back, and sometimes a timeout will take the user out of the list automatically. Sometimes the green handset key can be used to initiate a SMS sending shortcut, and sometimes it does not work. The i-mode domain in the handset UI is designed around a graphical user interface toolkit with on-screen buttons and fields, and the overall user experience is more appealing than in the offline menus. The menu layouts and softkey labels do not follow the same conventions in the offline menus and in the i-mode menus.

Figure 78. NEC N21i

In the course of the mobile Internet browser interaction style analysis it became clear that no matter how good the mobile Internet browser in the handset is, the user experience is to a large extent dependent on the quality of the service

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[162] Feature usage research conducted by Nokia indicates that the alarm clock is one of the most frequently used functions in contemporary mobile phones.

[163] *"The Meta Group has found that between 65 and 75 percent of WAP users in Europe and Asia are no longer using their WAP services via their mobile phones. Analysts are attributing the failure more to design than the theory and delivery systems behind it."* In: Internetnews.com. May-24-2001. [Cited 06-Jul-2004] Available from WWW: <http://www.Internetnews.com/wireless/article.php/772491>.

content and its interaction mechanisms, and the robustness of the servers. Studies at Nokia indicate also that a major barrier to mobile internet usage is that users don't have or don't know how to get the handset settings configured for mobile Internet access.

While accessing numerous mobile Internet sites, the author was trapped in never-ending loops, backstepping did not work, servers returned mysterious error messages, retrieving snippets of information was painfully slow, and for a couple of times the browsers (or the phones) simply stopped responding or crashed. Informative, useful, and usable mobile Internet sites exist, of course. Traditionally, the HCI researchers and practitioners have looked mostly at the user interface of an application or device. However, this is no longer enough as the Internet has become the computing platform, or the media. Internet content, and how to maximize its usability, both in the desktop computing environments and in the mobile terminals, is now moving to the focus of the worldwide HCI community. This broad topic is not within the scope of the research work reported here. Ramsay & Nielsen (2000) report on a WAP field study and conclude that WAP does not work, and that companies should plan on launching mobile services as soon as the next generation of devices ships. User-centered design issues and guidelines for mobile Internet WAP services are presented in more detail e.g. by Kaikkonen & Williams (2000, 2001).

3.5 Select, Back, and Menu

Hyperlink or item **selection**, **backstepping** to a previous state or menu branch, and accessing the available functions in a **menu** or submenu, are obviously not limited only to the mobile browser functionality of a mobile phone. These primary operations are equally relevant in the other functions and applications in the mobile phone. Some of the evaluated interaction styles in this study are designed around object–action or action–object principle denoting the sequence of user interactions: the user selects either the object to be manipulated first, and then selects the desired action to be conducted on the object, or vice versa. The browser UI paradigm, however, requires the system to be able to support both object (i.e. hyperlink) and action selection concurrently; the user should be able to select either a hyperlink or choose a browser function without switching between any two modes of operation. This requires the selection and menu functions to be constantly available in the user interface.

All phones evaluated in the study support these three functions; some with separate hardkeys, some with softkeys, and some with control key overloading, as can be seen from **Figure 79**:

Mobile phone	Select function	Back function	Menu function
Motorola Talkabout 192	Green OK key	Red C key	"MENU" key
Motorola V60	Right softkey	Left softkey	Center softkey ("MENU")
Motorola Timeport 280	Right softkey	Left softkey	Center softkey ("M")
Nokia 3330	Navi-key ("Select") or 1 key (in browser)	C key	Navi-key ("Options")
Nokia 6610	Left softkey ("Select") or green	Right softkey ("Exit"/"Back")	Left softkey

	key (in browser)		("Menu"/"Options")
Nokia 6650	Center softkey ("Select")	Right softkey ("Exit"/"Back")	Center softkey ("Menu") or left softkey ("Options")
Nokia 7650	Joystick press or left softkey ("Select")	Right softkey ("Exit"/"Back")	Menu key or left softkey ("Options")
Samsung N620	Left softkey or green key	Right softkey or browser/C key	Left softkey ("Menu"/"Options")
Samsung T100	Left softkey	C key or right softkey or red key	Left softkey ("Menu"/"Options")
Siemens MT50	Right softkey ("Select")	Red key	Right softkey ("Menu"/"Options") or left softkey ("Options")
Siemens S45	Right softkey ("Select")	Red key	Right softkey ("Menu"/"Options") or left softkey ("Options")
Ericsson T65	"Yes"/green key	"No"/red key	Left/right key (main menu) or Internet key (submenus)
Sony Ericsson T68i	"Yes"/green key	"No"/red key	Joystick left/right (main menu) or options key (submenus)
Ericsson T60d	Left softkey ("Select") or joystick press	Right softkey ("Back"/"Exit")	Right softkey ("Menu") or joystick left/right, options key (submenus)
Sony CMD-Z7	Jog dial press	Jog dial pull or C key	Jog dial press (main menu) or jog dial push (submenus)
Microsoft Smartphone	Joystick press	Back key	Left softkey ("Programs") or right softkey ("Menu")

Figure 79. Select-Back-Menu function mappings in evaluated mobile phones

3.6 Dominant Design in Mobile Phone User Interfaces

Cellular mobile telephone user interfaces are converging around the softkey interaction style: e.g. Motorola does not have any longer many non-softkey products in its product portfolio globally, and Sony Ericsson is gradually moving to a softkey-based interaction style in its new products.

Simultaneously, mobile handset software platform vendors Microsoft and Nokia have started to offer their mobile phone user interface software platforms — Microsoft Smartphone, and Nokia Series 60, respectively — for prospective licensees. These are signs of convergence in the mobile phone industry towards a more uniform mobile phone user interface or interfaces. This section will briefly illustrate and analyze the ongoing convergence activities in the mobile phone user interface domain. The section will also illustrate aspects of user interface *divergence* in the mobile phone industry — e.g. some mobile application developers are criticizing the mobile phone vendors for introducing several mutually incompatible versions of mobile Java in the marketplace. The section will conclude by briefly looking outside the mobile phone domain, e.g. at the automotive and home electronics industries that supposedly have established user interface conventions dating back to the early and late 20th century, respectively.

A *dominant design* is one that emerges from within the competitive offerings, and gradually other manufacturers start to adapt to this design. Utterback (1996) defines dominant design in a product class to be the one that wins the allegiance of the marketplace, and the one that competitors and innovators must adhere to

if they hope to command significant market following. According to Nokia, the two-softkey mobile phone user interface introduced by Nokia originally in the 2100 series mobile phones in the mid 1990s has become a de facto standard in mobile phone user interfaces (Kiljander & Järnström 2003).

The dominant design aspect is obviously broader than just the user interface, and often it is not possible to separate the UI from the total product design including the industrial design, and the handset functionality.

All evaluated, contemporary, mainstream mobile phones apply a menu interaction style. The two-softkey user interface is currently applied by most mobile phone manufacturers, in some form or another. All of the five largest mobile phone manufacturers listed in **Figure 21** are currently applying the two-softkey UI in some of the handsets in their contemporary product portfolio. Sony Ericsson who has long been applying a non-softkey Yes–No interaction style, is gradually rolling a softkey user interface out in its new products. However, it is worth noticing that the single most widely used mobile phone interaction style in the world, Nokia's Navi-key UI[164], is not widely being copied by other vendors, but they are more like re-inventing the two-softkey UI and thus making that the de facto standard UI convention. Also the commercially available mobile phone UI platforms from Microsoft and Nokia apply the two-softkey UI, as did the two UI platforms from Pixo in 1999–2000.

Even though the industry seems to be converging around two softkeys at the moment, the three softkey paradigm may actually become more broadly applied in the future. Motorola's Synergy UI is basically a two-softkey UI with the Menu key also implemented as a softkey, and Nokia's new Three-softkey UI has three real softkeys like its name implies. The Japanese mobile industry and marketplace is frequently considered to have a one…two year lead over the development in the Western markets, and most contemporary Japanese mobile phones are designed around a three-softkey user interface, such as the D503i phone illustrated in **Figure 80**.

Figure 80. D503i phone from NTT DoCoMo

When a manufacturer starts to adapt elements from a competitor's (dominant) design, it is sometimes commonplace to see comments from (design) critics, which happened e.g. when Ericsson announced the round–shaped T68 mobile phone at the CeBIT trade show in March, 2001:

> *"T68 looks like a Nokia turned upside down. I would like to say that it is almost plagiarism. … If one copies others, the end result will simply be a pancake. … There is a clear tendency in the mobile phones market for the various players to move closer to each other in their design language. Therefore the vendors must be active with their design strategies to profile themselves."*[165]

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[164] According to Alkio (2003), Nokia's mobile phones utilizing the Navi-key UI have sold more than 300 million units.

[165] FinansTidningen direct. DESIGNEXPERTER SÅGAR T 68:AN. Interview of Per–Olov Landgren from Högskolan för Design och Konsthantverk, and Designer Björn Dahlström. 23-Mar-2001. [Cited 23-Feb-2003] Available from WWW: <http://www.finanstidningen.com/fti/nd.nsf/Artiklar/C12569AA005892DDC1256A17003CF237>.

It can be noted that Motorola has recently reversed the placement of the dedicated call-management keys: the Motorola phones that were investigated in this study — see **Figure 70** — had the red End key on the left, and the green Send key on the right in the phone keypad, whereas more recent phone designs from Motorola — e.g. the Motorola RAZR V3 — incorporate the green Send key on the left, and the red End key on the right, in the same order as in phones from e.g. Nokia, Samsung, and Siemens. Thus, the dominant design is to have the green key on the left, and the red key on the right.

Market dynamics may be a stronger element in the establishing of dominant designs than a single product attribute such as usability (Utterback 1996). There may be a tendency to converge on the most appealing, mainstream conventions, instead of continuing to search for a more usable solution. After the trade customers, content developers, and consumers have been locked into a specific user interface convention, it may be difficult to affect their preferences, even when a new UI would offer usability improvements. This has been the case with the Qwerty and Dvorak keyboard layouts, and there might be some similar patterns in the evolution of the two-softkey and one-softkey interaction styles.

In case user interface conventions can be copyrighted, it may become impossible for a manufacturer to apply a user interface already established by another manufacturer. There will be no compatible competition for established products. (Stallman 1991). This means that if a user wants to shift to a different brand, she will have to retrain herself to be able to use the new product. The monopoly on the established user interface will yield in practice a monopoly on the functionality accessed by it. With his anti-copyright tone, Stallman argues that this will lead to higher product prices and less technological advancement.

3.6.1 User Interface Standardization and Guidelines

Weiss (2002) argues that the speed of design and development in the handheld arena has been so fast that many companies have reinvented the wheel, sometimes more than once; the outcome being lack of a standard layout for mobile telephone handset controls. Väänänen-Vainio-Mattila & Ruuska (2000) list lack of UI standards and conventions between different manufacturers' products being one of the main design constraints in mobile handsets.

The objective of standardization in the mobile industry is to ease and hasten user adoption of mobile services and technologies globally by ensuring seamless application, service, and handset interoperability across handset manufacturers, mobile operators, service providers, and markets. The major standardization efforts and organizations in and around the mobile industry are technology-focused; these include e.g.:

- 3GPP: 3rd Generation Partnership Project[166]
- 3GPP2: 3rd Generation Partnership Project 2[167]
- ETSI: European Telecommunications Standards Institute[168]

[166] 3GPP. [Cited 06-Jul-2004] Available from WWW: <http://www.3gpp.org/>.
[167] 3GPP2. [Cited 06-Jul-2004] Available from WWW: <http://www.3gpp2.org/>.

- IETF: Internet Engineering Task Force[169]
- JCP: Java Community Process[170]
- OMA: Open Mobile Alliance[171]
- W3C: World Wide Web Consortium[172]

User interface standardization in the mobile industry aims at defining and enforcing a consistent user experience for consumers and other interest parties across different manufacturers or cellular systems. *De jure* user interface standardization in the mobile industry is to a large extent carried out by the abovementioned standardization bodies. In addition, there are other, de jure or *de facto* user interface standardization efforts carried out by other bodies, consortiums and companies.

Under the eEurope Initiative of the European Commission, the ETSI Special Task Force (STF) 202 is driving the availability of common, harmonized interaction elements in mobile devices (ETSI 2002, von Niman et. al. 2003). The availability of common user interface elements aims at increasing the transfer of learning between devices and services, and thus improving the overall competitiveness of the European mobile environment. The proposal to harmonize these interface elements on the basic level is not meant to restrict handset manufacturers' freedom to apply brand-specific UI implementations. Elements considered for harmonization include:

- Basic elements and functions:
  - International access code
  - Emergency functionality and services
  - Symbols, icons and pictograms
  - Acoustic signals
  - Access to basic voice services
  - Basic terminology
  - Text entry and retrieval
  - Assistive device interfaces
- Configuration for service and application access:
  - UIs of services and applications
  - Configuration procedures
  - Service and application access, interworking and portability
  - Service and application terminology
- Advanced functionality-related interaction elements:

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[168] European Telecommunications Standards Institute.
[Cited 06-Jul-2004] Available from WWW: <http://www.etsi.org/>.
[169] The Internet Engineering Task Force.
[Cited 06-Jul-2004] Available from WWW: <http://www.ietf.org/>.
[170] Java Community Process.
[Cited 06-Jul-2004] Available from WWW: <http://www.jcp.org/>.
[171] Open Mobile Alliance.
[Cited 06-Jul-2004] Available from WWW: <http://www.openmobilealliance.org/>.
[172] World Wide Web Consortium.
[Cited 06-Jul-2004] Available from WWW: <http://www.w3.org/>.

- Structure and vocabulary of spoken commands
- Address book data format and portability
- Organizer data format and portability
- V-cards, business card information
- Terminology of network services
- Universal addressing in converging networks
- Positioning services
- Service and content presence and connectivity
- User data privacy and security

To offer equal access to mobile services and devices, elderly users and users with disabilities are an important focus area for mobile handset user interface design. Several standardization and design guideline creation efforts are taken place in this field, mandated by standardization bodies or e.g. the European Commission. There's a long history of landline telephone design guidelines for equal access (e.g. Brandt 1995), and the mobile phone guidelines build on top of those, such as the guidelines consolidated by Mercinelli (2001) and Roe (2001). These cover the following user interface areas for mobile phones, smart phones, and palmtops from the disabled users' viewpoint:

- Industrial design: size and shape of the handset, antennas and "flaps"
- Keypad: physical characteristics of the keys, keypad layout, raised and concave keys, visual contrast of legends on keys, tactual and acoustic feedback on key press
- Pointing devices, switches, and knobs
- Operation of the handset and interaction methods: one touch dialing, automatic pick-up, automatic power switch off, short number dialing, voice controlled dialing
- Acoustic output devices and sounds: incoming sound, ringing tones, warning tones
- Hearing and compatibility
- Microphone
- Display
- Visual indicators, background lights on/off
- Battery and recharging
- Slots, sockets, external connections
- Battery charging, audio indication of battery status
- SIM card
- Instructions of use

The design process to develop usable and safe interactive systems has been standardized in the ISO 13407 standard for *Human-centred design processes for interactive systems* (ISO 1999). According to ISO 13407, the following four activities need to be used in the design process, and there needs to be suitable evidence to describe the process:

1. Understand and specify the context of use: the nature of users, their goals and tasks, and the environment in which a product is to be used.

2. Specify the user and organizational requirements in terms of effectiveness, efficiency and satisfaction; and the allocation of function between users and the system.

3. Produce prototypes and designs of plausible solutions.

4. Evaluate designs against user criteria.

Human–centered design process involves iterating these activities until the design objects are satisfied, as illustrated in **Figure 81** (Kiljander 1997). The sequence of the activities and the level of effort and detail depend on the phase of the design process. It must be noted that a standard design process does not directly imply any standardization of the user interface to be created, per se.

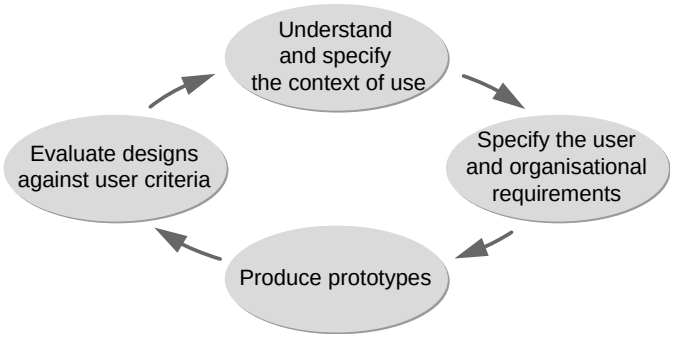

Figure 81. Human–centered design process according to ISO 13407

De facto mobile handset user interface standardization is currently explicitly driven by Microsoft and Nokia with their commercially available Smartphone and Series 60 smartphone user interface platforms. Both companies have chosen to compete in the marketplace by allowing handset manufacturers to base their handsets on these user interface reference platforms and reference designs. With an approach like this, the core user interface can no longer be seen as a proprietary competitive asset by a handset vendor, but the added value needs to come from other product attributes, such as industrial design, performance, additional software features, manufacturing efficiency, or e.g. operator customization capabilities. Microsoft explicitly raises Windows UI heritage as a key element of the Microsoft Smartphone platform:

> *"… The taxonomy is the same, the sort of knowledge you have gained on the desktop is reusable when you use it on a small device. We want to make sure the experience is very, very consistent… make sure the user does not have to pick up a whole new taxonomy or language. … for mass users, they don't want to have to deal with having to read manuals or call their son-in-laws to learn how it works… they just want to rip the shrink-wrap off the device and get using it immediately."*[173]

User interface standardization is also an appropriate solution when all the necessary information cannot be mapped in real world in a natural way. No matter how arbitrary the standardized mechanism is, it has to be learned only once (Norman 1988). Obviously it will take some time for the users to learn to

[173] Pocket PC Insiders. INTERVIEW OF MICROSOFT'S JUHA CHRISTENSEN. 03-Dec-2002. [Cited 06-Jul-2004] Available from WWW: <http://technologyreports.net/wirelessreport/?articleID=1284>.

use the standardized user interface. Sometimes it is also challenging to find the workable compromises between the industrial, political, academic, and other parties involved in the standardization effort.

3.6.2 User Interface Divergence

"*Diversity is not the goal of interface design*", argues Stallman (1991) and continues: "*users of any kind of machinery want consistency in interfaces because this promotes ease of use.*" Despite the dominant design and standardization developments in and around mobile handset user interfaces, the mobile phone industry is constantly introducing also radical or unconventional user interface solutions, and some industry activities are not completely supporting user interface convergence or consistency. User interface inconsistency between frequently needed functions such as 'hold' in multiple telephones is mentioned by Don Norman (1998) when he discusses bad design principles with telephone systems; other examples mentioned by him include access numbers for telephone credit cards being hard to remember, telephone's special features being very difficult to use, and telephone designs in general continuously becoming overly complicated.[174]

There is both intra-device and inter-device user interface divergence in mobile phone user interfaces. Intra-device UI divergence was discussed in **Section 3.4** that analyzed how the mobile Internet browser UIs in many cases break the underlying interaction style conventions of the handset.

Some recent mobile handsets express the manufacturers' desire to differentiate their products with a different physical user interface. As the mobile phone penetration rates in the most developed markets are above 70 percent, and the overall growth of the markets is at standstill, the manufacturers envision more growth can be achieved via multiple device ownership, and the individual devices need to emphasize certain aspects such as wearability or fashion:

> "*Today, most people buy the mobile phone that looks the best, and many have a habit of showing it off. This shows that mobile phones are potential fashion accessories like watches, handbags, and shoes. We envisage the scenario where people will own many fashion accessory phones and wear the one that matches their mood, the occasion, or their attire.*"[175]

Figure 82 below illustrates examples of mobile phones highly focused on a specific segment and explicitly designed to be fashion or lifestyle elements.

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[174] Norman (1998) argues that technological development tends to follow a U-shaped curve when it comes to complexity: starting high with very complex and difficult-to-use devices, dropping to a low, comfortable level when the industry and products reach a mature phase; then climbing again when ways to introduce new functionality and power are devised.

[175] Techworthy.com. Interview of George Appling,
President of Siemens fashion phone division Xelibri. [Cited 14-Mar-2003]
Available from WWW: <http://www.techworthy.com/news/201876.html>.

Haier P5	Nokia 3300	Nokia 3650	Siemens Xelibri	Nokia 7280

Figure 82. Unconventional mobile phone physical user interface

The Haier P5 is a slender, pen-resembling mobile phone with a laser pointer. The physical control keys have been reduced to a minimum: the user operates the phone's menu structure in landscape mode, selects menu items with the green handset key, and cancels selections with the downwards navigation key. The Nokia 3300 and 3650 models apply Nokia's Series 40 and Series 60 user interfaces styles, respectively. The 3300 is a music phone to play MP3 and AAC music, and listen to FM radio. The 3650 phone is an imaging phone with an embedded video camera. The phone belongs to Nokia's Expression category and the numeric keypad has been designed to support the category image. The Xelibri is the first fashion item phone from Siemens. Siemens planned to market these phones as fashion items with two collections per year, but due to low sales figures the company dropped the Xelibri phone range a year after its introduction.[176] The sleek, art-deco-styled Nokia 7280 offers a rotating control pad that replaces the traditional phone keypad. These fashion-driven phones are obviously not always liked by pragmatists:

> *"The cellular-phone industry, having pretty much saturated the market for basic handsets, is trying to turn the mobile phone into a fashion item, even if it means impairing basic functionality. … These radical designs distort or even abandon perhaps the single most familiar and successful user interface in the world: the standard 3-by-3 arrangement of the numbers 1 through 9, with a fourth row containing the 0 key centered below the 8, flanked by * and #."*[177]

Some products make radical changes to the mainstream mobile phone user interface components. Very low-cost mobile phones like the Hop-on disposable phone illustrated in **Figure 83** are designed to support only the most rudimentary voice communication, and in a product like that the display may be left out without making severe sacrifices to product usability. The usage model with a product like this may be more analogous with conventional landline phones than with mobile phones. The display module is one of the most expensive and power-consuming components in a mobile handset (Alkio & Raeste 2002) and removing

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[176] Wall Street Journal. 24-May-2004. [Cited 26-May-2004] Available from WWW: <http://online.wsj.com/article_email/0,,BT_CO_20040524_000481-IBjgoNklaB3mp2maKiIbKmCm4,00.html>.

[177] *"Fashion-Forward Phones Put Form Over Function"* In: The Wall Street Journal. 12-Feb-2003. [Cited 06-Jul-2004]
Available from WWW: <http://ptech.wsj.com/archive/solution-20030212.html>.

it will make it possible to create a significantly more inexpensive and smaller device.

Figure 83. Hop-on disposable cellular phone

Divergence and lack of consistency in the functionality of the handset user interface is often criticized from the developer viewpoint. User interface middleware software should facilitate straightforward design and implementation of mobile applications and services on different manufacturers' handsets. This is not always the case — due to inconsistent developer platforms and APIs. The early WAP standard raised criticism due to different handset manufacturers implementing the mobile browser and service user interface in a proprietary manner, as the WAP standard itself did not define the user interface elements and conventions in an unambiguous way. The latest WAP standard releases are addressing the incompatibility issues and moving closer to existing Internet standards: e.g. the clause "*Enable the creation of Man Machine Interfaces (MMIs) with maximum flexibility and vendor control*" has been deleted and replaced by "*Provide a web-centric application model for wireless data services that utilises the telephony, mobility, and other unique functions of wireless devices and networks and allows maximum flexibility and ability for vendors to enhance the user experience.*"[178]

Java is another example of middleware inconsistency causing problems. Java founder James Gosling criticizes mobile network owners for having deployed differing, incompatible flavors of Java; he says business arguments for this approach make *"little sense."*[179] Gosling thinks the most powerful source to push compliance are the developers and the customers.

UI inconsistencies in text entry functionality — how to enter the space character, where to find the accented characters, how to insert a special character — continuously make life harder for replacement buyers who change the device brand. Likewise, most handset manufacturers are currently offering a predictive text input method for the user to enter text faster and more conveniently than the earlier 'multi-tapping' mechanism that requires the user to e.g. press the "2" key three times to enter a "C" character. However, the widely applied predictive text entry technologies[180]have differences in their user interfaces.

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[178] Tom Worthington. WEBSITE DESIGN FOR INFORMATION TECHNOLOGY PROFESSIONALS. [Cited 06-Jul-2004]
Available from WWW: <http://www.tomw.net.au/2001/wd.html#L1198>.
[179] Wireless Watch Japan. GLOBAL LESSONS FROM MOBILE COMPUTING IN JAPAN. 14-Oct-2002. [Cited 12-Jan-2003]
Available from WWW: <http://www.wirelesswatchjapan.com/eps/36.htm>.
[180] E.g. Motorola Lexicus iTAP, Tegic T9, and Zi eZiText.

3.6.3 Digital Convergence User Interfaces

The development of digital technology applications has been rapid since the early 1970s.[181] The first digital electronic computers were applied in the military, space exploration, and large corporations' R&D departments. Mainframe computers facilitated the corporate and government management information systems to manipulate and analyze large amounts of information. Personal computers brought the computing power — and the chore of computer maintenance — to the end users at the grass roots. Then came mobile telephones, personal digital assistants, World Wide Web, Internet videoconferencing, digital cameras, peer-to-peer file sharing networks, and pocketable digital music jukeboxes.

These new digital technologies enhance human experience in new ways. The desktop computer has matured to contain vast amounts of memory, processing power unheard about just a couple of years ago, very large disk drives, fast input and output operations, and fast connection to a globally spanning network of digital information and services on the Internet. A variety of specialized tools have emerged for capturing, manipulating, and combining audio, image, text, and video in various multimedia formats. Digital communication technologies have improved simultaneously: digital networks connect computers over dedicated local area and wide area corporate networks, and over public computer networks such as the Internet. Mobile telephones, personal digital assistants, television set-top boxes, healthcare appliances, and cars are connected via a digital communications infrastructure.

Covell (1999) defines *digital convergence* as the *convergence of these improved computing capabilities, new digital multimedia technologies and content, and new digital communications technologies*. The combination of computing power and functionality, digital networked interconnections, and multimedia capability enables new forms of human interaction, collaboration, and information sharing. From a PC-centric viewpoint Covell further argues that the Web with its streaming media and videoconferencing capabilities is currently the dominant digital convergence technology.

From their mobile-phone-centric viewpoint, the cellular mobile telephones and wireless communication industries see the mobile phone becoming the centerpiece of digital convergence[182]. The software industry envisions that the growth rate of smart, embedded systems will be enormous. In general, the future of computing is seen to shift from desktop computers to embedded, smart devices: "*There's a new world emerging of smart devices. That is the future of computing.*" (Steve Ballmer, President and CEO of Microsoft, in Ricadela 2001); "*The embedded market will become everything. Embedded systems will ultimately displace desktop computers for everything except very specific applications.*" (Richard Newton, Dean of the College of Engineering at the University of California at Berkeley, in Kaihla 2001).

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[181] The integrated circuit was invented in 1958 – 1959 by Jack Kilby and Robert Noyce. Gilbert Hyatt patented the microprocessor in 1970, and in 1971 Intel Corporation introduced the world's first commercially viable microprocessor, the 4004.

[182] "*… the mobile phone is becoming the centerpiece of complete personal connectivity: people, content, devices.*" In: Nokia. ANNUAL PRESENTATION 2001. [Cited 03-May-2002] Available from WWW: <http://nds1.nokia.com/investor/2001/4Q/files/4QFF-e2.pdf>.

As the markets for embedded devices grow, the functionality provided by the devices will continue to evolve and spread across the traditional device category boundaries. As an example, the wristwatch form factor is already applied also to GPS navigators, medical wristbands such as glucose and heart rate monitors, personal digital assistants, digital cameras, mobile phones, pagers, altimeters, televisions, and MP3 players. Contemporary mobile telephones already contain functionality such that they can be used as FM radio receivers, stopwatches, and clocks — many mobile phone users no longer carry a wristwatch as they have the current time available in their phones.[183]

Understanding what the consumers want and need, and designing usable user interfaces are key elements making these digitally converging devices succeed or fail. We can list two major challenges to this in the domain on digital convergence user interface creation:

1. **Complexity.** If you try to make one device do many things, the complexity will inherently increase. If you try to make one device suffice for everyone in the world, the complexity increases ever more. Norman's (1998) classic example is the Swiss army knife, the perfect tool in the wilderness if it's the only thing you have with you, but an inappropriate tool in the home environment where real tools with superior utility and ease-of-use are available. Another example is the personal computer that tries to be a general-purpose device with the outcome of the users being forced to spend hours keeping the computer working, updating hardware or software, reading instruction manuals, help files, or the monthly PC magazine.

2. **Mixing of UI metaphors.** If you converge several products into one, which user interface metaphor you should choose? If you incorporate an FM radio to a mobile telephone, should the radio feature work like FM radios usually do, or should it work like the other features in the phone work? Should a camera in a phone work like a stand-alone camera?

Nielsen (1997) strongly advocates that smart phones should be designed around a computer user interface paradigm instead of being designed as telephones with a data add-on.[184] Nielsen's justification is that telephone user interfaces are not expressive enough to even facilitate services like call waiting, or call forwarding in a usable manner, whereas computer user interfaces support the design of multiple features in a more usable way. "*Users need an integrated user interface rather than something that is half-telephone and half-kludge.*"

Despite the challenges associated with converging multiple digital technologies and products into one, it is evident that the trend will continue. Many of the new features in digital convergence products can be implemented with a moderate software development effort, and downloadable software technologies like Java facilitate the upgrading of the device functionality as needed. If the benefits as

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[183] "*A major reason for … lackluster growth was the rapid penetration of mobile phones and other portable devices. With these alternatives, a wristwatch is simply no longer a necessity.*" In: Citizen corporation (the world's largest maker of wristwatches). ANNUAL REPORT 2001. [Cited 06-Jul-2004]
Available from WWW: <http://www.citizen.co.jp/english/annual/pdf/ar01.pdf>.

[184] In this context it should be noted that Nielsen's usability engineering background and expertise stem from the mainstream computing and WWW HCI fields.

perceived by the potential purchaser[185] achieved with the convergence product surpass the convenience and utility of separate devices, we will continue to see products and product categories to erode as the convergence products gain more popularity. To describe this kind of market development, we define the concept of *feature cannibalization*[186] as follows:

> ***Feature cannibalization*** *denotes a situation where a company introduces a product with features copied — and possibly improved — from another product or product category of its own or of another company, resulting in a decrease in sales of the original product.*

For example for a carpenter, the mobile phone has replaced the cheap pocket calculator, as the phones nowadays have basic calculator functionality incorporated. The carpenter is at a construction site, and carrying a phone in any case, so he is willing to sacrifice some of the pocket calculator's ease-of-use — like instant use[187] — since he can now carry just one device.[188] In Japan and Korea the sales of disposable cameras are declining as people are increasingly shooting photographs with their mobile phones.[189] We can see that feature cannibalization is highly user and context specific. An office worker who needs to perform frequent calculations is still likely to prefer a dedicated calculator, as the calculator can be always readily available on her desk, and the calculator itself will possess large, ergonomic keys and display.

Quite often the cannibalization direction is obvious: you incorporate a compass into maritime binoculars and not the binoculars into a compass. Sometimes the cannibalization direction is more blurred: the car central locking remote control does no longer hang in the key chain – it *is* the key chain – so did the key chain cannibalize the remote control or vice versa?

The wireless industry in general envisions mobile phones to cannibalize other personal devices; this has already happened to some extent with the abovementioned products and features like calculator, wristwatch, and FM radio. The author conducted a quick, informal survey on how the mobile phone has cannibalized the wristwatch, to find out that 23% of mobile phone users no longer wear a wristwatch as they are using the clock feature in their phones[190]. The mobile phone is also in the process of becoming the *personal trusted*

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[185] Feature usage research conducted by Nokia indicate that many (advanced) features in mobile phones are necessary to sell the product but they are seldom used by the majority of phone owners.

[186] Cannibalization as a financial and marketing term has several slightly inconsistent definitions; one definition is that *cannibalization occurs when the introduction of a new product causes sales of existing products to decline.*

[187] A simple pocket calculator is ready for calculation after taken out of pocket and the power key is pressed, whereas with e.g. the Nokia 6310 phone one first needs to unlock the keypad lock, then enter the menu, then scroll the menu to the Calculator application, and then start the application.

[188] Information based on anecdotal evidence collected by the author in 2001 – 2002. The situation outside Finland may be different; e.g. in the U.S. many mobile phone users still do not necessarily keep their phones switched on due to having to pay for incoming calls.

[189] Helsingin Sanomat. Interview of Don Listwin, CEO of Openwave. 02-Jul-2002. [Cited 02-Jul-2002] Available from WWW: <http://www.helsinginsanomat.fi/uutiset/juttu.asp?id=20020702TA14>.

[190] Study conducted with Nokia-internal and external people in summer 2002. Sample size 66.

device[191] (MET 2001) and cannibalize some items from the user's wallet, such as credit cards, smart cards, small cash, public transport tickets, addresses, and photographs, in addition to the already cannibalized phone numbers. However, the continuous incorporation of new features into a mobile phone — or any product — is likely to result in complex phones and user interfaces having much functionality the users will not be using in their daily lives. This '*creeping featurism*', or '*bloatware*', is to some extent inevitable: in order to create competitive products a manufacturer needs to make the product's feature list as long as possible as this will impact favorably the prospective buyer's purchasing decision (McGrenere et. al. 2002).

Mobile phone functionality for wireless voice and data transfer is itself being cannibalized by other products. A PCMCIA card phone can be inserted into a computer's card slot to be used as a radio modem or to turn the computer into an un-pocketable mobile phone. Many recently announced PDAs contain wireless data transmission or voice calling capabilities either as built-in or via snap-on solutions. Prestigious cars can be ordered with factory-installed mobile phones that are ergonomically — and presumably also more safely than standard mobile phones — accessible via in-dash displays and steering-wheel-mounted control keys. This trend is showing signs of analogy to Don Norman's description of the evolution of electric motors and computers:

> *"A motor, by itself, is not very useful to the average person. Motors are enablers, they are infrastructure. Couple a motor to the appropriate components and the result can be of great value. In the early days, electric motors, were large and expensive. A single motor was coupled to multiple belts and pulleys, the better to service a variety of specific tasks. … Today, the modern house has dozens of motors, but they are invisible, hidden inside such things as clocks, fans, coffee grinders, food mixers, and blenders. … The motors are embedded with these specialized tools and appliances so that the user sees a task-specific tool, not the technology of motors. … The same story can be applied to computers. … Computers are enablers, they are infrastructure. … They are hidden inside the most recent telephones and television sets. Computers make all of these devices possible, but note how the word computer does not appear in the names of the devices."* (Norman 1998)

In a couple of years we may not explicitly think about or even notice purchasing a mobile phone when purchasing a PDA, portable music player, or some other product that has wireless communications functionality incorporated.

It is worth noticing that feature cannibalization does not work solely on a utilitarian basis but also has non-utilitarian drivers. People have for a long time possessed a number of highly personal and intimate items that may well strike back when miniaturization of wireless handset electronics and battery technology has reached acceptable size thresholds. These items include the ubiquitous wristwatch, jewelry, key chains, eyeglasses and sunglasses, pens, cigarette packs, and recently the personal digital assistant. When mobile phone components are small enough to be incorporated into these objects with adequate amount of

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[191] Personal Trusted Device is a device with the following aspects: it is personal, controlled, and used by one person and carried by that person most of the time; it has an application platform with associated user interfaces for transaction related services such as banking, payment, bonus programs; it has the security functionality required for transaction related services: secure sessions, authentication, and authorization (MET 2001).

usability, we may well start to see these belongings cannibalizing the mobile phone, at least when it comes to basic voice communications.

3.6.4 User Interface Evolution in Some Other Industries

It is illustrative to look outside the mobile phone domain to see if and how the user interfaces have evolved in industries such as e.g. the automotive industry and consumer audio-video equipment. Like mobile phones, automobiles and audio-video equipment can be categorized as smart products[192]. There is convergence, standardization, and evolution in these user interfaces. The brief discussion in this chapter is just a cursory attempt to describe some developments in these domains and it may first sound irrelevant in the scope of this study. However, these industries are more mature than the mobile phones industry, and the user interface is a key element in the products of these industries. These user interfaces have evolved through various stages and we may have something to learn from these processes when it comes to mobile phones user interface convergence. The interesting notification from the reviewed product domains illustrates how manufacturers are turning to menu-based user interfaces as the number of product features grows so large that physical, separate controls and knobs can no longer be introduced for every new feature; this is exactly the same development that happened in mobile phone user interfaces some decades ago. However, the product reviews referenced in this section do not show an overly positive attitude towards menu-based interfaces in car controls, car audio systems, and consumer electronics. It is obvious that functionality that has been conveniently provided earlier via physical, direct manipulation controls, cannot simply be re-mapped to a 'smart' menu system without sacrificing some of the core elements, such as convenience and safety, in the user experience.

The automobile user interface has evolved during the 110 years history of the motor vehicle. The first *horseless carriages* were steered with a tiller bar that was in turn replaced by a two-handle steering column slightly resembling the steering column in a bicycle. The steering wheel, as we know it, finally emerged in the 1920s. Norman (1988) presents the early history of the automobile as an example when illustrating technological improvements being introduced through technology and standardization. The early cars were difficult to operate, as they e.g. required considerable physical strength and skill. Some of those problems were solved through advances in technology such as the choke, the spark advance, and the starter engine. Some other aspects had to be improved via standardization, such as which side of the road people drive, which side of the car the driver sits, and where the fundamental car controls — steering wheel, brake, clutch pedal, and accelerator — are placed. In some early cars the accelerator was on a hand lever.[193]

The basic driving user interface is nowadays to a great extent standardized. This standardization has happened mostly via car manufacturers' voluntary

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[192] Keinonen et. al. (1996) define smart products as data processing, compact, completely defined, and functionally independent interactive devices with limited interaction equipment, and are dedicated to a set of tasks.

[193] Cruise control works to some extent like an accelerator and in most contemporary cars its controls are located in one of the levers on the steering column. These steering control levers started to appear during the 1930s.

convergence to established control and interaction conventions. Stallman (1991) argues that through the standardization of the symbols on automobile dashboards, it has become possible for any licensed driver to operate any car without additional instruction.

However, the automotive user interface has gradually been hit by a syndrome called *creeping featuritis*. More and more functionality is being incorporated in the dashboards of modern cars. The driver must pay increased attention to differentiate the important controls and warning elements from the more superfluous ones. Automotive engineers and designers have traditionally mapped new functionality to new controls, which has been increasing the number of controls. Norman (1988) discusses the fundamental difference between the (landline) telephone user interface and the automotive user interface: the *mapping* of functions to the controls needed to execute the functions is fundamentally different. In Norman's reference phone, there are 24 functions, but only 15 controls, and none of those are labeled for specific actions. In contrast his car has 112 controls inside the car in total and e.g. the trip computer performs 17 functions with 14 controls. With minor exceptions, there is one control for each function. As the number of controls approaches the number of functions, each control can be labeled naturally. The visible car controls remind the user from the available possibilities, unlike the phone with unlabeled controls telling nothing about the device functionality. The good relationship between the car controls and what they do also makes it easier for the user to master the car functions.

The 112 controls in Don Norman's 1980s Mercedes-Benz are clearly overshadowed by the 2002 BMW 700 series with its controversial iDrive interface having 700 functions accessible via a multimodal push-turn-shove joystick-knob on the car's center console. BMW decided to introduce the completely new iDrive control UI as the number of controls was already high in the previous generation vehicle: there were 35 different gauges and indicator lights and 66 manual controls. The 2002 BMW 745i has 29 controls and 17 indicators due to the iDrive system, which is close to the 1952 BMW having 16 and 11, respectively. In (Wilkinson 2002) BMW's iDrive interface engineer Hermann Kuenzner explains:

> *"The people who designed the interface, we didn't need 700 functions. We always discussed whether we need this function or that function, because it would have made it for us much easier to build a simpler system. But OK, if our marketing department says we need it, we design it in."*

Jef Raskin, the creator of the original Macintosh user interface, complains in (Wilkinson 2002) about the menu-based iDrive interface as the habitual mapping between controls and their functionality is lost:

> *"There are too many menus. You should be able to use an interface habitually, the way you do the brake and the accelerator, which never change their positions or functions. An interface user's gesture or motion should elicit the same response every time. Turning the iDrive knob shouldn't mean different things in different modes. You shouldn't need to stop and ask, 'What mode is this thing in right now?' You can never train a person to not make mistakes when there are modes."*

User interfaces in car audio equipment is an area that for a long time evolved with few radical steps. However, the recent emergence and proliferation of digital music technologies has considerably increased the number of features that the manufacturers are integrating in car audio systems; this is exactly the same

phenomenon that made BMW to introduce the iDrive system. A consumer review of recent MP3 car radios summarizes the contemporary devices by stating *"flamboyance has surpassed usability"* and concludes that *"none of the reviewed devices is very easy to use, and some are even dangerous"* [194]. The reason to this is that while the displays have grown larger and more colorful, the area available for controls has decreased. As a result, the manufacturers have had to reduce the number of control keys and knobs and put most of the functionality into menus, which makes function access tedious due to long key press sequences; an example is the VDO CD 4802 CD/MP3 player and RDS tuner in **Figure 84** — only the basic functionality like volume control, channel search, and MP3 playback, works without the menu system. The review states that accessing the radios' settings while driving is as dangerous as sending text messages with a mobile phone. The review further complains about the lack of consistency in interface design: the seven devices were from five different manufacturers, and all devices applied a different menu structure and logic.

Abiko F-8131A (1964) Blaupunkt Bristol (1984) VDO CD 4802 (2002)

Figure 84. Car audio system UI evolution

The abovementioned 'menu syndrome' is also mentioned in a Bang & Olufsen Beocenter 1 television consumer review[195]. The Beocenter 1 was introduced some years ago with a futuristic remote control called Beo 1, that was described by the manufacturer:

> *"None of its buttons are numeric or source related, instead the operation focusses upon an intuitive interaction with on-screen display. It takes product control to a new transparent level where operation becomes a part of the total experience."*[196]

This may have sounded very fitting to B&O's design approach but in reality the remote control proved to be unacceptable for controlling an advanced entertainment center. The remote control, shown in **Figure 85**, had few keys so all functions had to be accessed via a menu system. The user interface also applied timeouts so the key press sequences felt even longer to the users. In addition to the cumbersome user interface, consumers complained about the shiny, metallic finish, that looked clean and futuristic in showrooms but would very easily collect and show greasy fingerprints. Bang & Olufsen has now replaced the Beo 1 remote control with the more conventionally functioning Beo 4.

Figure 85. Beo 1

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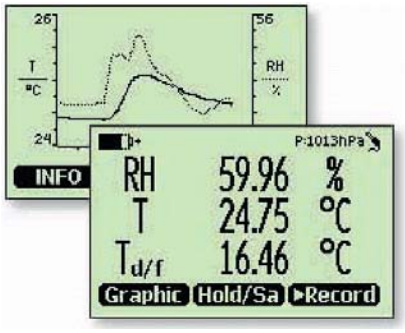
[194] Tekniikan Maailma. 8/2002. YHDEN LEVYN JUKEBOKSIT – MP3 AUTORADIOT. Review of seven MP3 car radios. Pp. 28 – 36. (The first statement in Finnish is *"Näytettävyys käytettävyyden edelle."*)

[195] Tekniikan Maailma. 5/2001. NAPPULAA. Review of Bang & Olufsen Beocenter 1 television. P. 127.

[196] Bang & Olufsen. BEO 1 DESCRIPTION. [Cited 05-Mar-2001] Available from WWW: <http://www.bang-olufsen.com>. (The B&O WWW site does not mention the Beo 1 any more in 2004.)

The ubiquitous mobile phone UI can and has already been utilized in completely other product domains. The Ensto Smart[197] shown below is a residential home control system to monitor and control the heating, lighting, ventilation, and safety of a house; the system also allows remote connectivity via a GSM modem option. The interaction style of the control panel user interface closely follows a mobile phone interaction style: the Ensto UI has two softkeys — the left one is used to make selection and confirmations, and the right one is used to cancel operations, and it has up and down scrolling keys. It's very much like the Nokia Two-softkey interaction style without the call handling keys; those are not needed in a home control system like this. The Vaisala HM70[198] hand-held humidity and temperature meter applies a three-softkey interaction style as shown below like the Panasonic P504i in **Figure 60**.

Ensto Smart user interface



Vaisala HM70 user interface displays

Figure 86. Mobile phone type interaction styles from other product domains

The mobile phone UI metaphor is obviously established well enough for companies in other industries, such as Finland's Ensto and Vaisala, to mimic it. Likewise, and in contrast to the abovementioned criticism towards multi-function, menu-based user interfaces in car environments, Lindholm (2003) thinks the Navi-key user interface logic could be used for many functions in a car. The Navi-key UI would probably be a working solution for *some* in-car functionality — provided that the number of features and menus is kept reasonable, and that the safety-critical functionality is still accessible via direct manipulation knobs, levers, and pushbuttons.

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[197] Ensto. HOME CONTROL SYSTEMS. [Cited 12-Oct-2004] Available from WWW: <http://www.ensto.com/www/english/index/home_electrification/SensibleSafetyandControlforYourHome/HomeControlSystems.html>.

[198] Vaisala. VAISALA HM70 BROCHURE. [Cited 12-Oct-2004] Available from WWW: <http://www.vaisala.com/DynaGen_Attachments/Att20571/HM70%20Brochure.pdf>.

4. RESULTS OF MEASURING INTERACTION STYLE USABILITY

The preceding sections in the thesis have introduced and investigated the drivers and approaches to consumer segmentation, product segmentation, and the related concept of user interface segmentation. The contemporary mobile handset user interfaces and interaction styles have been explored: practically all contemporary mobile phone user interfaces apply variants of the menu interaction style, the extended menus being indirectly manipulated with a small number of control keys. This section will approach the research problem from an empirical standpoint, and report about a usability testing experiment that was conducted with representative test users to investigate the measurable differences in usability caused by differences in mobile phone interaction styles.

The focus in the usability testing was Nokia's new Series 40 Three-softkey interaction style that was first introduced in the 3G Nokia 6650 W-CDMA phone[199] in September 2002. The section will first briefly describe the Three-softkey UI, and then the usability testing methodology is illustrated. The usability test findings and analysis are described at the end of the section.

The ISO 9241-11 (ISO 1998) definition of usability — *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* — does not explicitly mention errors. Nielsen (1993a) defines usability to comprise of the following attributes:

- Learnability
- Efficiency
- Memorability
- Errors
- Satisfaction

The empirical usability testing reported in this section focuses on the *efficiency*, and *errors* usability attributes. The initial objective was to measure also *learnability* and *memorability* but the business-driven technology development constraints did not allow these aspects to be incorporated into the testing schedule. These aspects are therefore touched in this work only briefly.

The objective in usability engineering is to create easy-to-use products, and to improve the efficiency of the operations. Keinonen (1998) calls this *inherent usability*. Without having used a specific product, it is obviously impossible to have a personal view on the usability of the product. However, people do create an assumption of the usability of a product or user interface already before they start to use it. This assumption is based on various factors such as the product's design language, the user's a priori knowledge of the product, or e.g. the manufacturer's brand (see e.g. Kurosu & Kashimura 1995, and Keinonen 1998). This viewpoint is often called *apparent usability*[200]. At Nokia, the terms '*real*'

[199] Nokia 6650 is the phone on the right in **Figure 89**.

[200] Keinonen (1998) uses the term 'one-dimensional usability' when studying the perceived usability in the domain of heart rate monitors. This 'one-dimensionalism' describes the

usability, and *perceived usability*, are often used to denote the same concepts, as illustrated in **Figure** 87.

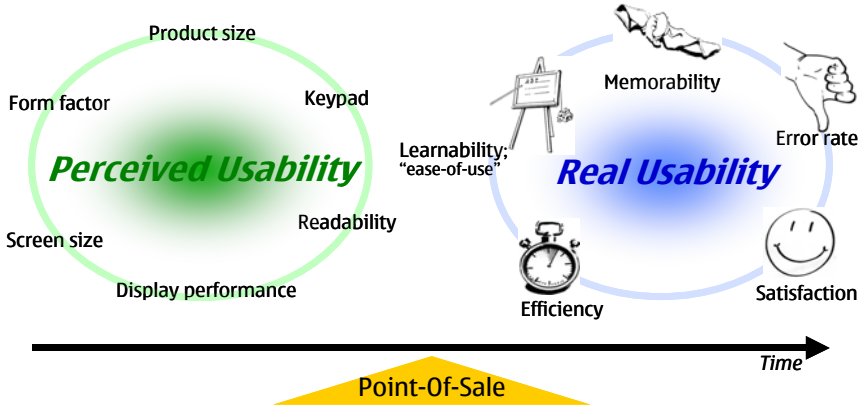

Figure 87. Perceived (apparent) and 'real' (inherent) usability[201]

As illustrated in **Figure** 87, *'real' usability* can be measured with Nielsen's usability attributes based on the user experience with the product and user interface. The *perceived usability*, however, denotes the understanding that the prospective consumer is establishing in her mind when e.g. considering a mobile handset in a store. The handset may be a non-functional mockup, and there is usually very limited time to familiarize oneself with a new handset in a store environment. Nevertheless, the consumer will usually create an impression of the new product, this being based e.g. on the perceived usability aspects such as product size and form factor, other industrial design aspects such as texture, color, and materials, display size and technology, and keypad ergonomics and readability; e.g. Keinonen (1998) reports that consumers regard only the number of buttons and display elements when assessing the versatility and complexity of heart rate monitors. We do not report any explicit, measurable aspects of the perceived usability of the mobile phone interaction styles in this study. It must be noted that the inherent usability measures do exist also before the purchase, and the notions of apparent usability are retained also when using the product — also, in this study the test users did not purchase the tested phones for themselves.

4.1 The Three-Softkey Interaction Style

In the empirical usability testing experiment the focus is on how people with different mobile phone usage backgrounds adopt and use a new mobile phone interaction style that they have no previous experience with. The new interaction style under scrutiny in the study is the **Three-softkey UI**, a new variant in Nokia's Series 40 user interface family[202]. A predecessor of the Three-softkey UI, the **Two-softkey Series 40 UI**, is a descendant of the original **Series 20 UI**[203] Nokia introduced in the 6110 and 6190 phones in 1997 (Kiljander & Järnström 2003).

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consumers' approach to apparent usability — only the number of buttons and display elements matter when assessing the versatility and complexity of the products.

[201] Image courtesy of Ms. Ako Shiraogawa.

[202] The working name "**Series 45**" was used for the Three-softkey interaction style, as illustrated in **Figure** 88.

[203] The author participated in the original Series 20 UI concept creation and usability engineering work in 1995 – 1996.

The Series 20 UI was an evolutionary step forward from the original **Two-softkey UI** Nokia had introduced in the 2100 series phones in 1995, as illustrated in the Nokia UI evolution timeline in **Figure 88**.

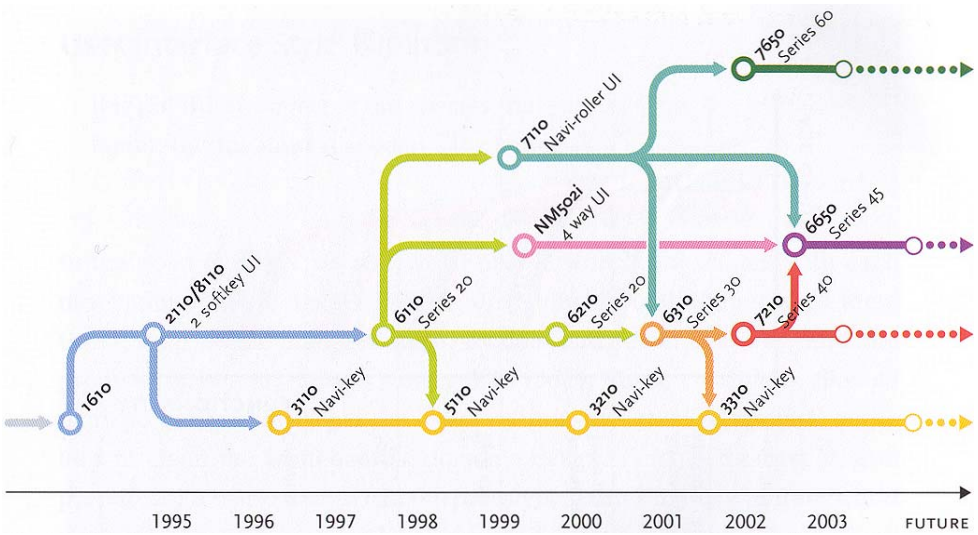

Figure 88. Nokia user interface evolution (Kiljander & Järnström 2003)

The Three-softkey UI was first developed for the Nokia 6650 W-CDMA phone illustrated in **Figure 89**.[204] The Three-softkey UI is an evolutionary step forward from the Navi-roller UI in the Nokia 7110 phone, the Four-way UI from the Nokia NM502i phone, and the Two-softkey Series 40 UI from the Nokia 7210 phone in the same figure below.

Figure 89. Nokia 7110, NM502i, 7210, and 6650 mobile phones

The Three-softkey interaction style shares many of its UI elements with the other Two-softkey UI variants. **Figure 90** illustrates the main similarities and differences between the older generations of the Two-softkey style and the new Three-softkey style.

[204] The author participated in the Three-softkey UI concept creation and design management work in 1999 – 2000.

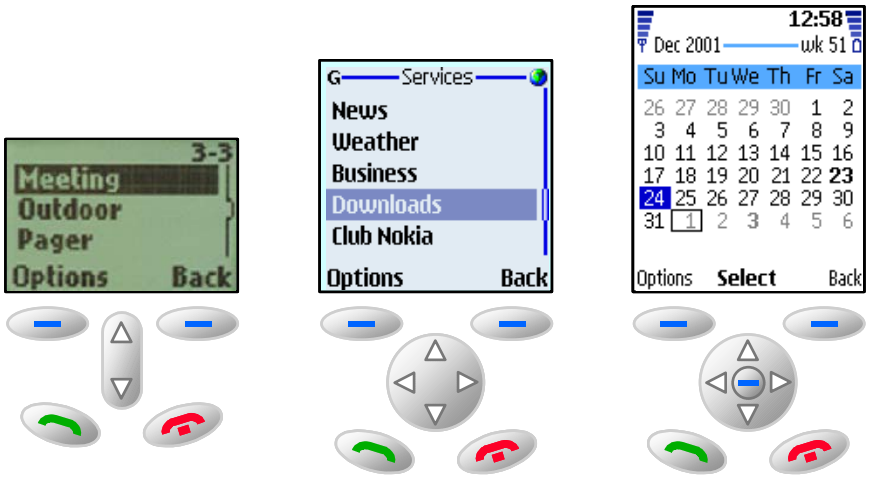

Figure 90. Original Series 20 (left), Two-softkey Series 40 (middle) and Three-softkey (right) user interfaces

The main interaction style difference between the Two-softkey and the Three-softkey user interfaces is the third, central softkey in the Three-softkey UI (Kraft et. al. 2003). The two-softkey user interfaces are based around an 'Options–Back' softkey interaction logic, where the leftmost softkey presents the forward-going selection action, or provides access to a context-specific list of available functions. The rightmost softkey provides a backstepping function or is used to erase characters in text editing states. This core logic facilitates a consistent interaction style available for individual phone UI applications. However, due to the increasing amount of features and functionality, it has also gradually led to situations where very often the leftmost softkey has to be labeled "Options", and there is no direct, labeled, one-key access to the most important function, such as e.g. "Select", "Reply", or "Open". This is a major usability deficiency in applications like Internet browsing, where the user is supposed to navigate between links on a content page and press a selection key to proceed. The Three-softkey UI attempts to solve this usability problem by introducing a new, centermost softkey that is used to provide immediate access to the most important function in each phone UI state. The centermost softkey can be implemented as a separate physical softkey or as the center element in the 4-way navigation device, and in the Nokia 6650 phone it has been integrated with the 4-way navigation rocker key due to product design considerations.

Obviously there are also other differences between the Nokia 6650 phone UI and the smaller-screen Two-softkey Series 40 phone UIs, such as the physically larger display in the 6650, and the new W-CDMA features such as the possibility to record, send, and receive video clips, but those are not directly related to the interaction style.

4.2 Measuring Usability against Earlier Usage Experience

Most of the consumers purchasing cellular mobile telephones in the developed markets are replacement customers — they have already been using one or more mobile phones. Due to this earlier experience with mobile phones and their user interfaces, we may assume that the users have learned to use these phones at least to some extent — they have formed a mental model of the products and their user interfaces. We may also assume that this earlier experience and expertise

plays a role when it comes time to replace the old handset and start using the new one.

The earlier experience can affect the initial replacement process at least in the following ways:

- If the user is satisfied with the previous handset, she is likely to consider the next one with the same brand. The user interface is likely to have influenced the establishment of the subjective satisfaction.

- If the user is unsatisfied with the previous device, she may be likely to consider other brands. The dissatisfaction may be caused by very diverse reasons such as unappealing design, poor usability, lack of right functionality, bad cellular coverage, inferior audio quality, unavailability of desired accessories, bad battery life, unsatisfying experience with customer support, unreliable mechanics or software, too high monthly bill, bad build quality, etc. Many of these, such as the subscription plan, are completely unrelated to the user interface or usability of the handset. Nevertheless, a complicated or unusable user interface is likely to create dissatisfaction as well.

- Earlier experience on using a wide variety of products is likely to ease the purchaser's concerns about purchasing something novel or more radical.

- Experience on using a certain type of interaction style is likely to ease the learning to use the new device, if the new device has a similar interaction style.

Keinonen (1998) reports that the user interface and perceived usability of the prospective new product do affect the purchasing decision making to some extent. Within the domain of the evaluated heart rate monitors this effect was quite superficial, though, as people considered devices with few buttons to be easier to use and have fewer functions than the ones with more buttons. It should be noted that there are many aspects in the mobile phone purchasing decision making process besides the user interface, such as the cost of the handset (subsidized or unsubsidized by the mobile operator or service provider), the subscription rate plan, the industrial design of the handset, the additional operator services bundled with the subscription, or even the free gifts sometimes offered by the mobile operators.

The main empirical research part in this study focuses on replacement customers' initial use of the new Three-softkey interaction style. Understanding the initial use of a new interaction style is relevant from several viewpoints:

- A mobile phone user wants to replace her previous handset and decides to have a new handset that may have a novel user interface. How easy will the transition be?
- A mobile phone manufacturer wants to get users of competing phone brands to buy its handsets. Will the different interaction style cause resistance or would the users be happy to move to something new?
- A mobile phone manufacturer introduces new user interface solutions in its product portfolio. Will this be seen as negative development, or as positive evolution?

- A mobile operator wants to harmonize and streamline its service offering and customer support. How will different interaction styles support this requirement?

4.2.1 Usability Testing Approach and Test Scenario

The objective in the empirical usability testing experiment was to find answers to the question of how easily consumers with varying mobile phone usage experience learn to master the new Three-softkey interaction style, and point out any specific problems in the new UI. The testing was conducted in the larger framework of the overall Three-softkey UI design and development work, and within that perspective the objective of the testing was to help to ensure that the transfer to the new Three-softkey UI will become as easy as possible for existing phone users.

Of the research questions outlined in **Section 1.2.1**, the empirical usability testing was devised to answer especially the following:

2. *What is the effect on usability caused by specific changes in the mobile phone interaction styles between products?*

From this top-level research question we deduced the following more detailed questions to drive the usability test setup:

2a. *Do people with different Nokia UI usage experience find the Three-softkey UI easy to use when they pick it up the first time? Is the Three-softkey UI intuitive for these users?*

2b. *Do people with non-Nokia UI usage experience find the Three-softkey UI easy/easier/harder to use? Are there significant differences between ex-Nokia and ex-non-Nokia users when it comes to usability of the new interaction style?*

2c. *Do people with varying mobile phone usage backgrounds learn the Three-softkey UI over a longer period of time? Do also those people learn the UI who had difficulties with initial use? Is the usage experience satisfactory?*

A fourth usability test research question was devised from a business perspective since the testing was part of the Three-softkey UI development effort, and we wanted to find out problematic issues that should still have to be improved in the user interface:

2d. *Are there specific issues we need to tackle when it comes to rolling the Three-softkey UI out in other mainstream phones? Should some elements in the Three-softkey UI still be revised before we introduce three softkeys in new phones? Is there something we should emphasize in the user guides, online help, marketing message, etc.*

To answer these research questions, we chose to conduct an empirical usability testing experiment with representative test users conducting a predefined set of representative test tasks. A heuristic usability evaluation or cognitive walkthrough would not have been an appropriate method since we wanted to investigate how the actual earlier usage experience affects the experience with the new UI. The tasks in the test scenario were chosen based on earlier, internal studies on mobile phone feature usage[205]. These studies had given an indication

[205] Mobile phone feature usage studies conducted in Taiwan, Italy, Philippines, and Denmark in 2002.

on the usage frequency of specific mobile phone functionality, so we chose to include some of these findings in our task set when defining the task priorities. Some of the test tasks stem from earlier usability testing conducted with UI prototypes. The three-softkey UI is first introduced in the Nokia 6650 W-CDMA phone with new functionality such as multimedia messaging and digital video recording, so we decided to use this test round to verify some earlier design decisions. One of the Nokia usability groups had conducted a separate usability testing project some months earlier[206] and we selected some of the test tasks from their test scenario in order to be able to compare our findings later. The set of usability test tasks eventually evolved into the task list presented in **Figure 91**.

Task	Task name	Task details	Justification
T1	Make a call from the phonebook	Start from idle. Find <observer> from the phonebook and call him/her to tell you have a new phone. End the call. Return to idle.	Voice calls are the most common use of a phone and phonebook is the most commonly used application.
T2	Set the time	Start from idle. Set the right time and put the clock visible on the idle display. Return to idle.	Study menu navigation.
T3	Save a name with multiple numbers	Start from idle. Save "Jenni Ahomaa", 09-9873298 (home), 040-7754082 (work) to the phonebook. Return to idle. Upper and lower case letters do not matter.	Test how intuitive the multiple numbers feature is.
T4	Take a picture	Start from idle. Take a picture (with the default settings) and name it "Hieno" ("Fine"). Return to idle.	Camera and Gallery are new features in Nokia phones.
T5	Send an MMS with a picture	Start from idle. Compose a MMS "Mahtavaa!" ("Cool!"), attach the newly taken picture, and send the MMS to own email address. Return to idle.	MMS must be very intuitive.
T6	Set the ringing tone	Start from idle. Change the current ringing tone to "Ring ring". Return to idle.	Study menu navigation.
T7	Set alarm clock	Start from idle. Set alarm to 06:00 tomorrow morning. Return to idle.	High-frequency task in real use.
T8	Set speed dial	Start from idle. Set up your phone so you can call <observer> with a speed dial. Return to idle.	Compare with CDMA usability study.
T9	Use speed dial	Start from idle. Call <observer> with the speed dial. End the call. Return to idle.	Compare with CDMA usability study.
T10	Find free meeting times next week	Start from idle. Find out if you have anything scheduled for the week starting on April 7th. Return to idle.	The task tests how well the UI presents complex information to the user.
T11	Set a meeting appointment	Start from idle. Create a calendar event "Palaveri" ("Meeting") in Ruoholahti for April 9th at 09:30-11:00 and set the alarm 30 minutes before the event. Return to idle.	Usage studies indicate reminders are used frequently.
T12	Use Zed to check Helsinki weather	Start from idle. Use the Zed service to find out the next-day weather forecast for Helsinki. Return to idle. The Zed bookmark is pre-defined in the phone.	Verify browser usability in the Three-softkey UI.
T13	Send SMS	Start from idle. Send SMS "Kohta tämä loppuu!" ("Soon this will be over!") to <observer>. Return to idle.	Compare with CDMA usability study.
T14	Download ringing tone content	Start from idle. Download the polyphonic midi ringing tone "X" from WAP-page "Y". Set it as the default ringing tone to your phone. Return to idle.	Study mobile service discoverability and usability.
T15	Manage Gallery folders	Start from idle. Create a new folder "Omat äänet" ("Own tones") under "Äänet" ("Sounds") folder. Move the ringing tone that you just downloaded to the new folder. Return to idle.	Study Gallery advanced usage.

Figure 91. Usability test scenario

[206] Comparative usability study conducted by Nokia CDMA Usability Group in San Diego in 2002.

To answer the four detailed research questions listed above we needed to conduct the usability tests with users having Nokia phone experience and also to find non-Nokia phone users to be tested. We also wanted to investigate the learnability of the Three-softkey UI so a long-term usage period had to be arranged. To facilitate all this within the constraints of business-driven usability engineering work, the full usability test scenario presented in **Figure 91** was split into focused test task sets as illustrated in **Figure 92** below.

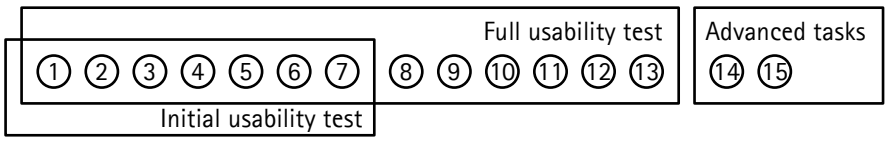

Figure 92. Usability test sets

The **full usability test** was run with Nokia and non-Nokia test user groups to find answers to our research questions 2a and 2b:

> ***2a.*** *Do people with different Nokia UI usage experience find the Three-softkey UI easy to use when they pick it up the first time? Is the Three-softkey UI intuitive for these users?*
>
> ***2b.*** *Do people with non-Nokia UI usage experience find Three-softkey UI easy/easier/harder to use? Are there significant differences between ex-Nokia and ex-non-Nokia users when it comes to Three-softkey usability?*

The **initial usability test** tasks, **full usability test** tasks, and the **advanced test** tasks were used in the usability tests before and after the long-term usage period to find answers to question 2c:

> ***2c.*** *Do people with varying mobile phone usage backgrounds learn the Three-softkey UI over a longer period of time? Do also those people learn the UI who had difficulties with initial use? Is the usage experience satisfactory?*

First the initial usability test was conducted, then the test users got Nokia 6650 phones to be used as their primary phones for a period of two months. After this period the users were called to the full usability test where we had also added two additional advanced tasks. The initial test was kept short to meet the practical considerations: the test phones had to be handed out to all test users in a rapid manner during one day.

All usability tests were used to gain insight into question 2d:

> ***2d.*** *Are there specific issues we need to tackle when it comes to rolling the Three-softkey UI out in other mainstream phones? Should some elements in the UI still be revised before we introduce the UI in new phones? Is there something we should emphasize in the user guides, online help, marketing message, etc?*

The role of question 2d was to provide insight into the possibly unresolved usability issues in and around the Three-softkey UI. A big portion of the data acquired during the experiment is actually focusing on these aspects of the UI and the total product, and not so much on the usability of the Three-softkey interaction style as such. The usability testing project revealed that the usability of the Three-softkey interaction style is on a good level, but there is still specific UI design and usability engineering work to be done to improve certain applications and functionality in the UI. These findings and improvement activities are not described in this thesis.

4.2.2 Earlier Experience Interaction Styles

Three Nokia, and three non-Nokia mobile phone interaction styles were selected as the earlier experience baselines to the study. These represent a majority of the contemporary user interaction style variants. The test user recruitment focused on finding representative test users using phones designed around the user interfaces illustrated in **Figure 93**.

Interaction style	Motorola	Nokia Navi-key	Nokia Series 60	Siemens	Nokia Two-softkey	(Sony) Ericsson Yes-No
Interaction style description	Two dynamic softkeys (usually Exit & Select), dynamic Menu softkey, joystick or scroll keys for navigation, red and green calling keys	One softkey for the context-sensitive primary function, Cancel key, up-down scroll keys for navigation	Two dynamic softkeys (usually Options & Back), static Menu key, joystick for navigation and selection, backspace and ABC keys, green and red calling keys	Two dynamic softkeys (usually primary function & Options/ Select), scroll keys for navigation, green and red calling keys	Two dynamic softkeys (usually Options/ Select & Back), scroll keys for navigation, green and red calling keys	Yes-No function keys, 4-way navigation keys, backspace/ cancel/menu key, Internet/ menu key
Representative mobile phone model	 Timeport 280	 3330	 7650	 MT50	 3360	 T65

Figure 93. Earlier experience interaction styles for usability testing

The Motorola interaction style shares the same control keys with the new Three-softkey interaction style but the softkeys are arranged so that the Cancel and backstepping softkey is on the left, the Select softkey is on the right, and the Menu softkey is in the middle. In the Three-softkey UI the menu (Options) softkey is on the left, Select is in the middle, and Cancel is on the right. The presentation styles are also somewhat different.

Nokia's Navi-key interaction style is the world's most widely used mobile phone interaction style with over 300 million users (Alkio 2003). Nokia's Two-softkey interaction style is used in numerous Nokia mobile phones, and despite the underlying similarities with the Navi-key interaction style, the look and feel of the Two-softkey-equipped phones is very different than the Navi-key ones. Nokia's Series 60 interaction style shares the Two-softkey interaction heritage with the Options-Back softkeys but adds a selection key, more navigation possibilities with graphical UI components, and a multitasking application environment.

The Siemens interaction style shares the same keys with the Nokia Two-softkey interaction style but instead of having the Options/Select – Back softkeys, Siemens maps the Options/Select on the right softkey and reserves the left softkey for a context-sensitive function. Canceling and backstepping is done with the red

handset key in Siemens. This is something the users must learn, as it is a hidden function, and not labeled on the keypad.

The (Sony) Ericsson interaction style is the one relying on a non-softkey interaction paradigm[207], and a large Ericsson mobile phone user community exists, so the Yes-No interaction style was chosen as one of the earlier experience interaction styles.

Samsung is the only one of the top five manufacturers whose interaction styles were not selected to the study. This was because the heuristic interaction style analysis concluded that the Samsung interaction style is quite similar to Nokia's Two-softkey UI with the exception of one additional key for erasing characters. The menu structure and presentation style in Samsung phones is also quite similar to the Nokia UI. It was anticipated that there would have been no significant differences between Samsung and Nokia Two-softkey users in the empirical usability study. Another aspect was that recruiting Samsung phone users with no Nokia phone usage experience would have been very difficult in Finland.[208]

4.2.3 Usability Test Users

The usability tests were conducted in Finland between January and April in 2003. Representative test users were recruited via personal contacts, Internet newsgroups, and through a sudden but fortunate access to a W-CDMA handset trial usage project between Nokia and Sonera, the largest mobile operator in Finland. One early pilot test session was conducted before the test scenario was finalized. The first test session with the full test scenario was initially considered as a pilot test but the arrangements were running so smoothly that its findings are included in the analysis here. In total, 38 test users participated in the actual usability tests, and on top of that three Nokia usability engineers were tested as reference expert users.

It proved to be very difficult to recruit people having no earlier Nokia mobile phone experience. It must be remembered that the tests were conducted in Finland where most people seem to have had at least some exposure to Nokia phones due to family members, friends, or colleagues. Initially the test plan was to recruit representative mobile phone users having either Ericsson, Motorola, Nokia, or Siemens phone usage experience but Motorola users proved to be very scarce. **Figure 94** lists the sizes of the test user groups based on the previous phone interaction style. The test user demographics are summarized in **Figure 95**.

[207] As explained in **Section 3.3.6**, Sony Ericsson is gradually moving to a softkey-based interaction style in its product portfolio.
[208] No Samsung phone users were found when recruiting test users to the usability tests.

Interaction style	Representative test users
Motorola	1 (user 9)
Navi-key	11 (users 16, 23, 31, 33, 34, 35, 37, 38, 39, 40, 41)
Series 60	4 (users 15, 17, 19, 27)
Siemens	6 (users 3, 5, 6, 10, 11, 12)
Two-softkey	10 (users 1, 18, 20, 21, 22, 24, 25, 26, 32, 36)
Yes-No	6 (users 2, 4, 7, 8, 13, 14)

Figure 94. Usability test user groups; expert users excluded

Test user	Age	Gender	Occupation	Current phone	Interaction style	How long has used phone[209]	Earlier phones	How long has used phones[210]
1	25-34	F	Development Manager	Nokia 9210i	Two-softkey	18	"Red Panasonic", Nokia 9210, Nokia 6310i, Nokia 3210, Nokia 7110	7
2	15-24	M	Student	Ericsson 110S	Yes-No	30	Ericsson 688, Nokia 3210	4.5
3	35-44	M	Editor	Siemens S35	Siemens	24	Nokia, Siemens, Panasonic, Siemens	7-8
4	25-34	F	Economics Student	Ericsson T29S	Yes-No	24	Nokia 2110, Panasonic, Ericsson	5
5	25-34	M	SW Engineer	Siemens ME45	Siemens	12	Ericsson, Panasonic	5.5
6	25-34	F	Industrial Designer	Siemens C35	Siemens	1	Ericsson T28, Ericsson, Nokia 1995	8
7	25-35	M	Carpenter	Ericsson R380S	Yes-No	6	Motorola Ringo, Nokia 3110, Ericsson, "one cheap phone", Nokia 6150	4-5
8	15-24	M	Student	Ericsson E28i	Yes-No	24	Ericsson T10, Panasonic, Nokia 3110, Nokia 2010	6-7
9	15-24	F	Student	Motorola V2280	Motorola	30	Nokia 8110, Ericsson 868	5-6
10	25-34	F	Industrial Design Student	Siemens S45	Siemens	12	Motorola -95, Ericsson	7-8
11	25-34	M	Industrial Design Student	Siemens M35	Siemens	12	Motorola Flare, Nokia 5110, Sony CDX100, Nokia 6110, Nokia 9110i	5
12	15-24	M	Student	Siemens C35	Siemens	18	Ericsson	2.5
13	35-44	M	Computer Science Professor	Ericsson	Yes-No	18	Ericsson R520m, Ericsson 880, Nokia 101	7-8
14	25-34	F	Student	Ericsson A2618S	Yes-No	24	Nokia Ringo -97, Nokia 6110 -97	5-6
15	55-	M	Development Manager	Nokia 7650	Series 60	7	Nokia 6110, Nokia 7650, Nokia 6310	15
16	25-34	F	Marketing Designer	Nokia 3310	Navi-key	24	Nokia 6150	5.5
17	25-34	M	Business Manager	Nokia 7650	Series 60	12	Nokia 2110, Nokia 6110, Nokia 6210, Nokia 7110, Ericsson T39, Ericsson T68, Ericsson T68i	12
18	25-34	M	Graphic Designer	Nokia 6210	Two-softkey	18	Ericsson, Nokia 3210, Nokia 6110	6
19	35-44	F	Development Manager	Nokia 7650	Series 60	6	Ericsson, Motorola, Nokia 2110, Nokia 6210, Nokia 9110, Nokia 6110, Nokia 8310, Nokia card phone	From ARP
20	15-24	M	SW Engineer Trainee	Nokia 5210	Two-softkey	1	Siemens c25	5
21	25-34	M	Design Engineer	Nokia 6110	Two-softkey	2	Nokia 7650, Nokia 5110	4
22	25-34	F	Administrative Assistant	Nokia 7250	Two-softkey	6	Nokia 2110, Nokia 6110, Nokia 8850, Nokia 7210	7
23	25-34	M	Patent Engineer	Nokia 3300	Navi-key	4	Nokia 7650, Nokia 8110, Nokia 6510, Siemens m35	7
24	25-34	F	Business Analysis Manager	Nokia 7210	Two-softkey	6	Nokia 6210, Nokia 6110, Nokia 2110	8
25	25-34	F	IM Specialist	Nokia 6800	Two-softkey	3	Nokia 6310i, Nokia 8310, Nokia 3210, Nokia 3110	5
26	25-34	F	IM Specialist	Nokia 7250	Two-softkey	1	Nokia 6100, Nokia 7210, Nokia 8210, Benefon IO, Ericsson	7
27	15-24	M	IM Specialist	Nokia 3650	Series 60	0.5	Nokia 6110, Nokia 9110, Nokia 6510i	5
28	15-24	F	Usability Engineer	Nokia 7650	Series 60	4	Several Nokia and other phones	6
29	35-44	M	Usability Engineer	Nokia 7650	Series 60	7	Several Nokia and other phones	7
30	25-34	M	Usability Engineer	Nokia 7250	Two-softkey	3	Several Nokia and other phones	7
31	25-34	M	Testing Engineer	Nokia 3210	Navi-key	42	Nokia 6110, Nokia 5110, Nokia 2110,	3.5

[209] Usage period of the current phone in months.
[210] Overall mobile phone usage period in years.

							Nokia 3110	
32	25-34	M	Police Officer	Nokia 6310	Two-softkey	1.5	Nokia 6310, Nokia 5110	7
33	15-24	F	Medical Student	Nokia 3310	Navi-key	18	Nokia 3210, Nokia 5110	4
34	25-34	F	Student	Nokia 3310	Navi-key	24	Nokia 880	7
35	15-24	F	Student	Nokia 3310	Navi-key	7	Nokia 1611. Nokia 3310, Nokia 6110	6
36	25-34	M	Testing Engineer	Nokia 6110	Two-softkey	42	Nokia 2110, Nokia 3310, Nokia 6110	6
37	25-34	F	Psychologist	Nokia 3310	Navi-key	18	Nokia 2110i, Nokia 3210, Nokia 3310	7
38	25-34	F	Medical doctor	Nokia 3210	Navi-key	60	Motorola, Nokia 3210	5
39	15-24	F	Student	Nokia 3310	Navi-key	24	Ericsson, Nokia	5.5
40	15-24	F	Student	Nokia 3210	Navi-key	30	Nokia 3110, Siemens C36	5
41	15-24	F	Student	Nokia 3310	Navi-key	4	Nokia 1630, Nokia 3110, Nokia 5110, Nokia 3210	4

Figure 95. Usability test users[211]

The age and gender distribution of the test users is illustrated in **Figure 96**.

	15–24	25–34	35–44	45–54	55–	Total
Male	5	10	2	-	1	18
Female	6	13	1	-	-	20
Total	11	23	3	0	1	38

Figure 96. Age and gender distribution of test users; expert users excluded

14 of the 41 test users were Nokia employees. Three of these were the representative expert users, and the remaining 11 users were screened to have no direct working relationship with mobile phone UI development.[212]

Users 1 – 14 and 20 – 41 conducted the full usability test[213] i.e. the test tasks 1 – 13 from **Figure 91**. The tests were conducted in a Nokia 'portable' usability laboratory setting; 'portable' denoting a facility such as a corporate meeting room not originally designed for usability testing but having all necessary usability testing equipment available.

The usability engineering team was able to team with a W-CDMA pilot project established as a joint effort between Nokia and Sonera. A number of Nokia 6650 phones were given to Sonera employees to test the new W-CDMA cellular network and 3G services in real usage situations and contexts. Users 15 – 19 were Sonera employees having no previous exposure to the Nokia 6650 phone. They first conducted the initial usability test consisting of test tasks 1 – 7. They were then given the Nokia 6650 phones to be used as their primary phone for the next two months. After the two months period the same people were called in for the full usability test with the additional two advanced tasks 14 – 15. The testing team decided to apply a usage period of two months since that was considered long enough for the test users to get reasonably familiar and competent with the phone user interface, and it was still short enough for the busy, business-minded test users not to upgrade their prototype phones to some newer model. Initially,

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[211] User 1 was a pilot test user but since the test setup was comparable to the other test sessions, the results were analyzed with the data from the other test sessions. Users 15 – 19 were Sonera people participating in the Nokia–Sonera W-CDMA pilot project. Users 28 – 30 were Nokia usability engineers who were tested as representative expert users for the 6650 handset and the Three-softkey interaction style.

[212] This is the standard screening criteria that is applied when internal test users are recruited for mobile phone usability testing at Nokia.

[213] See **Figure 92**.

there was a plan to test a larger group than just five long-term users, but the overall W-CDMA pilot project time schedule and constraints did not eventually make this possible, however.

4.2.4 Portable Usability Laboratory Setup

The usability testing sessions were conducted in Nokia premises in Helsinki, Salo, and Tampere, with the exception of tests 15 – 19 that were conducted in Sonera premises in Helsinki. The testing setup is illustrated in **Figure 97**.

A usability test session lasted between 45 minutes and two hours. After the test user had been escorted into the usability lab, the moderator explained the testing procedure and arrangements to him or her. The user was asked to sign a standard non-disclosure agreement, and to sign an agreement to approve the video recording. A pre-test questionnaire (see **Appendix 1**) was filled in by the moderator when interviewing the test user. The moderator then gave the test briefing (seen in **Appendix 2**) to the user and the actual testing started. A test task was read aloud to the test user, and in some tasks having several details to memorize (e.g. task 3: saving a name with multiple numbers) a test task handout was also given to the test user as illustrated in **Figure 97**.

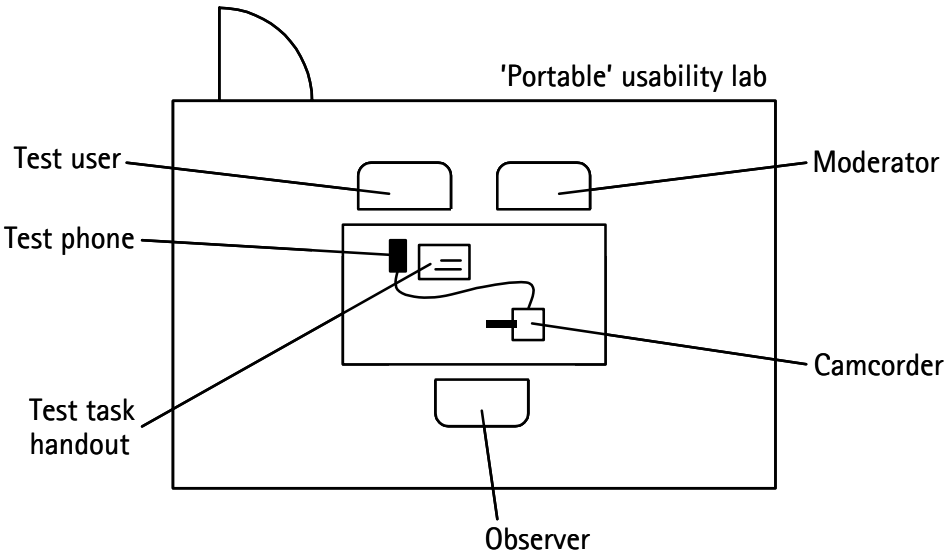


Figure 97. Usability testing facility setup

The observer was monitoring the test session as illustrated in **Figure 97**, taking notes, and assisting in problem situations (e.g. when the software in the prototype phones occasionally crashed). The test session was videotaped with the help of a small observation camera attached to the test phone as illustrated in **Figure 98**. The video signal from the observation camera was recorded with a camcorder, and the external LCD display of the camcorder was used by the observer to follow the user behavior with the handset. **Figure 98** also shows an image from the observation camera as viewed from the camcorder display.

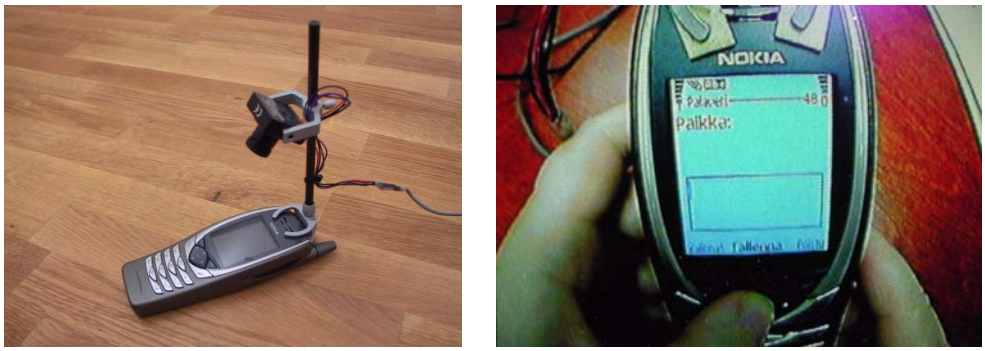


Figure 98. Mobile phone usability test observation camera[214] attachment and the camera image as seen on the observation monitor display

All test tasks started from the basic state of the phone (often referred to as the "idle display") and the user was instructed to return back to the same state after she had completed the task. After each task the user was asked to rate the ease of use of that specific task with a five-point Likert scale ranging from Easy to Difficult as illustrated in the post-test questionnaire in **Appendix 3**. The five-point ratings were afterwards mapped onto a three-point scale to facilitate comparable data analysis.

Between each usability test session the observer initialized the test phone back to the initial configuration which included resetting the phone clock, clearing any new calendar events the user had created, removing the newly created pictures, messages, alarms, etc.

At the end of the test the user was asked to express his or her feelings about the ease of use of the phone, to describe what was good, what was bad, and there was also a possibility for her to ask any questions that had been raised during the test session.[215] As a reward the user was then given two movie tickets before the moderator escorted him or her out of the usability lab.

4.2.5 Measuring Usability: Effectiveness

Effectiveness is about users achieving their goals and completing their tasks with the product and with the user interface. The effectiveness of the Three-softkey interaction style was measured with the task success rate and the number of hints given by the moderator. The moderator hints were not measured when assessing task completion. A task was reported not completed if the user did not complete the goal expressed in the task instructions. During the first tests it was noticed that some of the test case wordings were obviously causing some

[214] The 'snap-on' observation camera equipment has been developed by Nokia Research Center's Usability Group. The camera is attached to a rod protruding from the upper end of the phone so holding the phone naturally on one's ear is not possible; therefore the test users were instructed not to speak on the phone but just initiate the phone call and end it immediately in the calling tasks.

[215] Most of the test users felt very positive after the test even if they had gone through some complex tasks and been somewhat frustrated during the test. One of the most enthusiastic test users asked the usability team to improvise additional test tasks after the planned ones were completed, since he wanted to play more with the phone and "assist the design team in creating an even better UI."

misunderstandings so we decided to loosen the task completion criteria in the following test cases:

- In task 3 the user was asked to store a name with multiple numbers in the phone's memory. After observing some early test users it became obvious that some of the users did not realize the phone can support multiple numbers per one name so some users stored multiple name/number pairs into the phone memory. This was not classified an error since it was possible that the test briefing had been somewhat unclear, and some test users had not been aware of this functionality. Likewise, the test instructions indicated the phone numbers to be stored were of type 'home' and 'work'. The work number was also a mobile number as seen from the area code. Observing some users' behavior indicated they were consciously assigning or not assigning the number types based on their personal number coding schemes such as incorporating the number type in the name entry field. It would have been impossible to analyze which ones of the test users consciously deviated from the test instructions and who unconsciously skipped the test instructions, so we decided to ignore the number type settings when assessing the completion status for task 3.
- Due to the observation camera attachment it was impossible to hold the phone naturally close to one's ear, so we decided to measure the end time in the call management tasks at the point of call initiation. This also made the task times comparable as some users spent a considerable amount of time while the call was active and some users ended the call immediately after it was initiated.
- In task 4 the users were asked to rename a newly taken picture. Due to the phone software still being in prototype stage, the phone crashed in three test sessions at some point after the user had renamed the picture. We decided to set the end time for the task at the point when the user had just renamed the picture to get comparable timing data for all test users.

The success rate was very high in this study. One test user from the Two-softkey group did not complete task 5 (sending a multimedia message), as he did not attach the picture to the message. This was the only task that failed. In general the test users seemed to manage relatively well with the test phone, many of them seemed to take pride in completing the tasks, and practically all of them felt quite relaxed after the test session, even if some of the tasks had made them scratch their heads or turn to moderator hints.

The task moderator gave a short hint to the user if the user was stuck in a task with no visible progress for a couple of minutes. The hints were of type "You cannot do that in this place now – perhaps you should search some other location?" or "You have already been in the right place." The number of moderator hints per task is shown in **Figure 99** (left). **Figure 99** (right) illustrates the proportion of hints given for a specific user group compared to the proportion of the user group of the total test sample. It must be noted that some of the sample groups are quite small (see **Figure 94**) but we can see that the Two-softkey (n=10) and Yes-No users (n=6) were given relatively more hints than what e.g. the Series 60 (n=4) or Siemens users (n=6) received.

The number of hints per task proved to be a relatively good indication of faults in the UI design; not so much on the interaction style level but on an application or feature level. As an example, task 2 ("Set the right time and put the clock visible on the idle display.") was supposed to be a very easy task (and that is one reason why it was put at the beginning of the test scenario) but 9 users (2 Yes-No users and 7 Nokia users) still had to be assisted by the moderator. The tested UI design solves the goal in this task via a two-step procedure: first the user must set

the time, and then she has to go back to the time settings sub-menu to set the clock visible on the display. An improved UI design is obviously needed to simplify this.

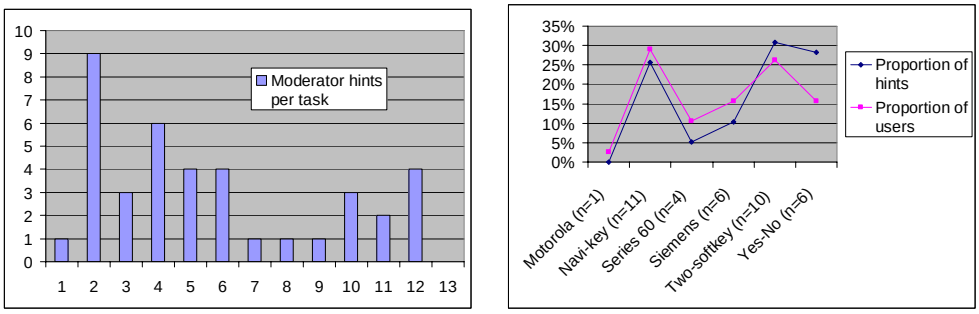


Figure 99. Moderator hints (across all user groups), and proportion of hints compared to user group's relative size

The expert users obviously received no moderator hints and their task completion rate was 100%.

4.2.6 Measuring Usability: Efficiency and Ease-of-Use

Efficiency is related to the effort required to complete a task with a product and a user interface. To analyze efficiency we measured task times and errors in task flow. The observation clock was started when the user made the first key press (or started to search for the camera in task 4) and it was stopped when the user had returned back to the idle state after having completed the task. Exceptions to these timing conventions and their justification were described in **Section 4.2.5**. The expert times were measured for reference by calculating the average task times for each of the three expert users when each of them conducted the test tasks three times in a consecutive manner.

We defined *error* as *a deviation from a correct interaction sequence*.[216] It should be noted that there may be several correct interaction sequences per each test task; e.g. one can access the phonebook via a shortcut (press the Down key from the idle state, or press the right softkey "Names"). One of the most common errors with small-screen mobile devices is that the user scrolls beyond the menu item she is looking for; we did not categorize this explicitly as an error. Searching for an item in a list or sub-menu was not flagged as an error, as long as the user did not leave the correct sub-menu or list by going deeper or backstepping. Backstepping from a correct state onto a wrong navigation path was counted as an error. If the user scrolled through a correct list twice without selecting the correct item, we counted this as an error. Selecting a wrong main menu or sub-menu was counted as an error. To make it possible to get comparable and reliable error data we decided to use a binary error count per test task: either there were no errors in a task or there were error(s). It would have been extremely tedious and error-prone to count the individual menu navigation errors per each task and each user.

[216] In the Nokia 7110 mobile phone usability test, Kiili (2002) registers an error when participant exits the right (navigation) path while performing a task, or if participant hesitates and takes a step backwards on the right path.

Since the phone was still in a prototype stage, we knew that the control key mechanics were likely to cause erroneous behavior. To collect research data for the mechanical engineers and industrial designers, we decided to flag navigation errors caused by inadequate tactile feel or bad ergonomics with the navigation cluster key also as errors.

Some tasks involved text entry with special characters. As there are no industry standard conventions for special characters, it was assumed that especially non-Nokia users will struggle to find the correct characters such as the exclamation mark or full stop. The users' erroneous actions when searching for the special characters were not counted as errors.

Figure 100 below illustrates the average percentage of users making errors per test task. The chart indicates that on the average, 29% of Series 60 group users made an error or errors in a test task, while 50% of Siemens group users did the same. The measured error counts for the larger groups (Yes-No, Two-softkey, Siemens, and Navi-key) are relatively close to each other.

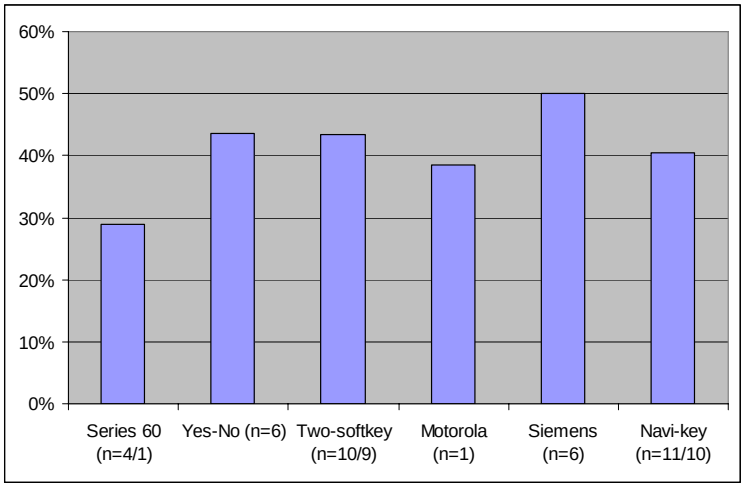


Figure 100. Average percentage of users making errors per task[217]

The cumulative average task times per user group are illustrated in **Figure 101**. The charts include only users who completed all task 1 – 13 so the long-term test user who could not participate in the final test have been excluded from the analysis.

Descriptive statistics for the average cumulative task times are shown in **Figure 102**. Applying the 90% confidence interval ($\alpha = 0.10$) shows statistically significant differences: the Navi-key user group and the Siemens user group are faster than the Yes-No user group. This finding is in line with the moderator hints; **Figure 99** shows that the Yes-No users were assisted by the moderator more often than the other user groups.

[217] Group sizes denote the number of users who conducted tasks 1–7 and 8–13, respectively. Some of the test users conducted only tasks 1–7.

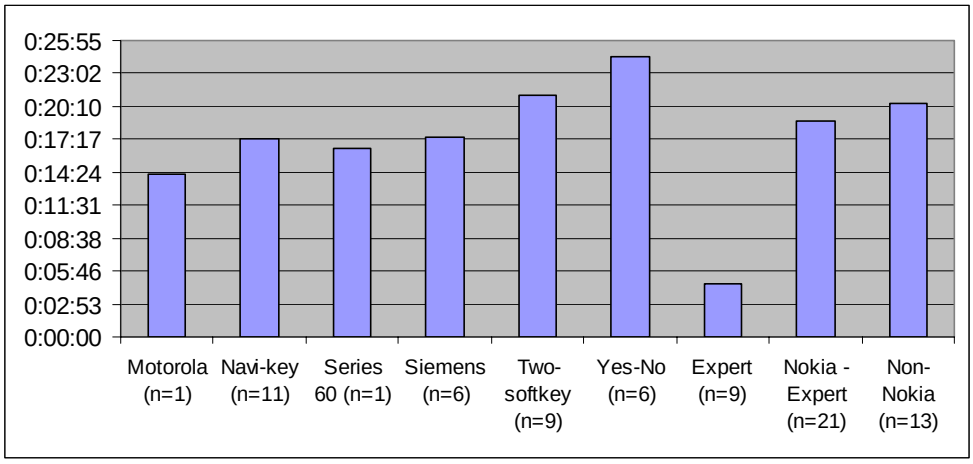


Figure 101. Average cumulative task times per user group

	Cumulative task times per group								
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	90% confidence interval	Novice/ Expert
Motorola	1	0:14:17							3.1
Navi-key	11	**0:17:18**	0:04:26	0:17:33	0:07:45	0:23:29	0:14:40 - 0:19:55	**0:15:06 - 0:19:29**	3.7
Series 60	1	0:16:33							3.6
Siemens	6	**0:17:25**	0:02:05	0:16:54	0:14:52	0:20:02	0:15:46 - 0:19:05	**0:16:02 - 0:18:49**	3.7
Two-softkey	9	0:21:05	0:07:18	0:19:56	0:11:32	0:36:26	0:16:19 - 0:25:51	0:17:05 - 0:25:05	4.5
Yes-No	6	**0:24:33**	0:06:02	0:24:42	0:18:05	0:34:55	0:19:44 - 0:29:23	**0:20:31 - 0:28:36**	5.3
Expert	9	0:04:39	0:00:26	0:04:34	0:04:10	0:05:24	0:04:22 - 0:04:56	0:04:25 - 0:04:53	1.0
Nokia - Expert	21	0:18:53	0:05:55	0:18:32	0:07:45	0:36:26	0:16:21 - 0:21:24	0:16:45 - 0:21:00	4.1
Non-Nokia	13	0:20:28	0:05:45	0:19:10	0:14:17	0:34:55	0:17:21 - 0:23:36	0:17:51 - 0:23:06	4.4

Figure 102. Descriptive statistics of cumulative task times

What we can see from the chart above is that the Yes-No users were the slowest to complete the test scenario, with the Two-softkey users being the second slowest, and the Navi-key, Series 60, and Siemens users being somewhat faster. This is a rather interesting finding when compared to the fact that the Yes-No users were the ones who regarded the 6650 phone to be the easiest when compared against their current phone, as illustrated in **Figure 129**.

The average cumulative task times for the test user groups are within 3.7 – 5.3 times the experts' cumulative task time; with the one-person Motorola group excluded. The Motorola group consisting of one lone user is included on the charts and tables below, but a one-person group clearly does not represent any users reliably so it is excluded from further analysis.

Task-specific ease-of-use was measured with a question asked after each test task as shown in **Appendix 3**:

How easy or difficult this task was? Easy □□□□□ Difficult

The task 1 (**"Find <observer> from the phonebook and call him/her to tell you have a new phone. End the call."**) user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 103**.

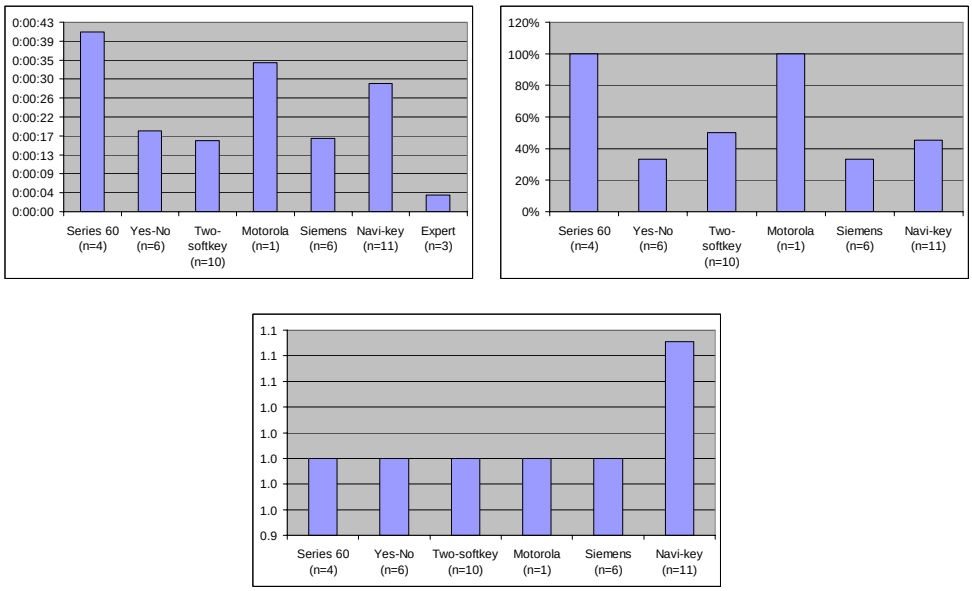


Figure 103. Task 1 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T1	Call from phonebook							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:00:34						9.0
Navi-key	11	0:00:35	0:00:25	0:00:23	0:00:08	0:01:34	0:00:20 - 0:00:50	9.2
Series 60	4	0:00:45	0:00:17	0:00:42	0:00:30	0:01:08	0:00:28 - 0:01:02	12.0
Siemens	6	0:00:17	0:00:13	0:00:12	0:00:05	0:00:34	0:00:06 - 0:00:27	4.4
Two-softkey	10	0:00:21	0:00:13	0:00:18	0:00:04	0:00:53	0:00:12 - 0:00:29	5.5
Yes-No	6	0:00:18	0:00:16	0:00:13	0:00:04	0:00:49	0:00:06 - 0:00:31	4.9
Expert	9	0:00:04	0:00:01	0:00:04	0:00:02	0:00:05	0:00:03 - 0:00:04	1.0
Nokia - Expert	25	0:00:31	0:00:21	0:00:23	0:00:04	0:01:34	0:00:22 - 0:00:39	8.1
Non Nokia	13	0:00:19	0:00:14	0:00:15	0:00:04	0:00:49	0:00:11 - 0:00:26	5.0
All - Expert	38	0:00:27	0:00:20	0:00:20	0:00:04	0:01:34	0:00:20 - 0:00:33	7.1

Figure 104. Task 1 timing descriptive statistics per user groups

The error chart shows the proportion of users per each user group who made errors in the task. For each test user we measured whether she made errors or not; the individual errors per user were not counted within one task. The error chart in **Figure 103** reveals e.g. that five Two-softkey users (of the total ten users in the Two-softkey group) made an error (or errors) in task 1, and that the other five Two-softkey users did not make any errors.

In task 1, some Series 60 and Navi-key users made errors because they believed the centermost key can be used to initiate the call, like it does in their current phones, but not in the Three-softkey UI. Several users also searched for the phonebook application from the main menu, but in the 6650 phone it is not found in the menu.

The task 2 (**"Set the right time and put the clock visible on the idle display."**) user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 105.**

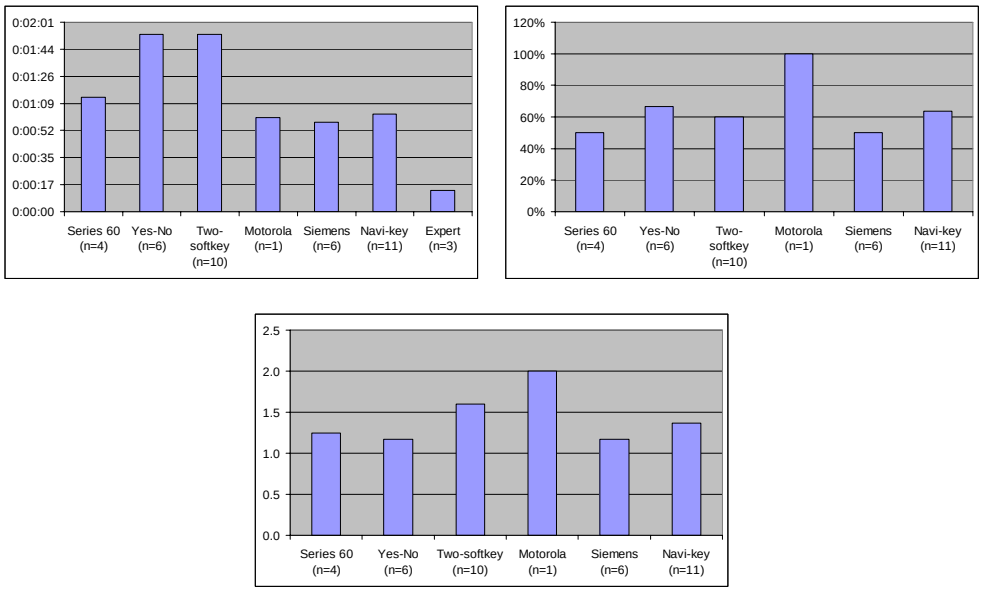


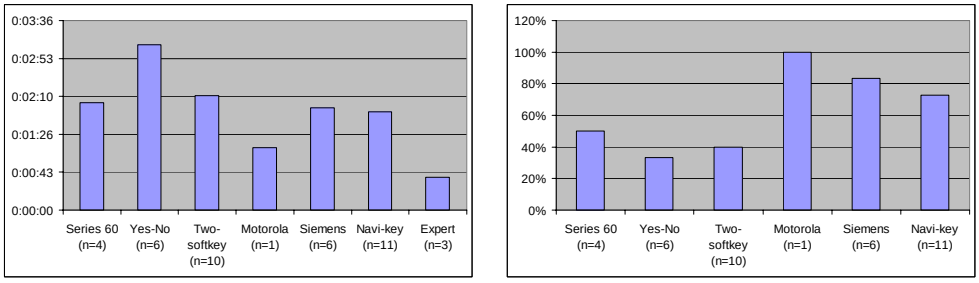
Figure 105. Task 2 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T2	Set time and show clock							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:01:00						4.4
Navi-key	11	0:01:02	0:00:33	0:00:54	0:00:29	0:02:07	0:00:43 - 0:01:22	4.6
Series 60	4	0:01:13	0:00:33	0:01:09	0:00:41	0:01:53	0:00:41 - 0:01:45	5.4
Siemens	6	0:00:57	0:00:24	0:00:51	0:00:36	0:01:39	0:00:38 - 0:01:16	4.2
Two-softkey	10	0:01:53	0:01:44	0:01:13	0:00:23	0:05:27	0:00:49 - 0:02:58	8.4
Yes-No	6	0:01:53	0:01:33	0:01:28	0:00:26	0:04:42	0:00:39 - 0:03:08	8.3
Expert	9	0:00:14	0:00:03	0:00:13	0:00:10	0:00:18	0:00:12 - 0:00:16	1.0
Nokia - Expert	25	0:01:24	0:01:12	0:01:02	0:00:23	0:05:27	0:00:56 - 0:01:53	6.2
Non Nokia	13	0:01:23	0:01:09	0:01:00	0:00:26	0:04:42	0:00:46 - 0:02:00	6.1
All - Expert	38	0:01:24	0:01:10	0:01:01	0:00:23	0:05:27	0:01:02 - 0:01:46	6.2

Figure 106. Task 2 timing descriptive statistics per user groups

Task 2 was problematic to many users due to unintuitive UI design and display texts. Users were in general expecting the phone to show the clock after the time was set, but the phone required them to go back to the sub-menu to put the clock visible on the display. These are not interaction-style-specific issues.

The task 3 ("**Save 'Jenni Ahomaa', 09-9873298 (home), 040-7754082 (work) to the phonebook.**") user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 107** below.



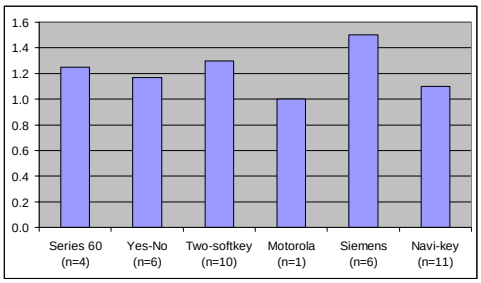
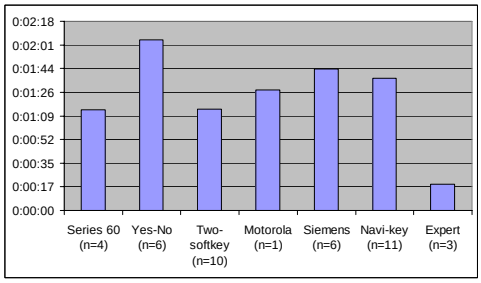


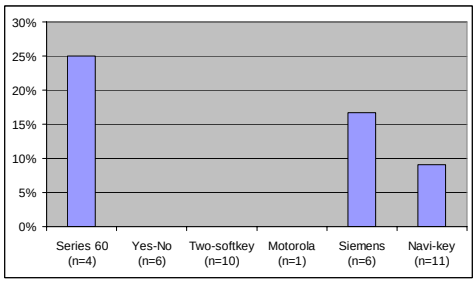
Figure 107. Task 3 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T3	Store name with multiple numbers							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:01:11						1.9
Navi-key	11	0:01:52	0:00:34	0:01:49	0:00:50	0:03:14	0:01:32 - 0:02:12	3.0
Series 60	4	0:02:02	0:00:22	0:01:53	0:01:49	0:02:35	0:01:41 - 0:02:24	3.2
Siemens	6	0:01:56	0:00:11	0:01:54	0:01:41	0:02:10	0:01:47 - 0:02:05	3.1
Two-softkey	10	0:02:10	0:01:04	0:01:48	0:01:14	0:04:36	0:01:31 - 0:02:50	3.4
Yes-No	6	0:03:09	0:02:42	0:02:20	0:01:25	0:08:32	0:00:59 - 0:05:18	5.0
Expert	9	0:00:38	0:00:07	0:00:38	0:00:27	0:00:49	0:00:33 - 0:00:42	1.0
Nokia - Expert	25	0:02:01	0:00:46	0:01:52	0:00:50	0:04:36	0:01:43 - 0:02:19	3.2
Non Nokia	13	0:02:26	0:01:53	0:01:57	0:01:11	0:08:32	0:01:25 - 0:03:28	3.9
All - Expert	38	0:02:10	0:01:15	0:01:52	0:00:50	0:08:32	0:01:46 - 0:02:34	3.4

Figure 108. Task 3 timing descriptive statistics per user groups

The task 4 ("**Take a picture (with the default settings) and name it 'Hieno'.**") user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 109** below.





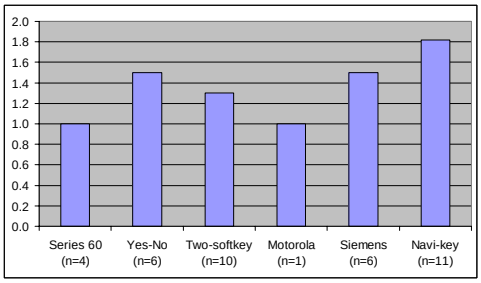


Figure 109. Task 4 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T4	Take a picture							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:01:28						4.6
Navi-key	11	0:01:36	0:00:46	0:01:22	0:00:38	0:02:56	0:01:09 - 0:02:04	5.0
Series 60	4	0:01:14	0:00:25	0:01:12	0:00:45	0:01:47	0:00:49 - 0:01:39	3.9
Siemens	6	0:01:44	0:01:20	0:01:02	0:00:42	0:03:51	0:00:39 - 0:02:48	5.4
Two-softkey	10	0:01:14	0:00:46	0:01:01	0:00:38	0:03:16	0:00:45 - 0:01:43	3.9
Yes-No	6	0:02:05	0:01:29	0:01:44	0:00:46	0:04:52	0:00:53 - 0:03:16	6.5
Expert	9	0:00:19	0:00:03	0:00:18	0:00:15	0:00:24	0:00:17 - 0:00:21	1.0
Nokia - Expert	25	0:01:24	0:00:43	0:01:11	0:00:38	0:03:16	0:01:07 - 0:01:41	4.4
Non Nokia	13	0:01:52	0:01:19	0:01:18	0:00:42	0:04:52	0:01:09 - 0:02:35	5.9
All - Expert	38	0:01:33	0:00:58	0:01:12	0:00:38	0:04:52	0:01:15 - 0:01:52	4.9

Figure 110. Task 4 timing descriptive statistics per user groups

The task 5 (“**Compose a multimedia message ‘Mahtavaa!’, attach the newly taken picture, and send the message to your own email address.**”) user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 111** below.

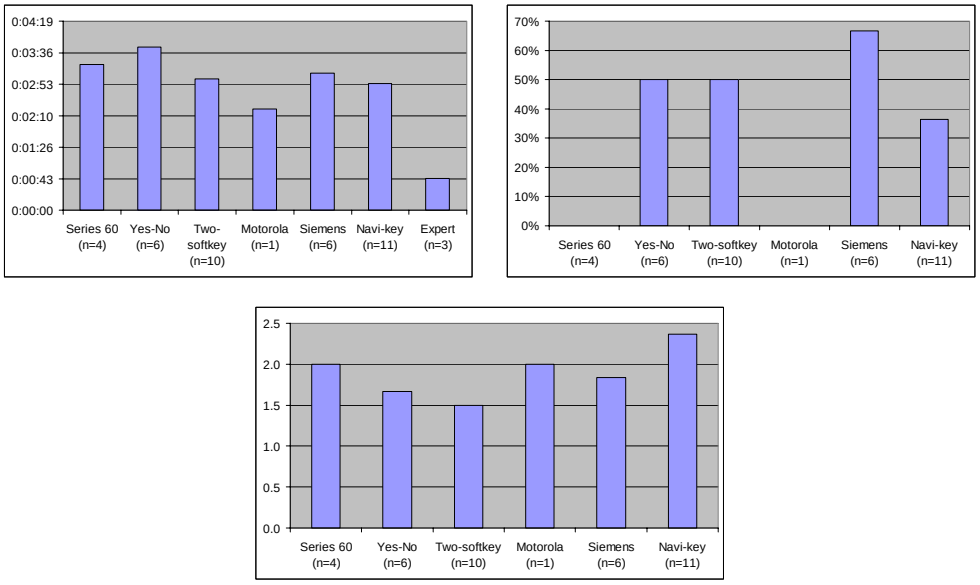


Figure 111. Task 5 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T5	Send MMS message							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:02:19						3.2
Navi-key	11	0:02:54	0:00:52	0:02:49	0:01:43	0:04:27	0:02:23 - 0:03:25	4.0
Series 60	4	0:03:20	0:01:07	0:03:02	0:02:21	0:04:55	0:02:14 - 0:04:26	4.6
Siemens	6	0:03:08	0:00:39	0:03:06	0:02:05	0:04:00	0:02:36 - 0:03:39	4.3
Two-softkey	10	0:03:00	0:01:37	0:02:43	0:01:18	0:05:46	0:02:00 - 0:04:00	4.1
Yes-No	6	0:03:43	0:00:45	0:03:32	0:02:47	0:04:39	0:03:07 - 0:04:20	5.1
Expert	9	0:00:44	0:00:05	0:00:43	0:00:37	0:00:53	0:00:40 - 0:00:47	1.0
Nokia - Expert	25	0:03:00	0:01:13	0:02:49	0:01:18	0:05:46	0:02:32 - 0:03:29	4.1
Non Nokia	13	0:03:20	0:00:46	0:03:15	0:02:05	0:04:39	0:02:55 - 0:03:46	4.6
All - Expert	38	0:03:07	0:01:05	0:02:59	0:01:18	0:05:46	0:02:47 - 0:03:28	4.3

Figure 112. Task 5 timing descriptive statistics per user groups

The task 6 (“**Change the current ringing tone to ‘Ring ring’.**”) user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 113** below.

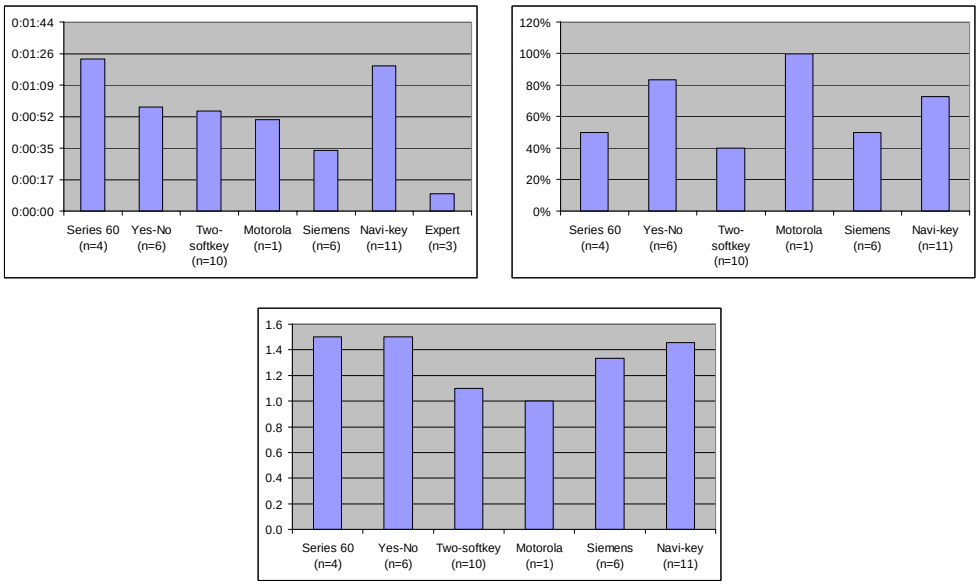


Figure 113. Task 6 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T6	Set "Ring ring" tone							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:00:50						5.3
Navi-key	11	0:01:20	0:00:58	0:00:56	0:00:17	0:02:59	0:00:45 - 0:01:54	8.4
Series 60	4	0:01:23	0:01:41	0:00:40	0:00:21	0:03:53	-0:00:16 - 0:03:02	8.8
Siemens	6	0:00:33	0:00:12	0:00:31	0:00:20	0:00:50	0:00:24 - 0:00:43	3.5
Two-softkey	10	0:00:55	0:01:14	0:00:28	0:00:16	0:04:20	0:00:09 - 0:01:41	5.8
Yes-No	6	0:00:57	0:00:31	0:00:53	0:00:26	0:01:53	0:00:32 - 0:01:22	6.0
Expert	9	0:00:09	0:00:01	0:00:10	0:00:08	0:00:11	0:00:09 - 0:00:10	1.0
Nokia - Expert	25	0:01:10	0:01:10	0:00:42	0:00:16	0:04:20	0:00:43 - 0:01:38	7.4
Non Nokia	13	0:00:46	0:00:24	0:00:44	0:00:20	0:01:53	0:00:32 - 0:00:59	4.8
All - Expert	38	0:01:02	0:00:59	0:00:43	0:00:16	0:04:20	0:00:43 - 0:01:21	6.6

Figure 114. Task 6 timing descriptive statistics per user groups

The task 7 (“**Set alarm to 06:00 tomorrow morning.**”) user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 115** below.

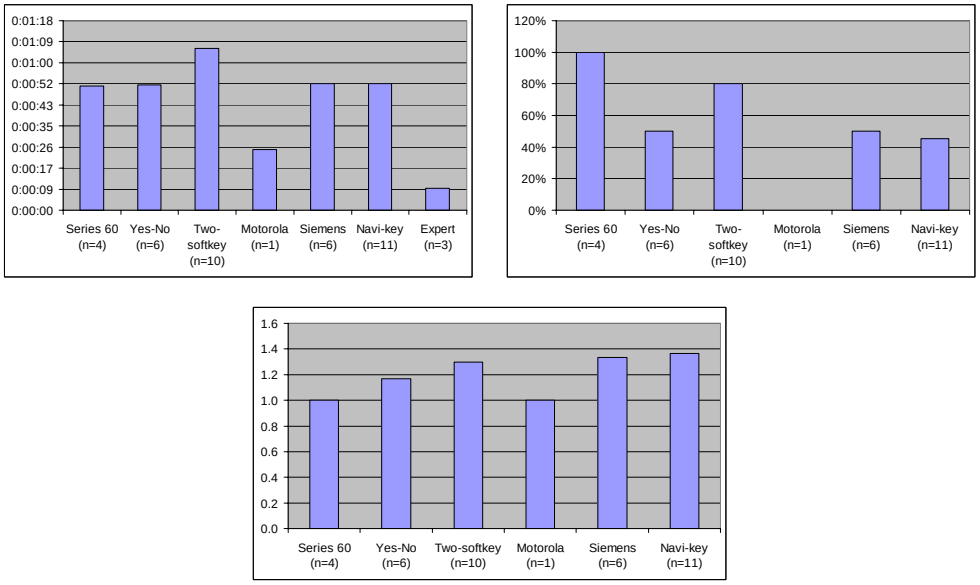


Figure 115. Task 7 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T7	Set alarm at 06:00							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:00:25						2.7
Navi-key	11	0:00:52	0:00:28	0:00:44	0:00:20	0:01:32	0:00:35 - 0:01:08	5.7
Series 60	4	0:00:51	0:00:22	0:00:56	0:00:21	0:01:11	0:00:30 - 0:01:12	5.6
Siemens	6	0:00:52	0:00:37	0:00:36	0:00:20	0:01:39	0:00:22 - 0:01:21	5.7
Two-softkey	10	0:01:06	0:00:50	0:01:02	0:00:15	0:02:58	0:00:35 - 0:01:37	7.3
Yes-No	6	0:00:51	0:00:27	0:00:40	0:00:33	0:01:43	0:00:30 - 0:01:13	5.6
Expert	9	0:00:09	0:00:02	0:00:09	0:00:06	0:00:12	0:00:08 - 0:00:10	1.0
Nokia - Expert	25	0:00:58	0:00:37	0:00:57	0:00:15	0:02:58	0:00:43 - 0:01:12	6.3
Non Nokia	13	0:00:50	0:00:30	0:00:38	0:00:20	0:01:43	0:00:33 - 0:01:06	5.4
All - Expert	38	0:00:55	0:00:35	0:00:45	0:00:15	0:02:58	0:00:44 - 0:01:06	6.0

Figure 116. Task 7 timing descriptive statistics per user groups

The task 8 ("**Set up your phone so that you can call <observer> with a speed dial.**") user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 117** below. It should be noted that the long-term users did not conduct tasks 8–13 in their initial testing sessions, and thus the Series 60, Two-softkey, and Navi-key user group sizes are smaller than in tasks 1–7.

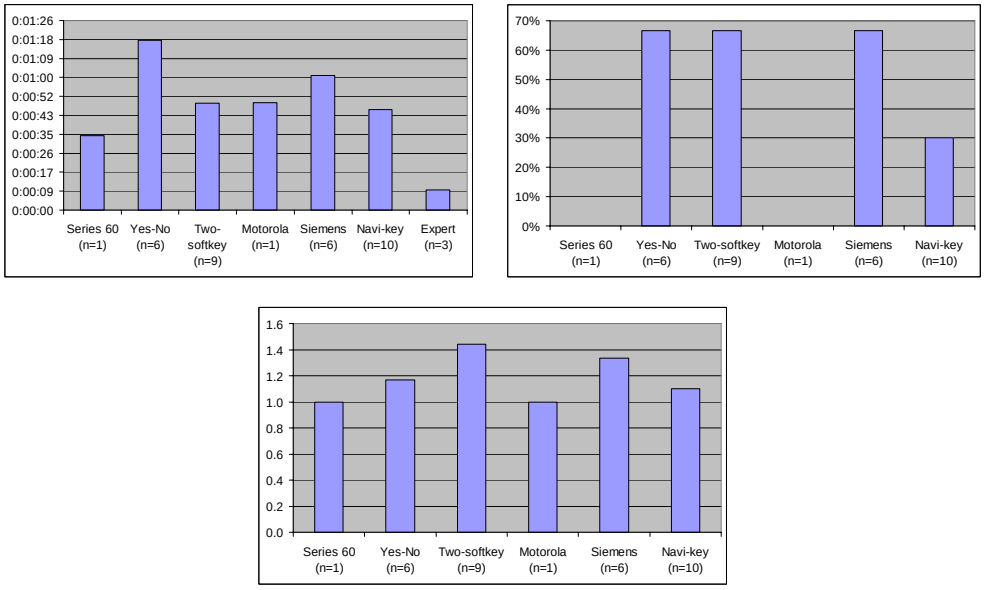


Figure 117. Task 8 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T8	Set speed dial							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:00:49						5.3
Navi-key	11	0:00:46	0:00:26	0:00:33	0:00:28	0:01:40	0:00:30 - 0:01:01	5.0
Series 60	1	0:00:34						3.7
Siemens	6	0:01:01	0:00:17	0:00:59	0:00:41	0:01:26	0:00:48 - 0:01:15	6.7
Two-softkey	9	0:00:49	0:00:22	0:00:47	0:00:26	0:01:34	0:00:35 - 0:01:03	5.3
Yes-No	6	0:01:17	0:00:43	0:01:05	0:00:28	0:02:23	0:00:43 - 0:01:52	8.4
Expert	9	0:00:09	0:00:01	0:00:10	0:00:07	0:00:11	0:00:08 - 0:00:10	1.0
Nokia - Expert	21	0:00:46	0:00:23	0:00:35	0:00:26	0:01:40	0:00:37 - 0:00:56	5.0
Non Nokia	13	0:01:08	0:00:31	0:00:56	0:00:28	0:02:23	0:00:51 - 0:01:25	7.4
All - Expert	34	0:00:55	0:00:28	0:00:49	0:00:26	0:02:23	0:00:45 - 0:01:04	6.0

Figure 118. Task 8 timing descriptive statistics per user groups

The task 9 ("**Call <observer> with the speed dial.**") user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 119** below.

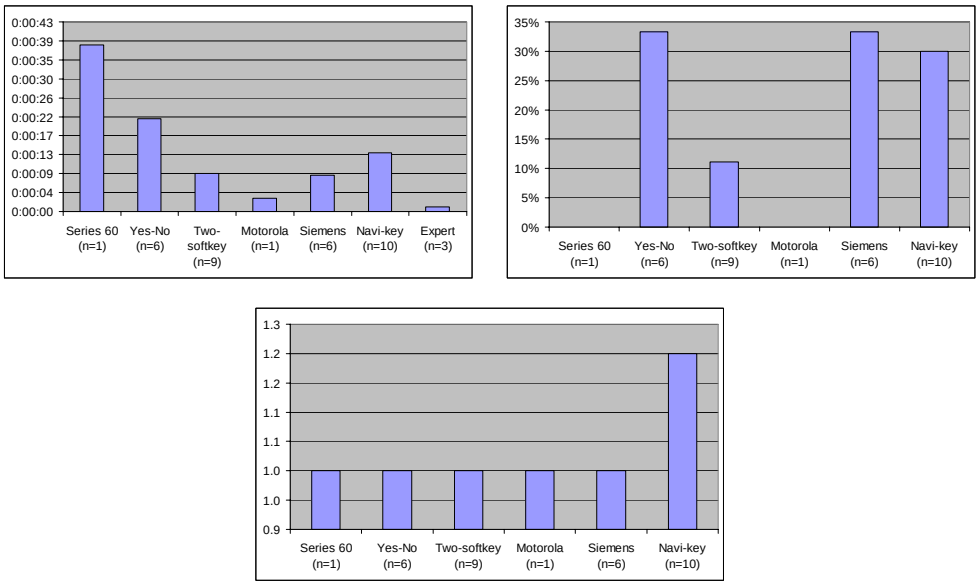


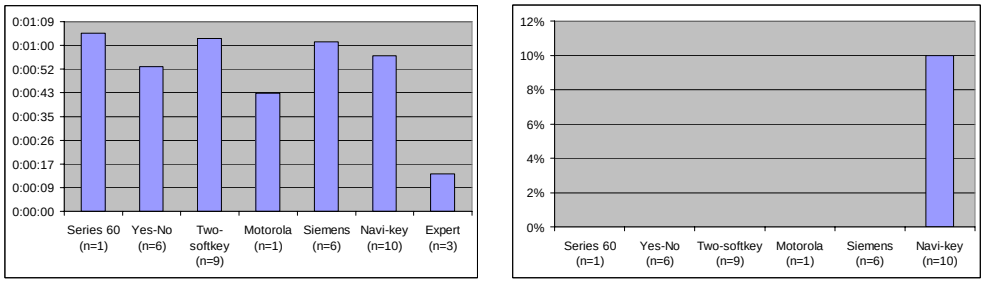
Figure 119. Task 9 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T9	Call with speed dial							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:00:03						3.0
Navi-key	11	0:00:17	0:00:16	0:00:13	0:00:03	0:00:57	0:00:07 - 0:00:26	16.9
Series 60	1	0:00:38						38.0
Siemens	6	0:00:08	0:00:08	0:00:08	0:00:00	0:00:22	0:00:02 - 0:00:15	8.3
Two-softkey	9	0:00:10	0:00:09	0:00:04	0:00:02	0:00:22	0:00:04 - 0:00:15	9.7
Yes-No	6	0:00:21	0:00:19	0:00:14	0:00:05	0:00:56	0:00:06 - 0:00:37	21.2
Expert	9	0:00:01	0:00:00	0:00:01	0:00:01	0:00:01		1.0
Nokia - Expert	21	0:00:15	0:00:14	0:00:10	0:00:02	0:00:57	0:00:09 - 0:00:21	14.7
Non Nokia	13	0:00:14	0:00:15	0:00:09	0:00:00	0:00:56	0:00:06 - 0:00:22	13.8
All - Expert	34	0:00:14	0:00:14	0:00:09	0:00:00	0:00:57	0:00:10 - 0:00:19	14.4

Figure 120. Task 9 timing descriptive statistics per user groups

The Series 60 group performance looks very bad in this task; it is caused by the small group size (one user): the user went to the phone settings sub-menu to activate speed dials, and was puzzled as the 6650 phone did not work like his current phone works.

The task 10 ("**Find out if you have anything scheduled for the week starting on April the 7th.**") user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 121** below.



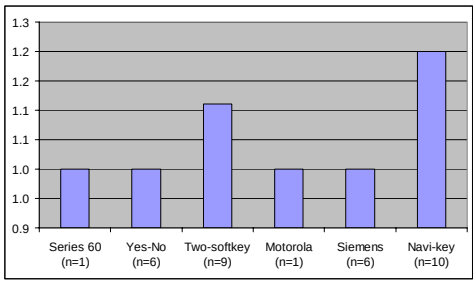


Figure 121. Task 10 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T10	Check calendar							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:00:43						3.2
Navi-key	11	0:00:57	0:00:19	0:00:56	0:00:14	0:01:18	0:00:46 - 0:01:08	4.2
Series 60	1	0:01:05						4.8
Siemens	6	0:01:02	0:00:31	0:00:52	0:00:39	0:02:01	0:00:37 - 0:01:26	4.5
Two-softkey	9	0:01:03	0:00:26	0:00:49	0:00:43	0:01:55	0:00:46 - 0:01:20	4.7
Yes-No	6	0:00:53	0:00:20	0:00:52	0:00:31	0:01:17	0:00:37 - 0:01:09	3.9
Expert	9	0:00:14	0:00:03	0:00:12	0:00:09	0:00:19	0:00:11 - 0:00:16	1.0
Nokia - Expert	21	0:01:00	0:00:22	0:00:56	0:00:14	0:01:55	0:00:51 - 0:01:09	4.4
Non Nokia	13	0:00:56	0:00:24	0:00:46	0:00:31	0:02:01	0:00:43 - 0:01:09	4.1
All - Expert	34	0:00:58	0:00:22	0:00:54	0:00:14	0:02:01	0:00:51 - 0:01:06	4.3

Figure 122. Task 10 timing descriptive statistics per user groups

The task 11 (**"Create a calendar event 'Palaveri' in Ruoholahti for April 9th at 09:30-11:00 and set the alarm 30 minutes before the event."**) user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 123** below.

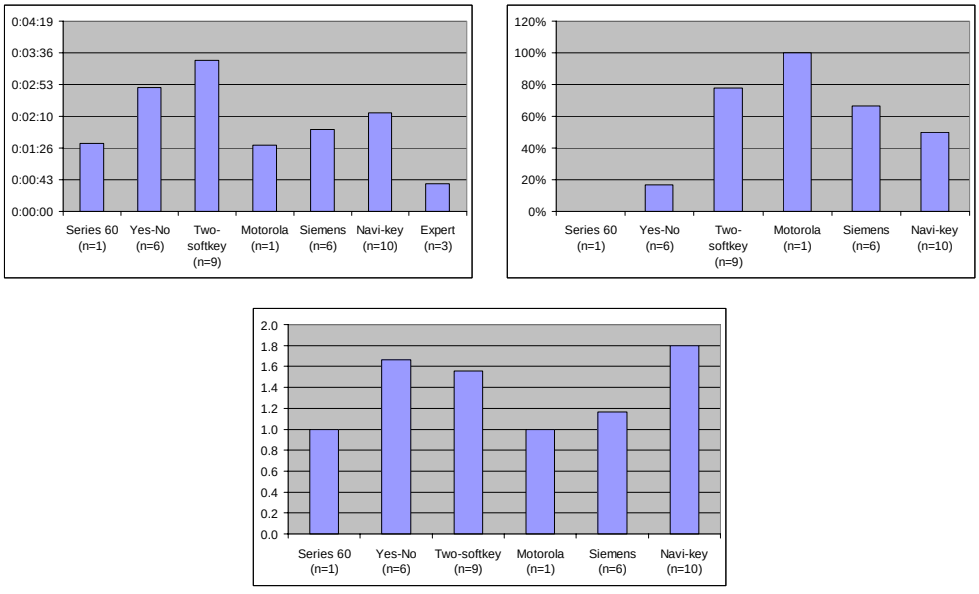


Figure 123. Task 11 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T11	Create calendar event							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:01:30						2.4
Navi-key	11	0:02:14	0:00:47	0:01:51	0:01:05	0:03:23	0:01:46 - 0:02:42	3.6
Series 60	1	0:01:33						2.5
Siemens	6	0:01:51	0:00:33	0:01:41	0:01:17	0:02:40	0:01:25 - 0:02:18	3.0
Two-softkey	9	0:03:26	0:01:34	0:03:01	0:01:13	0:05:15	0:02:25 - 0:04:27	5.5
Yes-No	6	0:02:49	0:01:45	0:02:06	0:01:15	0:05:28	0:01:25 - 0:04:13	4.5
Expert	9	0:00:37	0:00:06	0:00:37	0:00:28	0:00:50	0:00:33 - 0:00:41	1.0
Nokia - Expert	21	0:02:44	0:01:19	0:02:43	0:01:05	0:05:15	0:02:10 - 0:03:18	4.4
Non Nokia	13	0:02:16	0:01:18	0:01:45	0:01:15	0:05:28	0:01:34 - 0:02:58	3.6
All - Expert	34	0:02:33	0:01:19	0:02:02	0:01:05	0:05:28	0:02:07 - 0:03:00	4.1

Figure 124. Task 11 timing descriptive statistics per user groups

The task 12 (**"Use the Zed service to find out the next-day weather forecast for Helsinki."**) user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 125** below.

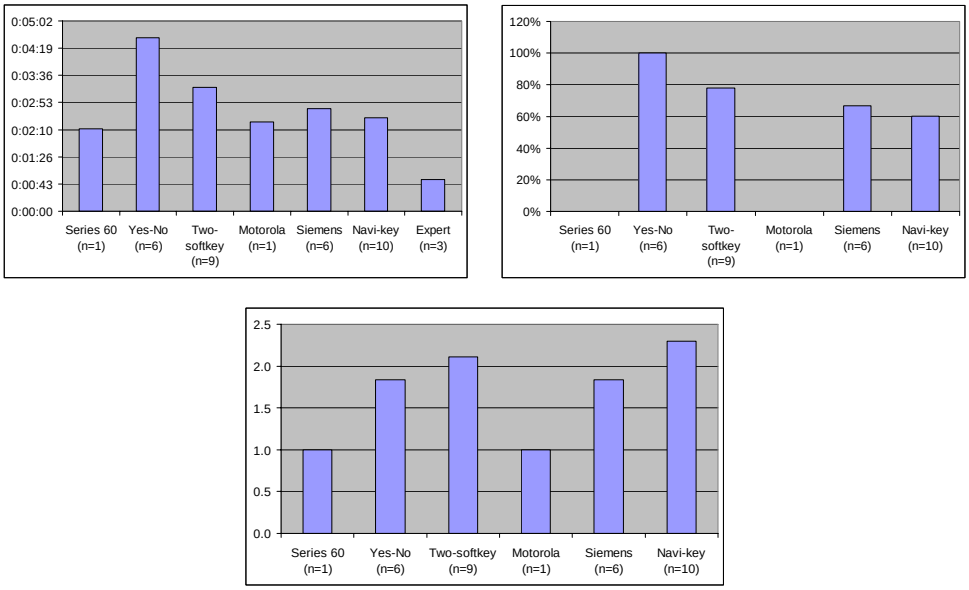


Figure 125. Task 12 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T12	Check Helsinki weather forecast with WAP Zed							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:02:22						2.8
Navi-key	11	0:02:28	0:00:37	0:02:26	0:01:26	0:03:30	0:02:07 - 0:02:50	2.9
Series 60	1	0:02:11						2.6
Siemens	6	0:02:43	0:00:37	0:02:37	0:02:05	0:03:32	0:02:13 - 0:03:13	3.2
Two-softkey	9	0:03:17	0:01:29	0:02:50	0:01:49	0:05:32	0:02:19 - 0:04:15	3.9
Yes-No	6	0:04:36	0:02:34	0:04:17	0:02:10	0:08:45	0:02:33 - 0:06:39	5.5
Expert	9	0:00:51	0:00:07	0:00:51	0:00:38	0:01:01	0:00:46 - 0:00:55	1.0
Nokia - Expert	21	0:02:49	0:01:08	0:02:27	0:01:26	0:05:32	0:02:20 - 0:03:18	3.3
Non Nokia	13	0:03:34	0:01:59	0:02:48	0:02:05	0:08:45	0:02:29 - 0:04:38	4.2
All - Expert	34	0:03:07	0:01:32	0:02:31	0:01:26	0:08:45	0:02:36 - 0:03:38	3.7

Figure 126. Task 12 timing descriptive statistics per user groups

The task 13 (**"Send SMS 'Kohta tämä loppuu!' to <observer>."**) user-group-specific task times, errors, and ease-of-use ratings are shown in **Figure 127** below.

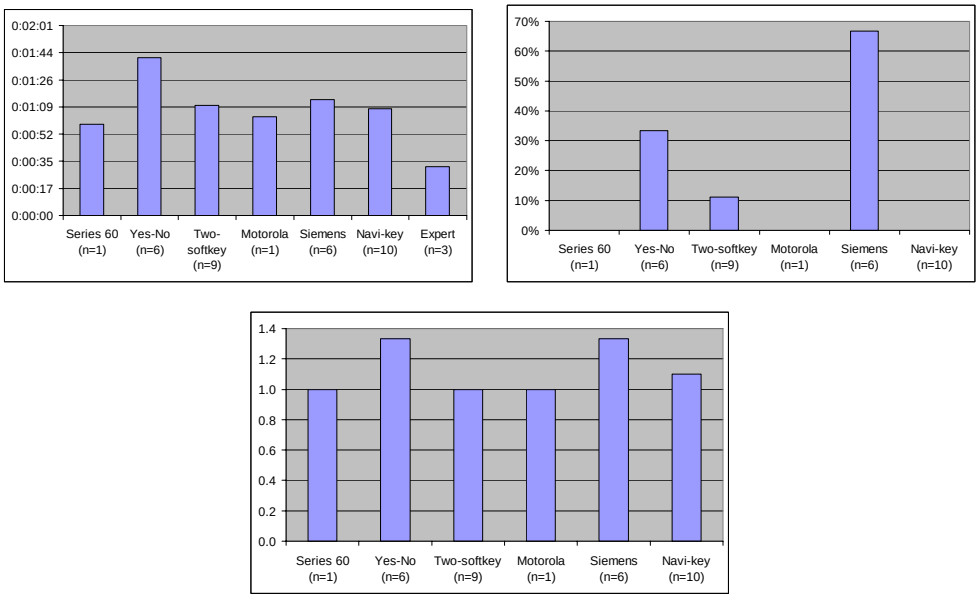


Figure 127. Task 13 times (top left), proportion of users making errors (top right), and subjective ease-of-use (Easy=1, ..., Difficult=3) per user group

T13	Send SMS							
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	Novice/ Expert ratio
Motorola	1	0:01:03						2.0
Navi-key	11	0:01:08	0:00:23	0:01:04	0:00:33	0:01:56	0:00:54 - 0:01:21	2.2
Series 60	1	0:00:58						1.9
Siemens	6	0:01:14	0:00:16	0:01:14	0:00:54	0:01:31	0:01:01 - 0:01:27	2.4
Two-softkey	9	0:01:30	0:01:16	0:00:52	0:00:40	0:04:36	0:00:40 - 0:02:20	2.9
Yes-No	6	0:01:40	0:00:45	0:01:26	0:00:56	0:02:46	0:01:05 - 0:02:16	3.3
Expert	9	0:00:31	0:00:05	0:00:32	0:00:24	0:00:38	0:00:28 - 0:00:34	1.0
Nokia - Expert	21	0:01:17	0:00:53	0:01:02	0:00:33	0:04:36	0:00:55 - 0:01:40	2.5
Non Nokia	13	0:01:25	0:00:34	0:01:18	0:00:54	0:02:46	0:01:07 - 0:01:44	2.8
All - Expert	34	0:01:20	0:00:46	0:01:06	0:00:33	0:04:36	0:01:05 - 0:01:36	2.6

Figure 128. Task 13 timing descriptive statistics per user groups

Tasks 14 and 15 are not analyzed in this study since there is no reference data available. Only the four long-term users conducted these tasks, and the usability study findings were not relevant regarding the interaction style usability.

4.2.7 Measuring Usability: Overall Ease-of-Use

To measure the overall subjective **ease-of-use** of the 6650 phone, the test users were asked to rate the overall ease-of-use on a five-point Likert scale after all test tasks were completed. This was done via the two questions as shown in **Appendix 4**:

a. Do you consider the phone easy or difficult to use?
Easy □□□□□ Difficult

b. Is the phone easier to use than your previous phone?
Easier □□□□□ More difficult

Initially, the questionnaire had been designed around a three-point Likert scale but we experienced some people having difficulties in using a three-point scale, so we changed this to a five-point scale during the course of the testing process. The five-point ratings were afterwards mapped onto the three-point scale to facilitate comparable data analysis as some answers had already been collected

with the three-point scale; the following conversions were used: 1, 2 ⇒ 1; 3 ⇒ 2; 4, 5 ⇒ 3. Some test users had used ratings of 2.5 and 3.5, and those were converted to 2.

The overall average ratings were:

a. The 6650 phone is quite easy to use: average 1.3
(n=37; expert users excluded. Easy=1, …, Difficult=3)

b. The 6650 phone is about as easy to use as the current phone: average 2.1
(n=34; expert users excluded. Easier=1, …, More difficult=3)

The user-group-specific ease-of-use and comparative ease-of-use ratings are shown in **Figure 129** below. The Navi-key users specifically regard the 6650 phone as more difficult than their current handset. Based on the unprompted, subjective comments from some Navi-key users, this is likely to be caused by the number of control keys in the Three-softkey UI: the new UI has three softkeys (Navi-key has one), the left and right navigation keys (Navi-key has only up and down), and the new UI also has the green and red handset keys (Navi-key does not have these).

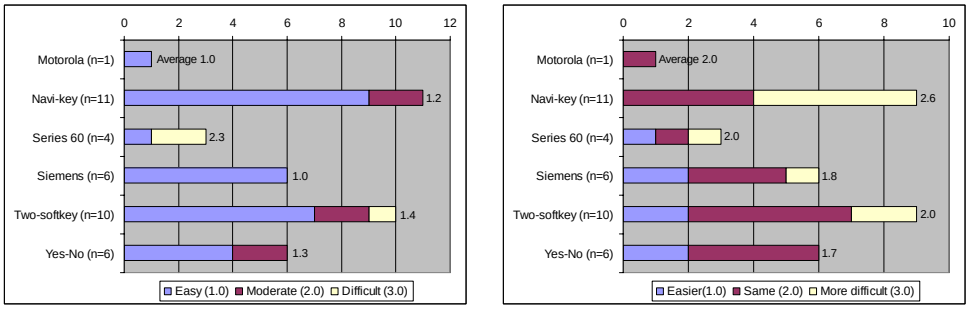


Figure 129. User-group-specific ease-of-use (left) and comparative ease-of-use (right)[218]

The descriptive statistics for the subjective ease-of-use measure are illustrated in **Figure 130**. With the 95% confidence interval ($\alpha = 0.05$) there are no statistically significant differences between the individual user groups, but if we apply the 90% confidence interval ($\alpha = 0.10$), we can see more clearly the difference between Nokia and non-Nokia users showing that non-Nokia users rate the 6650 phone to be easier to use than what the Nokia users say (confidence intervals 0.9 – 1.3, and 1.4 – 1.9, respectively). There are several possible explanations to this:

1. The non-Nokia users currently have a more difficult-to-use phone than what the Nokia users have, and therefore they feel the 6650 is easy

2. The Nokia users expect that since they already have a Nokia phone, the new Nokia 6650 should work in a familiar manner, and when it in reality has differences, the users feel it is difficult

It should be noted that all Siemens users rate the 6650 to be easy to use (average 1.0).

[218] It can be noted of the response group sizes that some of the test users did not provide an answer to the questions.

Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	90% confidence interval
Motorola	1	1.0						
Navi-key	11	1.2	0.4	1	1	2	0.9 - 1.4	1.0 - 1.4
Series 60	3	2.3	1.2	3	1	3	1.0 - 3.6	1.2 - 3.4
Siemens	6	**1.0**	0.0	1	1	1		
Two-softkey	9	1.4	0.7	1	1	3	0.9 - 1.9	1.0 - 1.8
Yes-No	6	1.3	0.5	1	1	2	0.9 - 1.7	1.0 - 1.7
Nokia - Expert	23	**1.6**	0.7	1	1	3	1.3 - 1.9	**1.4 - 1.9**
Non-Nokia	13	**1.1**	0.4	1	1	2	0.9 - 1.3	**0.9 - 1.3**

Figure 130. Descriptive statistics for user-group-specific ease-of-use; (1: Easy, 2: Moderate; 3: Difficult)

The users were also asked to compare the ease-of-use of the new 6650 phone against their current phone. The descriptive statistics for this comparative ease-of-use rating are shown in **Figure 131**. Using the 95% confidence interval (α = 0.05), we can see statistically significant differences between Navi-key users and Yes-No users. The Navi-key users rate the Nokia 6650 phone more difficult to use (average = 2.6) than what the Yes-No users think (average = 1.7). There are several possible explanations to this:

1. The Navi-key style is easier and simpler, and the users where overwhelmed because of the control keys and functionality in the new 6650

2. The Yes-No style users found the new 6650 easier than their current phones due to some reasons; it needs to be noted that both user groups rated the ease-of-use of the new 6650 UI rather similarly when there was no comparison as shown in **Figure 130**.

Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	90% confidence interval
Motorola	1	2.0						
Navi-key	9	**2.6**	0.5	3	2	3	**2.2 - 2.9**	**2.3 - 2.8**
Series 60	3	2.0	1.0	2	1	3	0.9 - 3.1	1.1 - 2.9
Siemens	6	1.8	0.8	2	1	3	1.2 - 2.4	1.3 - 2.3
Two-softkey	9	2.0	0.7	2	1	3	1.5 - 2.5	1.6 - 2.4
Yes-No	6	**1.7**	0.5	2	1	2	**1.3 - 2.1**	1.3 - 2.0
Nokia - Expert	21	2.2	0.7	2	1	3	1.9 - 2.5	1.9 - 2.4
Non-Nokia	13	**1.8**	0.6	2	1	3	1.5 - 2.2	**1.6 - 2.1**

Figure 131. Descriptive statistics for comparative ease-of-use; (1: 6650 is easier, 2: Same; 3: 6650 is more difficult)

If we apply the 90% confidence interval (α = 0.10), we can see further differences between the user groups as shown in **Figure 131**. The Navi-key users and the whole non-Nokia user group compare the relative ease-of-use of the new 6650 phone against their current phone rather differently (confidence intervals 2.3 – 2.8, and 1.6 – 2.1, respectively).

To summarize, we can observe the following statistically significant differences between the tested user groups:

1. User who currently do not have a Nokia phone rate the (absolute) ease-of-use of the new 6650 phone to be better (average 1.1 on the scale 1…3 where 1: Easy, and 3: Difficult) than what the current Nokia users say (average 1.6 on the scale 1…3 where 1: Easy, and 3: Difficult) (α = 0.05)

2. When asked to compare the (relative) ease-of-use of the new 6650 phone against their current phone, the Navi-key users rate the Nokia 6650

phone more difficult to use than their current phone (average 2.6 on the scale 1…3 where 1: Easier, and 3: More difficult) whereas the Yes-No users think that the Nokia 6650 is somewhat easier than their current phone (average 1.7 on the scale 1…3 where 1: Easier, and 3: More difficult) ($\alpha = 0.05$)

3. When asked to compare the (relative) ease-of-use of the new 6650 phone against their current phone, the Navi-key users rate the Nokia 6650 phone more difficult to use than their current phone (average 2.6 on the scale 1…3 where 1: Easier, and 3: More difficult) whereas the non-Nokia users think that the Nokia 6650 is somewhat easier than their current phone (average 1.8 on the scale 1…3 where 1: Easier, and 3: More difficult) ($\alpha = 0.10$)

These measurable differences are likely to be caused by several reasons. The Navi-key interaction style and the Yes-No interaction style are in some sense extremes in this test: Navi-key has one softkey, and no dedicated call-handling keys, whereas the Yes-No style has no softkeys, but Yes and No function keys, that are also labeled for call handling. The Yes-No style also has a horizontally arranged main menu compared to the vertically arranged, full-screen main menu items in the Navi-key UI.

The Yes-No users were generally the slowest to conduct the test tasks as illustrated in **Figure 102**. They also received the largest number of moderator hints as illustrated in **Figure 99**. There was no significant difference in the error counts between the user groups. Despite all this, the Yes-No users still felt that the new phone is somewhat easier to use than their current phone. In contrast to this, the Navi-key users were faster, they did not need as many hints from the test moderator, but yet they still say that the new phone is more difficult to use than their current phone. A similar difference can be seen more generally between the Navi-key users and the whole non-Nokia user group: the non-Nokia users feel that the new phone is somewhat easier to use than their current phone. When looking at the absolute ease-of-use without comparing the new phone against the current phone, both the Nokia and non-Nokia users think the new phone is quite easy to use, however, there is a statistically significant difference between these two groups in the direction of the non-Nokia users saying the new phone is easier than what the Nokia users think.

It could be tempting to explain these measured differences with a simple and straightforward reasoning: the Nokia phones, and especially the Navi-key interaction style, are easier to use than the interaction styles in the non-Nokia phones, where especially the Yes-No interaction style is difficult. Against this background, the Nokia users felt that the new Nokia interaction style is difficult since it does not work exactly like their current phones do, and the non-Nokia users felt the new Three-softkey interaction style is easier than their current phones, with the Yes-No user group being the extreme case.

This is probably at least a partial explanation. It is also supported by the findings by Ziefle (2002), Bay & Ziefle (2003), 3G LAB (2002), and SirValUse (2003). Ziefle (2002) found the Nokia 3210 phone user interface to be of lesser complexity than the Siemens C35i or the Motorola P7389, and as a result, her test users showed highest performance (effectiveness, shortest solution time, and smallest number of detour steps) with the Nokia phone. Bay & Ziefle (2003) further state that the Siemens C35i menu structure and control keys are significantly more complex than in the Nokia 3210 phone, so their Siemens test

users spent double the time and undertook three times as many detour steps back as users using the Nokia phone. 3G LAB compared the Sony Ericsson T68i against the Nokia 7650, and found that the test users were disappointed with the complexity of the Sony Ericsson menu system, but liked Nokia's intuitive menu system better. SirValUse tested eight MMS-equipped phones, and the Nokia 7650 phone was the only one to get a good result of the test, whereas the most complicated phones were found to be Sony Ericsson T300, Siemens S55, and Panasonic GD-87. Orange recently made a statement that their customers using Motorola handsets send on average 14 text messages a month compared with 45 a month sent by owners of equivalent Nokia phones, and they believe this is *"due to the simpler Nokia user experience."*[219]

It must be noted that the measured differences are most probably caused by several different user interface elements as described in **Section 2.3.2**. This study is focusing on the interaction style element, and there are inherent challenges in focusing on that alone, e.g. since the interaction style is an abstraction not directly visible to the user. The presentation style, the applications and their functionality, are the tangible UI elements. Ultimately, it is obviously the combination of all UI elements that together generate the total user experience.

4.2.8 Measuring Usability: Learnability

The original research plan included testing enough long-term users to be able to draw statistically reliable conclusions about the effect of the earlier usage experience on the learnability behavior. The goal was to measure how significant differences can be expected when it comes to learning a new mobile phone interaction style.

It was not possible to conduct the long-term usability testing with a magnitude that was initially planned. Due to the business-driven schedules and priorities in the W-CDMA pilot project, we could test only five users, and of these five users one could not attend the final testing session after the two months' usage period. A sample group of four users is not large enough to draw reliable conclusions about the learnability effect. All four long-term test users had previously used a Nokia phone: two users had previously used the Series 60 interaction style, one was a Navi-key user, and one had used a phone with the Two-softkey interaction style. Thus the long-term usage period reveals nothing of the non-Nokia users' learning patterns.

Nevertheless, we can analyze the improvements in effectiveness, efficiency, and ease-of-use after this usage period, and also compare the efficiency attribute values against the efficiency benchmark set by the three expert users.

Figure 132 below illustrates the relative task time differences between the measured task times in the initial test for the four long-term test users and the task times measured after the long-term usage period. Since these four users completed only seven test tasks in their initial test, the chart shows also the relation between their measured task times in the final test and the measured task times for the 33 users who completed all 13 test tasks in the usability test, but did not conduct the long-term usage period. The average ratio between the final test times and the initial test times of the first seven tasks for the long-term users is

[219] Dow Jones, 14-Oct-2003.

70% showing a measurable improvement. The chart also illustrates the ratio between the measured task times for the four long-term users and the task times for the three expert users.

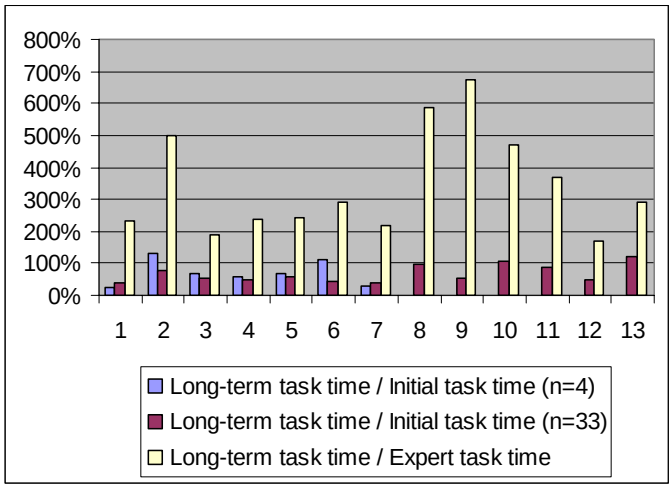


Figure 132. Efficiency improvement after the long-term usage period

The chart indicates no major surprises; however, it must be noted that the sample size is only four users so the results are not statistically reliable. Of the first seven tasks, the long-term test users' task times improved noticeably in five tasks, and got worse in tasks 2 and 6, but this change for the worse was not significant. Of the remaining six tasks we cannot reliably conclude anything, but the measured task times for the long-term users show either improvement or are only marginally worse than the average task times for the non-long-term test users.

Looking at the long-term users' final task times against the expert user performance reveals that eight of the 13 tasks were completed around 200%–300% of the expert users' task times, but tasks 2, 8, 9, 10, and 11 took up to 700% of the expert users' time. Analyzing the test session transcripts illustrates how large the random effect can be in a sample of four users:

- Task time in task 2 for one of the four test users was 2 minutes 54 seconds, while the average task time for the three other users was 32 seconds. The user was lost in the Settings menu and did not recognize the correct sub-menu due to a possible terminology problem; the moderator gave two hints to the user.
- Task times in task 8 for two of the four test users were 1 minute 48 seconds, and 51 seconds, while the average task time for the two other users was 29 seconds. The two users spent time browsing the Profiles menu.
- Task time in task 9 for one of the four test users was 23 seconds, while the average task time for the three other users was 1 second. The user went to the Call settings sub-menu.
- Task time in task 10 for one of the four test users was 2 minutes 39 seconds, while the average task time for the three other users was 32 seconds.
- Task time in task 11 for one of the four test users was 4 minutes 13 seconds, while the average task time for the three other users was 1 minute 38 seconds. The user created the calendar event on a wrong date and spent the time recovering from the error.

Figure 133 below illustrates the ratio between the long-term task time and the expert users' task times when the abovementioned anomalies have been excluded from the data. The chart now shows 10 tasks fitting around the 200%–300% time compared with the experts' task times, and three tasks being around 150%

of the experts' task time. The average ratio between the long-term users' task time and the expert users' task time is 222% after the two months' usage period; with the abovementioned outliers excluded.

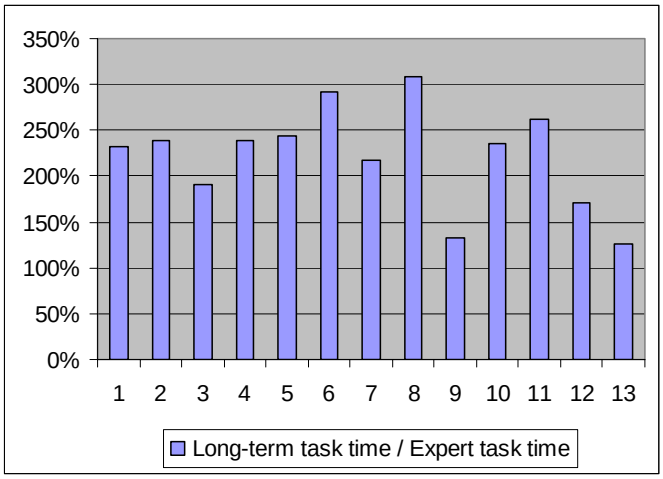


Figure 133. Efficiency improvement after the long-term usage period; outliers excluded

5. DISCUSSION

The background to this study was in improving the knowledge about mobile phone interaction style evolution — especially in the context of replacement users i.e. people who already possess or use a mobile telephone, and are replacing their handset with a newer model that may have a different user interface. The main research problem was formulated as:

> *How do mobile phone interaction style changes affect the initial usability of a mobile phone for users with earlier experience with mobile phones?*

The fundamental concept in the study, the *mobile phone interaction style*, was defined in this study as:

> *Mobile phone interaction style is the framework consisting of the physical interaction objects, the abstract interaction elements, and the associated behavior or interaction conventions that are applied throughout the core functionality of the mobile phone. Within the context of this study, the interaction style definition excludes the stylistic appearance elements of the user interface, that are often referred to as the 'look' of the user interface.*

Two, more detailed research questions were deduced from the research problem:

1. *What is the interaction style applied in contemporary mobile telephones, and how does it differ from the interaction styles in mainstream HCI?*

2. *What is the effect on usability caused by specific changes in the mobile phone interaction styles between products?*

Finding answers to these research questions should allow design and usability practitioners in the industry to make more justified decisions when novel mobile phone user interfaces are being designed and developed.

In the study we have approached the 1st research question with a literature study focusing on interaction styles in mainstream HCI, and with a heuristic evaluation of contemporary mobile telephones and their interaction styles. The 2nd research question has been approached with an empirical usability testing experiment with 38 test users conducting usability test tasks on a novel mobile phone model with a new interaction style. Of the 38 test users and 13 test tasks, only one task failed for one user, while assistance from the test moderator was needed by some users to complete some tasks.

The main results of the study, and the answers to the abovementioned research questions, can be summarized as in **Figure 134**.

1. **Interaction styles applied in contemporary mobile telephones are designed around menu navigation, and they implement the three primary operations — Select, Back and Menu access — with dedicated hardkeys, context-sensitive softkeys, or using special control devices like joysticks or jog dials. The control keys are converging around various two- and three-softkey conventions.**
2. **Despite differences between interaction styles in contemporary mobile phones, users do not face significant difficulties when transferring to a novel mobile phone model.**

Figure 134. Main results of the thesis

The following chapters will discuss these results and findings in more detail from the different viewpoints: interaction style dominant design, interaction style usability, and interaction style evolution. The contribution of the author is explicated in **Chapter 5.4**, the applicability of the used research methods is discussed in **Chapter 5.5**, while **Chapter 5.6** suggests research items for further study.

5.1 Interaction Styles and Dominant Design

The mobile phone user interface is constructed of several elements, and the elements can be categorized in several ways. As illustrated in **Figure 135**, the mobile phone UI consists of software and hardware components. The variability capability of the UI elements increases when moving from the UI platform layer to the UI applications and UI 'skin' layer. The software user interface platform can be divided into interaction style and presentation style: the interaction style is the combination of the product-wide input and output dialogue conventions used in communicating or interacting with a mobile phone, and the presentation style defines the windows, layouts, colors, icons, fonts, sounds, and other presentation UI components and guidelines available for individual UI applications.

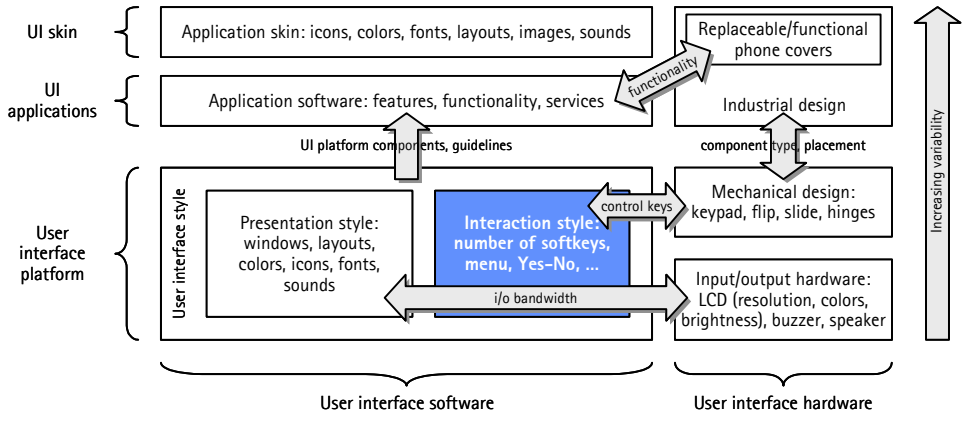


Figure 135. Mobile phone user interface elements

Contemporary, voice-centric mobile telephones generally apply an interaction style that has been categorized as **indirect manipulation menu** in this work. The Nokia 3330 phone in **Figure 136** illustrates this interaction style: the hierarchically structured on-screen menu (*extended* menu since it does not fit on one display) is used with a multi-functional, dynamic softkey that is used for item selection, the canceling function is implemented as a dedicated hard key (with the label "C"), navigation in the menu is facilitated by the up and down navigation keys, and there is no general mechanism to revert actions. This is much unlike the prevailing interaction style in the desktop computing domain: direct manipulation or graphical interfaces that usually have more objects and functions represented continuously to the user, utilize pop-up and pull-down menus, and offer general and consistent "Undo" mechanism.

Figure 136. Nokia 3330 phone

The analysis of the contemporary mobile phone interaction styles reveals no explicitly defined dominant UI designs on the marketplace today. The most widely deployed individual interaction style in the industry — the Navi-key UI from Nokia[220] — is a proprietary style used by one manufacturer only. Generally, the mobile phone manufacturers are globally converging around the use of two or three softkeys: Motorola's Synergy UI is applying three softkeys as illustrated in **Figure 33**, Nokia's new Three-softkey UI is adding a third softkey to the earlier Two-softkey UI, Siemens and Samsung are using a two-softkey UI in their product portfolio, and the long-time non-softkey UI advocate Ericsson is deploying softkey interaction style in its product portfolio as illustrated in **Figure 61**. Several Japanese manufacturers are applying a three-softkey interaction style as illustrated in **Figure 60** and **Figure 80**.

Obviously the definition of *dominant design* affects this conclusion; if we agree on the dynamic softkeys and hierarchical menu structures defining the dominant design, then we can say that one exists. In this study, however, we have chosen to apply a finer granularity when defining the interaction style elements — including e.g. the number of softkeys. Therefore, based on the investigation of contemporary, voice-centric mobile phone interaction styles, we conclude that there is no single dominant design in mobile phone interaction styles on the marketplace today. Commercially available smartphone UI software platforms such as the Microsoft Smartphone and Nokia Series 60 are obviously trying to establish dominant designs in the more high-end product segments, but it remains to be seen whether one of these or some other entrant will dominate the high-volume marketplace as well.

Studying the contemporary mobile phone interaction styles revealed various interaction style inconsistencies in and around several mobile Internet browsers incorporated in the handsets. E.g. the phone may usually display the available menu when the user presses a softkey labeled "Menu" or "Options" but when the user is browsing Internet, the menu is available only by pressing the * (Star) key in the numeric keypad — and there is no indication on the keypad or on the

[220] According to Alkio (2003), Nokia's mobile phones utilizing the Navi-key UI have sold more than 300 million units.

display that the menu is accessible only this way.[221] Many of the interaction styles applied by mobile phone manufacturers in their contemporary handset models have not been initially designed to support effective Internet browsing. As described earlier, the conventional mobile phone user interfaces have been designed around *hierarchical menu navigation and item selection* interaction style instead of *content navigation and hyperlink selection* style. Mobile internet content, however, applies the content navigation and hyperlink selection metaphor.

Another reason to the mobile Internet browsers' non-conformance to the mobile phone interaction style is that in several cases the mobile Internet browser is a separate piece of software that has been originally developed without a specific mobile phone user interface in mind. The mobile phone product development team may just integrate a browser software package designed, developed, and delivered by an external company. It may be the case that the UI platform lacks some specific keys, or that the display is too narrow, or that the phone manufacturer's interaction style dictates a different use for the softkeys than what the browser developers have envisioned.

However, designing a usable mobile Internet phone user interface is not overly complicated. The Microsoft Smartphone, Motorola V60, Nokia 6650, and Ericsson T65 demonstrate that if the underlying interaction style has the appropriate elements, then the mobile Internet browsing user experience — at least from the device point-of-view — is consistent and predictable. The abovementioned products deliver a consistent mobile browsing user experience by offering the following three operations intuitively and consistently in the user interface:

1. *(hyperlink) selection* function
2. *backstepping* function
3. *menu* containing the other available functions

These operations are obviously needed frequently also when using other functions of a mobile phone than the browser, but the established mobile browsing usage conventions emphasize the need to have all of them simultaneously available. In a non-browser UI application, this functionality can be adequately implemented with mapping the three operations dynamically on two keys — like in the Navi-key user interface. In the abovementioned mobile phones, these functions are designed consistently across the whole device user interface, whereas in some other devices that were evaluated in this study, their behavior is not consistent between the mobile browser and the other functionality of the device.

5.2 Interaction Style Usability

The concept of *interaction style* may be most relevant within the context of UI design work. Interaction style is the underlying framework and lighthouse that the product designers and developers use as the guiding baseline: a user interface

[221] The mobile Internet browser menu in the Samsung N620 and T100 phones is accessed this way.

designed around a direct manipulation style needs to be designed differently from another interface design based on a command language style. This study attempts to investigate the role of the interaction style, and specifically the changes in mobile phone interaction styles over time, from the usability perspective. The end users are not directly dealing with the interaction style of a mobile phone, but the tangible mobile phone artifact itself. The interaction style as an underlying, abstract framework is not directly within reach of the users, but its realization in the product's user interface is. When investigating the role and relevance of the interaction style from the usability perspective, we must carefully attempt to isolate the abstract interaction style from the more tangible and visible presentation style, applications, application skins, input/output hardware, mechanical, and industrial design, as illustrated in **Figure 29**.

The key artifact under investigation in this study, the Three-softkey interaction style, was not evaluated in isolation, but as an element in the Nokia 6650 product, since we chose to conduct empirical usability tests. To reduce any possible interference by other UI and product design attributes, we chose to evaluate only the Nokia 6650 phone and not any other phones. The interaction style comparison was based on comparing a set of interaction styles associated with the users' earlier mobile phone experience against the new Three-softkey interaction style. The empirical usability testing generated a significant amount of data; some of the data and findings are related to the phone interaction styles, and some of the findings are more about individual features or applications, or about the presentation style in the user interface. These findings that are not related to the interaction style components are not discussed in this thesis, but they have been communicated to the respective UI design and development teams at Nokia.

41 test users participated in the usability tests. They were selected based on their earlier experience with mobile phones, as illustrated in **Figure 94**. 25 users were users of Nokia phones, 13 users were users of Ericsson, Motorola, or Siemens phones, and three expert users[222] participated to set the efficiency benchmark. The non-Nokia users were selected to have no or minimal earlier experience with Nokia mobile phones.

The test scenario and setup were designed to find answers to the question of how easily consumers with varying mobile phone usage experience learn to master the new Three-softkey interaction style in the new Nokia 6650 phone illustrated in **Figure 89**, and to point out any specific problems in the new UI. A set of 15 test tasks was devised, and that was divided into three sub-sets as illustrated in **Figure 137**.

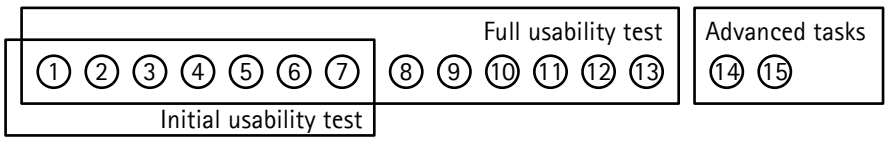


Figure 137. Usability test sets

[222] The expert users — one of them the author of the thesis — were from different Nokia usability teams, and they are regularly switching between different Nokia and competitor mobile phone models. They had practiced the usability test tasks for maximum efficiency. Each expert user conducted the tasks three times and therefore some charts in the thesis show n=9 for the Expert user group.

The **full usability test** was run with Nokia and non-Nokia test user groups to find answers to the following research questions:

a. Do people with different Nokia UI usage experience find the Three-softkey UI easy to use when they pick it up the first time? Is the Three-softkey UI intuitive for these users?

b. Do people with non-Nokia UI usage experience find the Three-softkey UI easy/easier/harder to use? Are there significant differences between ex-Nokia and ex-non-Nokia users when it comes to usability of the new interaction style?

The **initial usability test** tasks, **full usability test** tasks, and the **advanced test** tasks were used in the usability tests before and after the long-term usage period, as explained in **Section 4.2.1**, to find answers to the following question:

c. Do people with varying mobile phone usage backgrounds learn the Three-softkey UI over a longer period of time? Do also those people learn the UI who had difficulties with initial use? Is the usage experience satisfactory?

To measure the overall **ease-of-use** of the new Three-softkey UI, the test users were asked to [1)] rate the overall ease-of-use of the 6650 phone and [2)] compare the 6650 phone with their current phone after all test tasks were completed. The overall average ratings were:

1. The 6650 phone is quite easy to use: average **1.3**
(n=37; expert users excluded. Easy=1, …, Difficult=3)

2. The 6650 phone is about as easy to use as the current phone: average **2.1**
(n=34; expert users excluded. Easier=1, …, More difficult=3)

The user-group-specific ease-of-use and comparative ease-of-use ratings are shown in **Figure 138** below.

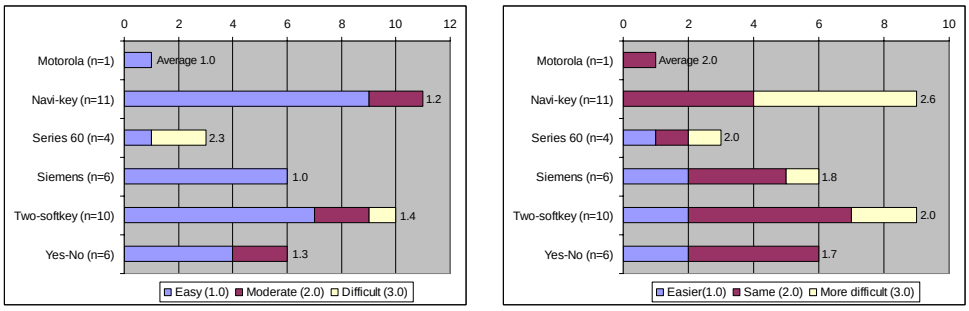


Figure 138. User-group-specific ease-of-use and comparative ease-of-use of the 6650 phone

The descriptive statistics for the subjective ease-of-use measure are illustrated in **Figure 139**. With the 90% confidence interval ($\alpha = 0.10$) we observe a statistically significant difference between Nokia and non-Nokia users showing that non-Nokia users rate the 6650 phone to be easier to use than what the Nokia users say (confidence intervals 0.9 – 1.3, and 1.4 – 1.9, respectively). An interesting notification is that all Siemens users rated the 6650 to be easy to use.

Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	90% confidence interval
Motorola	1	1.0						
Navi-key	11	1.2	0.4	1	1	2	0.9 - 1.4	1.0 - 1.4
Series 60	3	2.3	1.2	3	1	3	1.0 - 3.6	1.2 - 3.4
Siemens	6	**1.0**	0.0	1	1	1		
Two-softkey	9	1.4	0.7	1	1	3	0.9 - 1.9	1.0 - 1.8
Yes-No	6	1.3	0.5	1	1	2	0.9 - 1.7	1.0 - 1.7
Nokia - Expert	23	**1.6**	0.7	1	1	3	1.3 - 1.9	**1.4 - 1.9**
Non-Nokia	13	**1.1**	0.4	1	1	2	0.9 - 1.3	**0.9 - 1.3**

Figure 139. Descriptive statistics for user-group-specific ease-of-use; (1: Easy, 2: Moderate; 3: Difficult)

The users were also asked to compare the ease-of-use of the new 6650 phone against their current phone. The descriptive statistics for this comparative ease-of-use rating are shown in **Figure 140**. Using the 95% confidence interval (α = 0.05), we can see statistically significant differences between Navi-key users and Yes-No users. The Navi-key users rate the Nokia 6650 phone more difficult to use (average = 2.6) than what the Yes-No users think (average = 1.7). If we apply the 90% confidence interval (α = 0.10), we can see further differences between the user groups as shown in **Figure 140**. The Navi-key users and the whole non-Nokia user group compare the relative ease-of-use of the new 6650 phone against their current phone rather differently (confidence intervals 2.3 – 2.8, and 1.6 – 2.1, respectively).

Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	90% confidence interval
Motorola	1	2.0						
Navi-key	9	**2.6**	0.5	3	2	3	**2.2 - 2.9**	**2.3 - 2.8**
Series 60	3	2.0	1.0	2	1	3	0.9 - 3.1	1.1 - 2.9
Siemens	6	1.8	0.8	2	1	3	1.2 - 2.4	1.3 - 2.3
Two-softkey	9	2.0	0.7	2	1	3	1.5 - 2.5	1.6 - 2.4
Yes-No	6	**1.7**	0.5	2	1	2	**1.3 - 2.1**	1.3 - 2.0
Nokia - Expert	21	2.2	0.7	2	1	3	1.9 - 2.5	1.9 - 2.4
Non-Nokia	13	**1.8**	0.6	2	1	3	1.5 - 2.2	**1.6 - 2.1**

Figure 140. Descriptive statistics for comparative ease-of-use; (1: 6650 is easier, 2: Same; 3: 6650 is more difficult)

The Navi-key users specifically regard the 6650 phone as more difficult than their current handset. Based on the unprompted, subjective comments from some Navi-key users, this is likely to be caused by the number of control keys in the Three-softkey UI: the new UI has three softkeys (Navi-key has one), the left and right navigation keys (Navi-key has only up and down), and the new UI also has the green and red handset keys (Navi-key does not have these).

The absolute and relative ease-of-use ratings from all user groups can be summarized as follows:

1. Users with no earlier experience with Nokia phones (n=13) perceive the 6650 easier to use (average 1.1) than what Nokia users (n=23) think (average 1.6).
2. The Siemens user group (n=6) is the one who unanimously thinks the 6650 is easy to use (average 1.0).
3. Navi-key users (n=9) think the 6650 phone is harder to use than their current phone. However, they still think the 6650 is quite easy to use (average 1.2).
4. Yes-No users (n=6) think the 6650 phone is easier to use than their current phone, and they think the 6650 is almost as easy as what the Navi-key users (n=9) think (Yes-No users' average 1.3).
5. Users with no earlier Nokia phone usage experience (n=13) generally think the 6650 phone is somewhat easier to use than their current phone.

Figure 141. Ease-of-use findings summary from the empirical usability test

A possible explanation to these findings may be that the users' current Nokia phones are easier to use than the non-Nokia phones. The non-Nokia users may have been giving a better ease-of-use rating for the 6650 phone as their current phones are more difficult to use than the Nokia phones, with the Yes-No users being the extreme case: none of the six Ericsson users regarded the 6650 phone to be more difficult to use than their current phone, whereas five of the tested nine Navi-key phone users said the 6650 is more difficult than their current phone, and none said it is easier. The usability test tasks had been defined to cover the key functionality of a contemporary mobile telephone in an initial usage setting; however, the selection or possible omission of tasks may have affected the study results, although the other than interaction style related aspects of the test findings have been extracted as carefully as possible. Another possible explanation is that the current Nokia users saw the new UI being just another version of their existing user interface, which they already know and like. Thus they may have experienced no big changes, but no big disappointments either. A possible viewpoint is also that since the test users knew that the test was arranged by Nokia, the non-Nokia users were trying to please the Nokia personnel by being over-positive towards the tested phone; about half of the tested Nokia phone users were also Nokia employees, and maybe they did not have a reason to behave over-positively. However, in Nokia usability tests we have not experienced this kind of bias since the standard procedure is always to recruit test users outside the mobile phone UI development units.

The **effectiveness** attribute of the Three-softkey interaction style was measured with the task success rate and the number of hints given by the moderator. The success rate was very high in this study. One test user from the Two-softkey group did not complete task 5 (sending a multimedia message), as he did not attach the picture to the message. This was the only task that failed. In general the test users seemed to manage relatively well with the test phone, many of them seemed to take pride in completing the tasks, and practically all of them felt quite relaxed after the test session, even if some of the tasks had made them scratch their heads or turn to moderator hints.

The task moderator gave a short hint to the user if the user was stuck in a task with no visible progress for a couple of minutes. The number of moderator hints per task is shown in **Figure 142** (left). **Figure 142** (right) illustrates the proportion of hints given for a specific user group compared to the proportion of the user group of the total test sample. It must be noted that the sample group sizes are

very small (see **Figure 94**) but we can see that the Yes-No and Two-softkey users were given relatively more hints than what e.g. the Siemens users received. The number of hints per task proved to be a good indication of faults in the UI design; not so much on the interaction style level but on an application or feature level, and these issues have been communicated to the respective UI design teams.

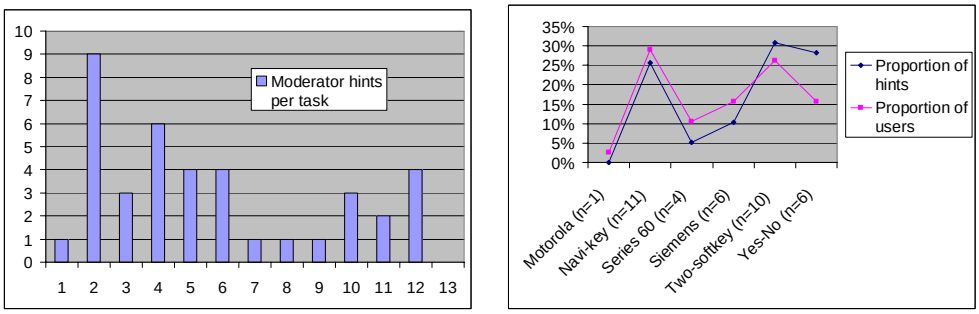


Figure 142. Moderator hints (across all user groups), and proportion of hints compared to user group's relative size

To analyze **efficiency** we measured task times and errors in task flow. The cumulative average task times per user group are illustrated in **Figure 143**. The average task times for the first seven tasks are counted for all users who completed tasks 1 – 7, and in the tasks 8 – 13 the long-term users are not included as they did not conclude these tasks in the initial testing; e.g. the sample size for the Series 60 group is marked as "n=4/1" denoting the fact that four Series 60 users completed the first seven tasks and one Series 60 user completed tasks 8 – 13. It needs to be noted that the group sizes are relatively small — e.g. only one Motorola user.

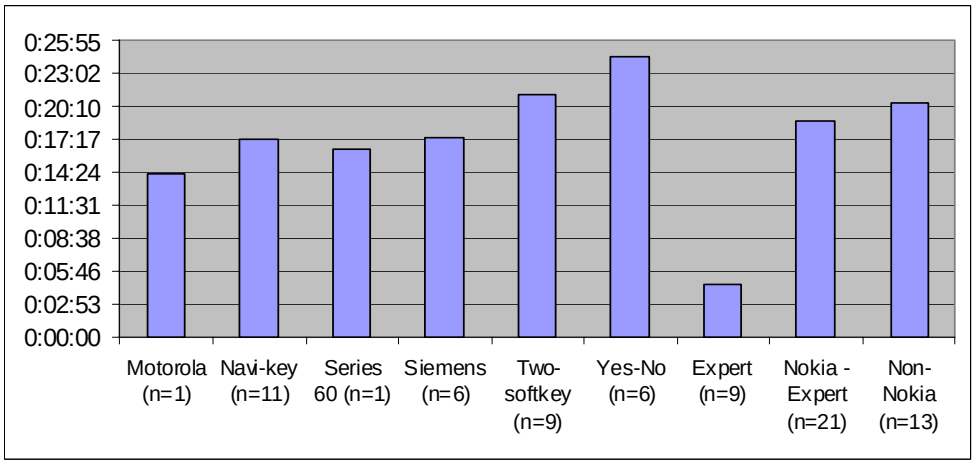


Figure 143. Average cumulative task times per user group

Descriptive statistics for the average cumulative task times are shown in **Figure 144** below. Applying the 90% confidence interval ($\alpha = 0.10$) shows statistically significant differences: the Navi-key users and the Siemens users are faster than the Yes-No users. This finding is in line with the moderator hints; **Figure 142** shows that the Yes-No users were assisted by the moderator more often than the other user groups. This is a rather interesting finding when compared to the fact that the Ericsson users were the ones who regarded the 6650 phone to be the easiest when compared against their current phone, as illustrated in **Figure 138**.

	Cumulative task times per group								
Group	n	Average	Standard deviation	Median	Min	Max	95% confidence interval	90% confidence interval	Novice/ Expert
Motorola	1	0:14:17							3.1
Navi-key	11	**0:17:18**	0:04:26	0:17:33	0:07:45	0:23:29	0:14:40 - 0:19:55	**0:15:06 - 0:19:29**	3.7
Series 60	1	0:16:33							3.6
Siemens	6	**0:17:25**	0:02:05	0:16:54	0:14:52	0:20:02	0:15:46 - 0:19:05	**0:16:02 - 0:18:49**	3.7
Two-softkey	9	0:21:05	0:07:18	0:19:56	0:11:32	0:36:26	0:16:19 - 0:25:51	0:17:05 - 0:25:05	4.5
Yes-No	6	**0:24:33**	0:06:02	0:24:42	0:18:05	0:34:55	0:19:44 - 0:29:23	**0:20:31 - 0:28:36**	5.3
Expert	9	0:04:39	0:00:26	0:04:34	0:04:10	0:05:24	0:04:22 - 0:04:56	0:04:25 - 0:04:53	1.0
Nokia - Expert	21	0:18:53	0:05:55	0:18:32	0:07:45	0:36:26	0:16:21 - 0:21:24	0:16:45 - 0:21:00	4.1
Non-Nokia	13	0:20:28	0:05:45	0:19:10	0:14:17	0:34:55	0:17:21 - 0:23:36	0:17:51 - 0:23:06	4.4

Figure 144. Descriptive statistics of cumulative task times

The average cumulative task times for the test user groups are within 3.6 – 5.3 times the experts' cumulative task time; with the one-person Motorola group excluded.

Figure 145 below illustrates the average percentage of users making errors per test task. The chart indicates that on the average, 29% of Series 60 group users made an error or errors in a test task, while 50% of Siemens group users did the same.

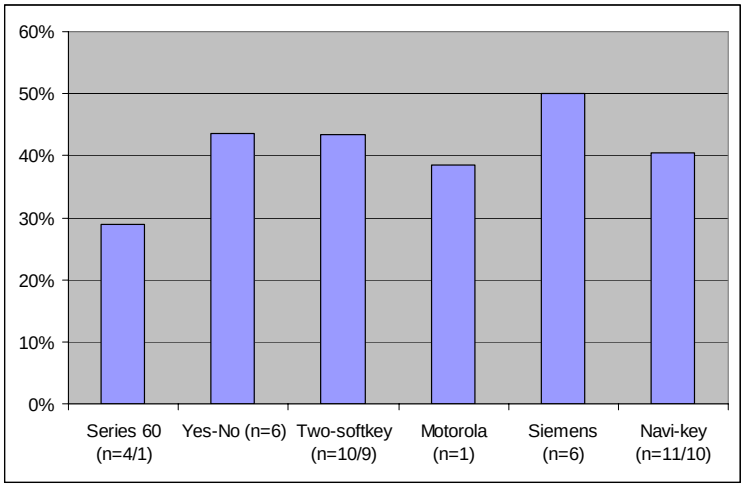


Figure 145. Average percentage of users making errors per task[223]

The measured three aspects of usability — effectiveness, efficiency, and ease-of-use — can be consolidated from the perspective of the different earlier experience user groups:

> The **Yes-No** users (n=6) gave the highest satisfaction rating to the 6650 when compared to the current phone; they actually saw the 6650 being somewhat easier to use than their own phone. However, these users were the slowest to complete the tasks, and they needed more moderator hints than any other user group. There was only one task (task 12; see **Figure 125**) where these users made more errors than any other user group. These results can be interpreted so that the Yes-No interaction style is the furthest away from the Three-softkey interaction style, and therefore the Yes-No users spend the longest time figuring out how the Three-softkey style works, and also need the largest number of operator hints. These users still didn't make the highest number of errors, which might indicate that instead of exploring the UI and going to the wrong locations, they navigate around the UI less than the other user groups. The highest subjective ease-of-us rating of

[223] Group sizes denote the number of users who conducted tasks 1–7 and 8–13, respectively. Some of the test users conducted only tasks 1–7.

all groups may indicate that when these users finally complete their tasks, they are the ones who like the tested UI the most. Ericsson's traditional 'non-dominant' interaction style conventions — Yes-No control keys instead of softkeys, and horizontally presented tab menu instead of a vertical or grid menu — seem to make it quite tedious for an Ericsson user to migrate to a different, softkey-based interaction style that has a vertical or grid menu. However, even if the transfer is tedious and slow, the users seem to find the new UI being an improvement over the old one.

The **Series 60** users (n=4) and **Two-softkey** users (n=10) saw the 6650 phone being about as easy to use as their current phone. The Two-softkey users needed slightly more moderator hints than the Series 60 users. The Two-softkey users were also slightly slower than the Series 60 users. Neither user group made significantly more errors than the other user groups. The findings can be interpreted so that the Three-softkey UI is relatively similar to both Series 60 and Two-softkey UI, but the Series 60 users have a slight advantage over the Two-softkey users due to Series 60 having a center select key like the Three-softkey UI has. The standard deviations for these two user groups are rather large, and no statistically significant differences are visible.

The **Navi-key** users (n=11) rated the 6650 phone the most difficult when compared to the current phone; however, they still regarded the 6650 phone being quite easy to use as such. Their average task times were about the same with the Series 60 users i.e. somewhat faster than the Two-softkey users, and they also received slightly less moderator hints than the Two-softkey users. There was only one task (task 10; see **Figure 121**) where the Navi-key users made more errors than any other user group; this is probably because their current phones do not have a calendar application[224]. The Navi-key users made relatively many errors in the calling tasks since they tried to use the center softkey for call management due to the transfer from the Navi-key UI. The findings can be interpreted so that despite the fact that the Navi-key users performed the tasks quite fast and without errors, they still felt uneasy with the tested UI. A probable reason to this is the sheer number of new elements in the UI compared to their current phone: the Three-softkey UI adds two softkeys, two navigation keys, the green and red call handling keys, the larger display, and the integrated camera. This supports the *one-dimensional usability* conclusion of Keinonen (1998): only the number of buttons and display elements are applied to assess the versatility and complexity of a product.

The **Siemens** users (n=6) seemingly can transfer their softkey usage skills to the new UI, and they don't suffer from the 'Nokia UI legacy' the way the Nokia Two-softkey users seem to do: the Siemens users don't expect the phone to work completely similarly to their existing phone. All Siemens test users rated the 6650 phone to be easy to use, on the average they rated the phone to be about as easy to use as their current phone, they needed less hints than the Yes-No or Two-softkey users, and their average task times were the fastest of all user groups (Motorola excluded). On the other hand, the Siemens users made the largest number of errors in several tasks, which indicates that they were exploring the UI and ended up in wrong places, but were still able to recover from the errors without major problems. Some Siemens users tried to use the red handset key as a backstepping key; it works that way in Siemens but in the Three-softkey UI it works as a 'global exit' key taking the user back to the idle state.

Comparing the efficiency, effectiveness, and ease-of-use of the Three-softkey UI between the tested user groups reveals some notable similarities and differences, as summarized in **Figure 146**. When looking at the relative differences between

[224] The more recent Navi-key phones from Nokia include a calendar application.

the Siemens and Navi-key user groups, we can observe some similarities with the findings of Ziefle (2002) and Bay & Ziefle (2003). They compared Siemens and Navi-key phones and found out that the test users spent more time on their test tasks with the Siemens phone and undertook more detour steps and hierarchical steps back than the users with the Navi-key phone. They claim this is because of the significantly more complex menu structure and control keys in the Siemens phone. In our study, Navi-key users said the 6650 phone is more difficult than their current phone, and Siemens users concluded that the 6650 phone is slightly easier than their current one. All Siemens test users (n=6) rated the 6650 phone to be Easy, (1) when they were given the options Easy (1), Moderate (2), and Difficult (3) to choose from.

User group	Effectiveness	Efficiency	Ease-of-use
Motorola (n=1)	Group size too small for analysis		
Navi-key (Nokia; n=11)	High success rate, average number of moderator hints	Short task times, average number of errors	Users think the 6650 phone is quite easy to use, but still more difficult than their current phone
Series 60 (Nokia; n=4/1)	Group size too small for analysis		
Siemens (n=6)	High success rate, moderator hints less than average	Short task times, highest percentage of users making errors	Users think the 6650 phone is (very) easy to use, and slightly easier than their current phone
Two-softkey (Nokia; n=10)	High success rate, average number of moderator hints	Average task times, average number of errors	Users think the 6650 phone is quite easy to use, and about as easy or difficult as their current phone
Yes-No (Sony Ericsson; n=6)	High success rate, moderator hints above average	Longest task times, average number of errors	Users think the 6650 phone is quite easy to use, and a bit easier than their current phone

Figure 146. Usability findings per earlier experience interaction styles[225]

Due to schedule priority conflicts we could not conduct as many long-term user tests as we were planning, and eventually we only managed to test four test users after they had used the 6650 phone for two months as their daily phone. After the two months usage period the four test users reached an average efficiency level of around 220% compared to the expert users' efficiency when task completion times were measured. **Figure 147** illustrates the task-specific task time ratio between long-term users and expert users.

[225] See **Figure 93** for a description of the interaction styles and representative phone models.

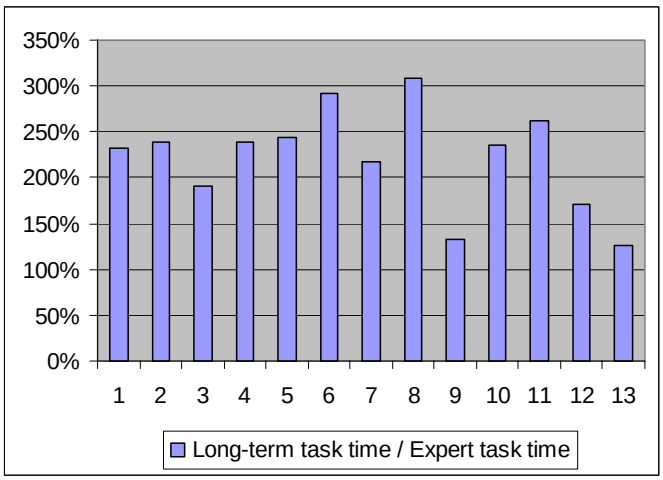


Figure 147. Efficiency after the long-term usage period

Several usability test findings were actually not related to the Three-softkey interaction style as such, but more related to specific features and functionality in individual phone applications. The usability team consolidated a detailed report illustrating and analyzing specific problem areas in and around multimedia messaging, camera functionality, terminology issues, calendar application, clock settings, ergonomics of the navigation key, and several other topics. These issues are not described in more detail in this thesis as they are clearly outside the scope of the study. They have been communicated to the UI design teams so that the UI can be improved in the upcoming releases and products.

5.3 Interaction Style Evolution

Based on the findings from the contemporary mobile phone interaction style analysis and from the empirical usability testing of the Three-softkey UI, we can conclude some suggestions and guidelines that would be applicable when mobile phone interaction style evolution is planned.

The study provides insight of three mobile phone manufacturers' interaction style evolution:

> **Nokia** is introducing a new three-softkey interaction style in the Nokia 6650 phone. This interaction style is resolving some known usability deficiencies in Nokia's earlier Two-softkey interaction style by introducing a third softkey to perform selection function with one clearly indicated key press. Nokia's Navi-key and Series 60 interaction styles share some elements with the Two-softkey style, such as the softkey concept, and menu structures.
>
> **Siemens** is using its proprietary two-softkey interaction style in several phone models, it is introducing the Series 60 UI from Nokia in the SX1 smart phone model, and its upcoming 3G phone U1C is based on the Motorola A820 shown in **Figure 45**. The interaction styles in these phones all apply softkeys but the function assignments are different: in the traditional Siemens interaction style one e.g. backsteps to the previous display by pressing the red handset key, and in the Motorola UI one must press the left softkey to do the same, whereas in the Series 60 style one backsteps with the right softkey, and pressing the red handset key will exit an application.
>
> **Sony Ericsson** is moving towards a two-softkey interaction style in its global product portfolio. Ericsson has been using a Yes-No hard key interaction style for

> several years in its products, and the new softkey-based UI will align Sony Ericsson closer to the other major mobile phone manufacturers' UI conventions.

The empirical usability testing conducted on Nokia's new Three-softkey interaction style revealed that the overall effectiveness with the new UI is good: one test user did not complete one task — all other tasks were completed by all other users with few hints offered by the test moderator as illustrated in **Figure 142**. Most of the hints focused on application-specific usability issues instead of the interaction style.

Long-time Ericsson users were the slowest to complete the test tasks with the new Three-softkey UI as illustrated in **Figure 143**. Together with the other non-Nokia users, they regarded the new UI to be easier than what the current Nokia users felt. Especially the Nokia Navi-key users thought the new UI is more difficult than their current phone, although they had completed the test tasks faster than the Ericsson users, and roughly at the same speed with the Siemens group. Of the Nokia users, the ones who had used the Two-softkey UI in the past were the slowest, and they also needed the biggest number of hints from the test moderator. They did not rate the Three-softkey UI to be as difficult as what the Navi-key users concluded, though.

These findings suggest some patterns in and around the consumer adoption of a new mobile phone interaction style.

First of all, **the user's subjective feeling of ease-of-use does not directly correlate with the effectiveness and efficiency** with the new UI.

> The Ericsson Yes-No users were significantly slower than the Nokia Navi-key users (average cumulative task times 0:24:33 and 0:17:51, respectively), they needed more hints (total 11 hints per 6 Ericsson users, versus 10 hints per 11 Navi-key users), but these groups still rated the ease-of-use of the tested UI about the same (Ericsson users' rating 1.3, and Navi-key users' 1.2; 1=Easy, …, 3=Difficult). Actually the Ericsson, Nokia Two-softkey, Nokia Navi-key, and Siemens user groups all rated the ease-of-use of the new UI rather similarly, the ratings being between 1.0 (Siemens) and 1.4 (Nokia Two-softkey).

However, when the users were asked to rate the ease-of-use of the Nokia 6650 phone compared with their current phone, there were considerable differences between the user groups, as illustrated in **Figure 138** and **Figure 140**. We can conclude that **the earlier mobile phone usage experience has an effect on the perceived initial ease-of-use of a new UI.**[226]

> The Nokia users on the average felt the 6650 was slightly more difficult to use than their current phone (rating 2.2) and the non-Nokia users felt the 6650 was slightly easier (rating 1.8). The most remarkable difference was between the Ericsson and Nokia Navi-key users: the Ericsson users gave a rating of 1.7 to the 6650, and the Navi-key users' rating was 2.6. None of the Ericsson users felt the 6650 was more difficult than their current phone, and none of the Nokia Navi-key users felt the 6650 was easier. It must be noted that in the current Nokia product portfolio, the Navi-key UI phones can be found in the entry-level product

[226] In a way this is obvious. What needs to be noted, however, is that there are significant differences in the different usability attributes when it comes to initial usability. In our study, for example, the Navi-key users were faster, and made fewer errors than the Yes-No users, but both groups rated the absolute ease-of-use of the 6650 phone rather similarly, and still the Yes-No group said the new phone is easier than their current one.

segments, whereas the Nokia 6650 phone is clearly aimed at the early adopters and technology enthusiasts.[227]

In order to generalize the findings from the empirical usability study, we need to analyze the (relative) complexity of the interaction styles under study. One tangible measure for the complexity of the interaction style is the number of distinct UI components that are accessible for the user. By categorizing the UI components in representative phones we can see that there are differences in the complexity, as illustrated in **Figure 148**.

	Ericsson Yes-No	Nokia Series 60	Nokia Two-softkey	Nokia Navi-key	Siemens	Nokia Three-softkey
Select key	Yes	Joystick press	Left softkey	Navi key	Right softkey	Center softkey
Cancel key	No	Right softkey	Right softkey	Clear	End key	Right softkey
Navigation keys	Two-way: left/up, down/right	Four-way joystick	Two-way: up, down	Two-way: up, down	Four-way rocker key	Four-way rocker key
Other control keys (numeric 3x4 keypad excluded)	Clear	Left softkey, Menu key, ABC key, Clear key, Talk, End	Talk, End	-	Left softkey, Talk key	Left softkey, Talk, End
Control key count	5	12	6	4	8	9

Figure 148. Interaction style complexity measured by control key count[228]

Looking at the interaction style complexity measured by the control key count shows significant differences between the reviewed interaction styles. When the interaction style complexity is compared against the empirical usability test findings, we can conclude the following hypotheses:

> **Using a more complex mobile phone interaction style will make it easier for the user to transfer to a new style**: the subjective ease-of-use rating is higher. This is supported by the findings in the cases of Series 60 ➔ Three-softkey style, and Siemens ➔ Three-softkey style. It needs to be noted that in both cases both interaction styles are applying the softkey metaphor.
>
> When transferring from a less complex style to a more complex one, the different usability attributes — effectiveness, efficiency, and satisfaction — clearly indicate that usability is affected by several factors: the transfer from the one-softkey Navi-key style to the new Three-softkey UI resulted in relatively high effectiveness and efficiency, yet the users regarded the new phone more difficult to use than their current phone. This is likely due to a large extent of the increased number of control keys that made the users feel overwhelmed or uneasy. The transfer from the simpler Yes-No style to the more complex new Three-softkey style, on the

[227] Obviously, product segmentation must not be used as an excuse for inferior UI design. However, the user needs and priorities, and the replacement users' previous experience are likely to be different in these user segments.

[228] We do not include the display UI components here. One could argue that the softkey-based interaction styles would be even more complex since the user has to glance at the softkey label and locate the physical key, whereas in the Yes-No style one only has to locate the control key. Taking this approach would not significantly change the interaction style complexity order.

other hand, resulted in the users perceiving the new UI being easier to use than their current phone, although the effectiveness and efficiency measures were lower.

We can draw a conclusion — that cannot be fully or reliably verified within the context of this study — that **the softkey interaction style may result in a more usable UI than the Yes-No UI, since with the labeled softkeys the users are always informed of the key functionality**. One of the fundamental HCI design principles is to support the user's feeling about being in control (see e.g. Trewin 2000), and with a non-softkey based mobile phone interaction style such as the Yes-No style the feeling of being in control may be weaker. It must be noted that the industry trend is clearly moving towards the softkey paradigm; Sony Ericsson being the last major manufacturer to hold on a different interaction style.

Consistency is a key element in creating usable products and user interfaces (Nielsen 2002a). Despite that the Nokia Navi-key users felt that the Three-softkey UI is more difficult to use than their current phone, they were intuitively using the centermost softkey in the new UI, since they were familiar with the similar concept already from their current phones. Looking a couple of years back, Nokia's Navi-roller interaction style was based on the earlier Two-softkey UI, where it added a centermost select key in the form of a roller press (see **Figure 89**). In the case of the Navi-roller style, UI consistency was partially broken: e.g. Kiili (2002) names the lack of consistency between the select key and the softkeys to be a key usability problem in this user interface. Qualitative data from a Nokia-internal study conducted in 2002 revealed that consumers prefer user interface consistency across different products from the same brand.

Based on the contemporary mobile phone interaction style analysis and the empirical usability testing of the new interaction style, we can summarize the recommendations that can be applied when design decisions are made around interaction style evolution. The proposed recommendations would assist in ensuring that replacement consumers would find it intuitive to start using a new mobile phone that may have a novel interaction style.

6. The new interaction style needs to be based on some earlier design heritage and core interaction elements, if a significant consumer segment and established consumer base already exist. Case: users with earlier Navi-key experience found the new phone with the Three-softkey UI intimidating and more difficult than their current phones. This did not prohibit them from conducting the test tasks with the new phone effectively and efficiently, however. Obviously, there are no fundamental reasons prohibiting the current Navi-key users from becoming proficient users of the Three-softkey interaction style, if they find the new style appealing, or there is some other reason for them to continue using the new interaction style.
7. If interaction style continuity needs to be retained, the primary interaction style elements such as select and cancel functionality should be left unmodified, unless a clear usability or some other benefit can be introduced via the modification. Case: The Ericsson Yes-No users who had previously used a non-softkey interaction style were slow with the new UI and needed help from the moderator. However, their subjective verdict of the phone was quite positive, due to the usability benefits introduced by the softkey paradigm: they may have felt more in control when seeing the softkey labels telling what functions are available.
8. Some fundamental interaction style elements should span across the mobile phone manufacturer's whole product portfolio. Case: it was clearly visible in the empirical usability testing that Nokia Navi-key users could benefit from their earlier experience with a UI that is based around a centrally located softkey, although they felt the new UI is more difficult than their current phone due to the number of new UI components.
9. Design and development work for an individual product should obviously follow user-centered design principles and practices.

Figure 149. Recommendations for mobile phone interaction style evolution

The long-time, traditional Ericsson Yes-No hard key user interface is currently in the process of being replaced by Sony Ericsson's new softkey-based interaction style, as illustrated in **Figure 61**. Sony Ericsson's 3G W-CDMA phone, the Z1010, is evolving this softkey-based UI even further, as illustrated in **Figure 150**. The average mobile phone replacement cycle is currently around 2.5 years (Nokia 2002) which means that the owners of e.g. the popular[229] Ericsson T68 and T68i models (see **Figure 74**) may be replacing their handsets with the Z1010. The new UI no longer has the traditional Yes-No keys, the Menu key has been replaced by a dedicated backstepping key, and there are two new dedicated function keys beneath the navigation keys. The phones are targeted at the same, technology-focused, early adopter segment, so it is likely that the users will face some difficulties learning to use the new UI with the new softkey interaction logic and the new control keys.

Figure 150. Sony Ericsson Z1010 W-CDMA phone UI

[229] The T68 and T68i have been Ericsson's most popular phone models to date. In: Business 2.0. 25-Sep-2002. [Cited 01-Jun-2003] Available from WWW: <http://www.business2.com/articles/web/0,1653,43841,00.html>.

5.4 Contribution of the Author

The study has been conducted and the monograph thesis written by the author between 1998 and 2004. Conducting a project of this scope as a secondary activity has made the work progress relatively slowly with the exception of three more intensive periods: the initial formulation of the research topic in late 1998, a four-month sabbatical for user interface analysis and thesis writing during the summer of 2002, and the final effort to document and analyze the Three-softkey usability testing, and to pull the thesis manuscript together between the spring and autumn of 2003.

Like the thesis writing activity, the actual usability engineering and research work has been conducted over a longer period of time. The UI concept creation work for the revised Two-softkey UI started in 1995; the author was one of the interaction designers creating the early UI concepts, implementing UI simulations, and conducting usability engineering activities in the project. The Series 60 smart phone UI concept work was initiated in 1996, and the author belonged to one of the three UI concept creation teams working to submit a UI concept in a friendly but tough internal UI concept contest. In 1998 – 1999 the author was the responsible usability engineer in the Nokia 9290 Communicator project and assisting some other mobile phone development projects. In 1999 – 2000 the author participated in the Three-softkey UI concept creation work and was the design manager for this UI in Nokia's global mobile phone UI design unit. At the same time he was also responsible for the company's mobile phone UI strategy and roadmap creation. In 2002 the author started a new UI strategy formulation project; this time one of the activities was a thorough competitor handset usability analysis that also provided some of the data to this thesis. The author then participated in the Three-softkey UI usability verification project during the late 2002 – spring 2003.

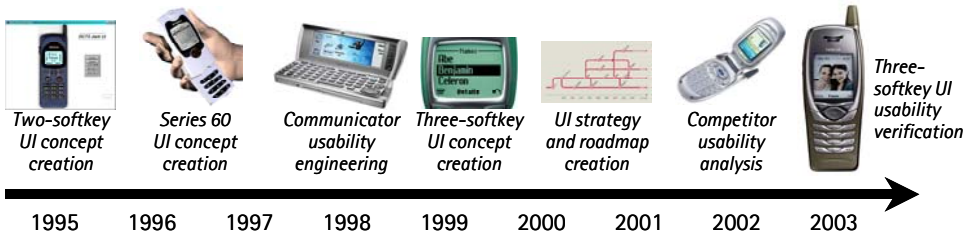


Figure 151. Timeline of the author's usability engineering activities contributing to the thesis

Of the specific activities reported in this thesis, the author's participation and scientific contribution has been the following:

- The constructs of mobile phone interaction style, and the mobile phone user interface model were devised by the author, and analyzed based on the mainstream HCI definitions for user interface and interaction styles. The analysis of consumer segmentation models and mobile device UI dominant designs were conducted by the author.

- The heuristic mobile phone UI analysis was conducted by the author with John Rieman and Dana McKay. Most of the interaction style element analysis reported in the thesis was conducted by the author, while John Rieman

defined the underlying methodology and UI complexity model that were used in analyzing the competitor phone usability against a pre-defined set of core tasks.[230]

- The empirical Three-softkey UI usability testing was conducted by the author with Aino Ahtinen, Matti Helenius, Tuula Varis, and the usability group of TeliaSonera in Helsinki. The author carried out the initial test user recruiting, prepared the usability test plan, and observed 9 of the 41 usability test sessions. The other sessions were observed by Matti Helenius and Tuula Varis. Aino Ahtinen moderated all test sessions. The statistical analysis of the research data was conducted by Aino Ahtinen and the author. John Rieman was in a key role in the usability testing project by devising the testing methodology and statistical analysis approach.

- The author also conducted some secondary research analyzing Nokia phones marketing research studies to find out how much relevant data the reports could provide to this research. The consumers' UI preference and earlier usage history aspects were not sufficiently covered in these marketing research reports to be incorporated in this study.[231]

5.5 Applicability of the Methods

This section will briefly analyze and justify the applicability of the research methods. The contemporary mobile phone interaction style review was conducted during the summer and autumn of 2002 by selecting the five manufacturers with the largest global market share at that time. These five manufacturers continue to have the largest market share in 2004.

Empirical usability testing as conducted in the study can most naturally focus on testing intuitiveness. Ketola (2002) refers to this as *instant usability* or *walk-up-and-use usability*. The participants have no earlier exposure to the product to be tested, and they are provided only with a couple of minutes familiarization time, so most findings really focus on how intuitive the user interface is. This includes keypad printings, menu structures, and display texts, icons, and animations. The original usability test plan included a larger long-term usability testing, but due to some external business-driven priorities, a larger group of test users was not available for this usability testing project. Eventually we could test only four users who used the Nokia 6650 phone for a period of two months. This group is not large enough for use to draw statistically reliable conclusions on interaction style learnability, and therefore the findings from the long-term usability testing are presented in this study very briefly in **Section 4.2.8**. From an industry-pragmatic usability engineering viewpoint we may still assume that the new interaction style has 'practically high-enough usability' since with the exception of one test task with one test user, all tasks were completed, and most of the (few) hints given by the test moderator (see **Figure 142**) were focusing on feature-specific issues instead of the interaction style. The feature-specific issues have been communicated to the UI designers for design improvements.

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[230] The comparative competitor phone usability study findings are not reported in this thesis as they mostly focus in user interface elements other than the interaction styles.
[231] Utilizing the marketing research data is brought up in **Section 5.6** when discussing further research suggestions, though.

Usability of the new interaction style was measured through application of the usability attributes defined in (ISO 1998): effectiveness and efficiency. The data acquired in the test was analyzed statistically to find out significant differences between the test user groups. Some user groups were too small for reliable data analysis: 1 Motorola user, and 4 Nokia Series 60 users. Nevertheless, the research findings indicate trends that have been analyzed to draw conclusions on interaction style transfer and propose approaches to interaction style evolution.

A fundamental limitation in the empirical usability study was that we only tested transfer from many interaction styles to one, i.e. the relation was n:1. Obviously, this can reveal how easily the specific interaction style under study can be approached by various user groups, but in order to get a more accurate understanding of the usability differences between interaction styles, we should have evaluated several interaction styles, i.e. a n:m relation. From a pragmatic viewpoint, this would have been a lot more time-consuming, and it would not have added so much value from an industrial usability engineering viewpoint. It needs to be remembered that the focus in this study has been very much applied research, and the overall research priorities have been defined with a business-driven mobile phone R&D mindset.

It must be noted that the interaction style as an abstract construct introduces inherent difficulties when trying to measure the usability of different interaction styles with an empirical usability evaluation method. The interaction style of a mobile telephone is not a tangible artifact directly accessible by the users. When investigating the role and relevance of the interaction style from the usability perspective, we have tried to carefully isolate the abstract interaction style from the more tangible and visible presentation style, applications, application skins, input/output hardware, mechanical, and industrial design, as illustrated in **Figure 29**. To make it easier to avoid harmful influence by other UI and product elements than the interaction style, the empirical usability testing experiment was defined to focus on only one interaction style, namely the Three-softkey style. Testing a number of products or interaction styles would have created a situation where the other elements and attributes could have easily influenced the test users' perceptions and attitudes.

Due to the industry-oriented nature of the study, many of the used references are not from the academia but from industry or trade sources. These, often less scientific references, are usually presented in this thesis as footnotes, whereas the more scientific, academic research papers, textbooks, and articles, are listed in the References section of the work.

5.6 Suggestions for Further Research

This study initially started with a substantially broader topic of mobile device user interface portfolio management; the early idea was to devise mechanisms and theories to guide the user interface strategy and roadmapping work from usability perspective. During the course of the work it became obvious that the breadth of the topic was simply too wide, so eventually the focus sharpened on defining and studying the usability of mobile phone interaction styles. Several interesting and uncharted research topics and issues were approached, defined, explored, and abandoned in the process. Many of these have been briefly discussed in this thesis. The following list briefly introduces some of those that could be relevant from a pragmatic mobile phone usability engineering and more theoretical human-computer interaction research perspectives.

1. Based on the empirical usability testing, the study hints that the interaction styles in Nokia phones used by the test users, may be easier to use than the Siemens and Ericsson interaction styles, or phones, that their users were using. In this study we did not directly measure the usability of these mobile phone manufacturers' products against each other. Some published usability studies exist that indicate some differences in usability in favor of some Nokia products (e.g. 3G LAB, 2002; Ziefle, 2002; Bay & Ziefle, 2003; and SirValUse, 2003). Further studies to investigate specific mobile communications user experience topics are needed to increase the understanding of usability related to different design conventions, and this knowledge would in turn be applicable in creating more usable mobile communications devices and services.

2. The study is indicating a hypothesis that softkey-style control keys in contemporary mobile telephones could be used to create a more usable user interface and product than what is possible with the Yes-No function key approach. This hypothesis is supported by the statistical analysis of the usability study data, but it is not fully verified in this study. However, since it is not possible to conduct an empirical evaluation of the abstract interaction styles as such, but to study the physical mobile phone artifacts instead, it may be so that some other aspect in the whole product usability happens to be better with the softkey-based products when compared to Ericsson's implementation of the Yes-No function key style. Maybe some other UI design based on the Yes-No function keys would result in a more usable total product that would be superior to the evaluated softkey approaches? It could be possible to design comparable sample user interfaces with both the softkey and the Yes-No control key design, implement e.g. comparable computer simulations, and evaluate those against each other. However, the business interest towards this kind of an experiment may be decreasing, since the largest proponent of the Yes-No keys interaction style — Sony Ericsson — seems to be in the process of migrating towards the softkey style.

3. Nokia products have sometimes been used as benchmarks in usability.[232] Nevertheless, even at Nokia there is no definite understanding of the absolute, quantitative value of usability and good UI design for the company. There are books and articles about cost-justifying usability on a general or case-study level (see e.g. Mayhew & Bias 1994) but from the overall business perspective it would be good to be able to estimate the value of the mobile phone UI as a company asset. This is likely to be somewhat similar to how corporate brand values are calculated.

4. The study has explored the concept of dominant design in the field of mobile telephone user interfaces. The conclusion is that there is convergence but a true dominant UI is yet to be established. When or if one gets established some day, it would be interesting to study and understand the role of usability in this development, or is it mostly the other aspects like market dynamics that establish a dominant design, as suggested e.g. by Utterback (1996).

5. One of the initial research topics was to explore if consumers mapped to belong to a certain consumer segment actually purchase phones designed for them. There is some, limited marketing research available to answer this

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[232] "*… for example, customers will be able to create a text message in a few easy steps, much like the way they can on a Nokia handset. Also following Nokia's lead, callers will be able to use a scroll button to get to their phone book, …*" In: Reuters. MOTOROLA TO SIMPLIFY WIRELESS SCREENS. 08-Apr-2002. [Cited 06-Jul-2004] Available from WWW: <http://news.com.com/2100-1033-877643.html>.

question, but more global, and statistically reliable studies are yet to be conducted. Likewise, in this study we did not explore the relationships between consumer segmentation attributes and usability test findings. Studying consumer segmentation empirically would require larger test user groups in order to be able to conclude statistically significant results.

6. Another initial research topic was to gain understanding on the replacement purchasing process: do consumers stay loyal to an interaction style when they upgrade their phones? There is some data available that indicates that many people stay loyal to e.g. the Nokia Navi-key UI, and they find it difficult if they by mistake or via a conscious decision get a new phone with the Two-softkey UI. Nokia is conducting marketing research studies for new phone models that are launched, and the author conducted secondary research on this marketing research data to investigate what can be said of the replacement customers' earlier phones, but the analysis data proved to be somewhat inconsistent between different studies, so no firm conclusions can be made.

7. A separate aspect that was investigated with the help of the existing marketing research data was consumers' subjective satisfaction with specific mobile phone user interfaces. The author reviewed eight Two-softkey phone marketing research reports and four Navi-key phone reports to find out that these consumers (n=2400) had rated the 'satisfaction with ease of use' and 'satisfaction with menu system' attributes very similarly between the different interaction styles; there was no statistically significant difference. This kind of study could be duplicated across a broader consumer base to cover also other than Nokia users.

8. From the interaction perspective the Motorola Synergy user interface is quite close to Nokia's Three-softkey style: both have three softkeys (menu, selection, and cancel), navigation keys, and call handling keys. Nokia's other interaction styles such as the Two-softkey UI are closer to the Three-softkey UI if the handset functionality or menu structures are compared. It would be possible to compare the transfer effect from Synergy and the Two-softkey UI to the Three-softkey UI, and analyze whether it is the control keys or the functionality and information architecture that play a stronger role in this transfer between user interfaces. The study would have to be conducted somewhere else than in Finland to find enough representative Motorola users.

9. Personalization of the mobile handset UI is currently supported on a presentation layer level (ringing tones, wallpapers) or by downloading and installing new applications. We do not currently fully understand whether consumers would also prefer personalization on the interaction style level. An analogy can be taken from the automotive industry: consumers can usually choose between manual and automatic transmission when ordering their new car, but in mobile phones we do not offer a choice between a menu interaction style and e.g. a wizard interaction style.

10. Some indications exist that a domestic broadband Internet connection may have a significant effect on consumers' lifestyle, preferences, and media consumption. The instant-on, high-speed Internet facilitates services and behavior that are not possible without. It is yet to be seen if a comparable phenomenon will take place when the wireless bandwidth increases enough, the mobile terminals become expressive enough, and wireless Internet becomes commonplace. This is definitely a topic for further consumer, socio-cultural, and end user needs research, and it may have significant impacts on the mobile terminals and their interaction styles.

11. The Smart Product Evaluation Space (SPES) methodology is presented by Keinonen (1998) to evaluate heart rate monitors. The same methodology could be applied to evaluate mobile telephones.

6. CONCLUSION

Mobile telephones are consumer electronics products designed and developed by industry practitioners within explicit business constraints. Evolution is rapid as new technologies and services are introduced on the marketplace. However, at the same time, a growing number of people are already familiar with using mobile telephones. Therefore, product designers are faced with a question: how big or discontinuous steps can they take when designing the user interface for their next product, or how closely should they stick with the already existing UI conventions that may already be familiar to users.

The objective of this research work is to create and communicate new knowledge for design and usability practitioners about how to design and evolve interaction style conventions in mobile telephones. The study aims at improving the understanding of how relevant a stable interaction style is to the mobile phone end users, specifically to the ones replacing their earlier handsets with newer models. In the context of this study, we define *interaction style* as:

> *Mobile phone interaction style is the framework consisting of the physical interaction objects, the abstract interaction elements, and the associated behavior or interaction conventions that are applied throughout the core functionality of the mobile phone. Within the context of this study, the interaction style definition excludes the stylistic appearance elements of the user interface, that are often referred to as the 'look' of the user interface.*

The main research problem in the study is defined as:

How do mobile phone interaction style changes affect the initial usability of a mobile phone for users with earlier experience with mobile phones?

Figure 152. Main research problem

From the research problem we have deduced the following, more detailed research questions:

1. *What is the interaction style applied in contemporary mobile telephones, and how does it differ from the interaction styles in mainstream HCI?*

2. *What is the effect on usability caused by specific changes in the mobile phone interaction styles between products?*

The focus of the study is on the interaction styles of mainstream, high-volume, voice-centric cellular mobile telephones. The study investigates mobile phone interaction styles primarily from the usability viewpoint, not e.g. from a user interface software implementation process or architecture viewpoint.

Several different methods have been applied in the study when investigating mobile phone interaction styles and searching for answers to the abovementioned research questions. The study is a synthesis of literature study, industry analysis, heuristic evaluation of contemporary mobile phone user interfaces, and empirical usability testing experiment. By investigating the topic of mobile telephone

interaction styles from these different viewpoints and by different methods, the study aims at creating new knowledge and useful information that is applicable in an industrial setting constrained by business priorities and product development realities.

The main results of the study are summarized as:

1. **Interaction styles applied in contemporary mobile telephones are designed around menu navigation, and they implement the three primary operations — Select, Back and Menu access — with dedicated hardkeys, context-sensitive softkeys, or using special control devices like joysticks or jog dials. The control keys are converging around various two- and three-softkey conventions.**
2. **Despite differences between interaction styles in contemporary mobile phones, users do not face significant difficulties when transferring to a novel mobile phone model.**

Figure 153. Main results of the study

Contemporary, voice-centric mobile telephones generally apply an interaction style that has been categorized as **indirect manipulation menu** in this work. The Nokia 3330 phone in **Figure 136** illustrates this interaction style: the hierarchically structured on-screen *extended menu*[233] is used with a multi-functional, dynamic softkey that is used also for selection, the canceling function is implemented with a dedicated hard key (with label "C"), navigation in the menu is facilitated by the up and down navigation keys, and there is no general mechanism to revert actions. This is much unlike the prevailing interaction style in the mainstream, desktop computing domain: direct manipulation or graphical interfaces that usually have more objects and functions represented continuously to the user, utilize pop-up and pull-down menus, and offer general and consistent "Undo" mechanism.

Analysis of the contemporary mobile phone interaction styles reveals no explicitly defined dominant UI designs on the marketplace today. The most widely deployed[234] individual interaction style in the industry — the Navi-key UI from Nokia — is a proprietary style used by one manufacturer only. Generally, the mobile phone manufacturers are converging around the use of two or three softkeys: Motorola's Synergy UI is applying three softkeys as illustrated in **Figure 33**, Nokia's new Three-softkey UI is adding a third softkey to the earlier Two-softkey UI, Siemens and Samsung are using a two-softkey UI in their product portfolio, and the long-time non-softkey UI advocate Ericsson is deploying softkey interaction style in its product portfolio as illustrated in **Figure 61**. Several Japanese manufacturers are applying three-softkey interaction styles as illustrated in **Figure 60** and **Figure 80**.

The empirical usability testing experiment focused on studying the initial usability of the new Three-softkey interaction style of Nokia. To reduce any possible interference by other UI and product design attributes, we evaluated

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[233] *Extended menu* as defined by Shneiderman (1992), since all menu items do not fit on the display.

[234] According to Alkio (2003), Nokia's mobile phones utilizing the Navi-key UI have sold more than 300 million units.

only the Nokia 6650 phone and not any other phones. The interaction style comparison was conducted by comparing a set of interaction styles associated with the users' earlier mobile phone experience against the new Three-softkey interaction style.

41 test users participated in the usability tests. They were selected based on their earlier experience with mobile phones, as illustrated in **Figure 94**. 25 users were users of Nokia phones, 13 users were users of Ericsson, Motorola, or Siemens phones, and three expert users participated to set the efficiency benchmark. The non-Nokia users were selected to have no or minimal earlier experience with Nokia mobile phones.

Comparing the efficiency, effectiveness, and ease-of-use of the Three-softkey UI between the tested user groups reveals some notable similarities and differences, as summarized in **Figure 154**. In our study, Navi-key users said the 6650 phone is more difficult than their current phone, and Siemens users concluded that the 6650 phone is slightly easier than their current one. All Siemens test users (n=6) rated the 6650 phone to be Easy, (1) when they were given the options Easy (1), Moderate (2), and Difficult (3) to choose from.

User group	Effectiveness	Efficiency	Ease-of-use
Motorola (n=1)	Group size too small for analysis		
Navi-key (Nokia; n=11)	High success rate, average number of moderator hints	Short task times, average number of errors	Users think the 6650 phone is quite easy to use, but still more difficult than their current phone
Series 60 (Nokia; n=4/1)	Group size too small for analysis		
Siemens (n=6)	High success rate, moderator hints less than average	Short task times, highest percentage of users making errors	Users think the 6650 phone is (very) easy to use, and slightly easier than their current phone
Two-softkey (Nokia; n=10)	High success rate, average number of moderator hints	Average task times, average number of errors	Users think the 6650 phone is quite easy to use, and about as easy or difficult as their current phone
Yes-No (Sony Ericsson; n=6)	High success rate, moderator hints above average	Longest task times, average number of errors	Users think the 6650 phone is quite easy to use, and a bit easier than their current phone

Figure 154. Usability findings against earlier experience interaction styles[235]

Based on the findings of the empirical usability testing, we conclude that users with earlier experience in using mobile phones, manage fairly easily to start using a new mobile phone with a novel, different interaction style. Some real or perceived difficulties with the initial usage are observed, but they do not generally hinder the users from using the basic functionality of the products.

The original test plan for the empirical usability testing included a long-term usage period to study learnability, but schedule constraints set from outside the research project did not allow the project team to study the long-term usage effects with a user group large enough for reliable statistical analysis.

[235] See **Figure 93** for a description of the interaction styles and representative phone models.

Epilogue

When our son Kristian was five I was using a Nokia 6210 prototype phone for some time and my wife had a Nokia 6150. Kristian had learned to answer and end phone calls with no hesitation. The 6150 and 6210 phones with their Two-softkey interaction style make call handling quite intuitive: you press the green handset key to answer and the red handset key to end a call. Unfortunately, I had just broken down my 6210 phone – even Nokia phones are not immune to extreme physical misuse – and had started to use a new Nokia 3310 prototype instead. The 3310 applies the Navi-key interaction style with no green or red handset keys since the phone functions are primarily operated with the NaviKey™ – a function key with dynamically changing functionality and a corresponding textual label on the display. Caveat emptor.

On a Saturday afternoon in January 2001 we were driving home from Kristian's judo class when my wife called me; I picked up the call and then handed the phone over to the back seat to Kristian. He took the phone, gave his judo class report, said bye-bye, and then tried to end the call. However, the familiar handset keys were gone, so he asked with a confused and slightly distrustful voice:

> *"Dad. What do I press? There is no red key."*[236]

It did not help that he was already reading a little since he had learned to rely on the familiar, color-coded handset keys, so a key with no handset symbol but a corresponding label on the display saying "End" did not look applicable to him at all.

So – the real-life usability test case had failed and the facilitator (me!) decided to step in: I explained that he needs to have a look at the bottom part of the display to see what it says in there, and then press the key below the display.

At the time of finalizing this thesis manuscript, Kristian is nine years old, and he has had a mobile phone of his own for some time. His first phone, a model with the Nokia Two-softkey interaction style, was recently replaced by a newer model with the new Three-softkey style. After he had been using the new phone for a week, I asked him what he thinks of the new phone, and whether he had stumbled into any difficulties with it. His only complaint was that he had not been able to find the function to change the ringing tone, and when explicitly asked, he said that he had not noticed the usage logic — the *interaction style* in the jargon of this study — to be different from his previous phone at all. The transfer from the old interaction style to the new one had been completely natural and seamless to him.

As a parent and a usability engineer it is fascinating to observe the new generation and its natural and fearless attitude to the new digital world. This 'digital literacy' will be a major enabler for the future.

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[236] "Isi. Mitä mun pitää painaa?! Tässä ei ole punaista nappia."

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Appendix 1:
PRE-TEST QUESTIONNAIRE

Test user	
Test session date, time, location	___.___.2003, time ___:___,
Kenny SW & HW version	Vp 12.55 13-12-02 NHM-1 PR2 P1.2

Test user to fill in	Age:	□ below 15	□ 15...24	□ 25...34	□ 35...44	□ 45...54	□ above 55
	□ male			□ female			
	Occupation:						

Make and model of your current mobile phone?		
How long have you used this phone?		
How long have you used mobile phones in total; which makes and models?		
Do you have experience in using Nokia phones during the last about 5 years; which models? (See the attached phone images.)		
How many phone calls do you make and receive with your mobile phone per day on the average?		
How many text messages do you send and receive with your mobile phone per day on the average?		
What features do you use regularly with your mobile phone?	a) Voice calls b) Voice mailbox c) games d) phonebook/names e) calendar f) calculator g) alarm clock h) (WAP) browser i) text messaging	j) picture messaging k) one-touch dialing l) FM radio m) camera n) downloading of logos and ring tones o) profiles p) quick note taking q) something else – what? _____
Do you use a PC at work? Do you have a PC at home?		
Do you have a digital camera or a digital video camera? Do you store and organize digital photos on your PC?		

Appendix 2: TEST BRIEFING

"During this usability test session we are not testing your skills or abilities. We are testing the new phone and its user interface features. The phone is still in a prototype stage and it may even behave in an unexpected manner occasionally.

In case you encounter situations that are incomprehensible or you don't know how to proceed, please "think out loud". This will provide us valuable information on what is still wrong with the phone, and what we need to improve. In these cases, please verbalize what you think is confusing, what you expect the feature or device to do, or how it should work.

You will be working as independently as possible. If you don't understand a task, please keep trying to perform the task on your own, as if we were not even here. If it seems to us that you need a hint or some guidance, we will intervene to get you back on track. Don't worry if you get stuck on a task or cannot perform something, it is NOT your fault but rather the fault of the Nokia design.

In some test cases you are asked to make phone calls. The test camera attached to the phone makes natural calling posture impossible so you don't have to hold the phone naturally or speak in the phone.

You will start all test tasks from the idle or basic state of the phone (the display showing the "Sonera" name). After you have completed a task you need to return back to this same display.

All information gathered is confidential, and your name will only be known by us, and no one beyond this group. We will use the video recordings only within this group to further analyze the test sessions and learn what we still need to improve in the phone.

You may now spend a couple of minutes familiarizing yourself with the phone. Try to imagine you've just bought this new phone and have now returned home and opened the sales box."

[The moderator needs to cut the exploring after 3 minutes. This chapter is obviously not relevant in the Sonera post-test session where the users are supposed to be familiar with the phone already.]

Appendix 3:
POST-TEST QUESTIONNAIRE

This form will be filled in by the moderator or the observer.

Test session: _____

1 / calling	How easy or difficult this task was?	Easy □□□□□ Difficult
2 / clock	How easy or difficult this task was?	Easy □□□□□ Difficult
3 / Jenni	How easy or difficult this task was?	Easy □□□□□ Difficult
4 / camera	How easy or difficult this task was?	Easy □□□□□ Difficult
5 / MMS	How easy or difficult this task was?	Easy □□□□□ Difficult
6 / ring	How easy or difficult this task was?	Easy □□□□□ Difficult
7 / alarm	How easy or difficult this task was?	Easy □□□□□ Difficult
8 / speed1	How easy or difficult this task was?	Easy □□□□□ Difficult
9 / speed2	How easy or difficult this task was?	Easy □□□□□ Difficult
10 / calendar	How easy or difficult this task was?	Easy □□□□□ Difficult
11 / meeting	How easy or difficult this task was?	Easy □□□□□ Difficult
12 / WAP	How easy or difficult this task was?	Easy □□□□□ Difficult
13 / SMS	How easy or difficult this task was?	Easy □□□□□ Difficult
14 / download	How easy or difficult this task was?	Easy □□□□□ Difficult
15 / folders	How easy or difficult this task was?	Easy □□□□□ Difficult

When conducting the test tasks, did you find something very well designed or intuitive?

_____

Did you find something specifically difficult or troublesome? What?

_____

Do you consider this phone easy or difficult to use? Easy □□□□□ Difficult

Is this phone easier to use than your current phone? Easier □□□□□ More difficult

Appendix 4:
LONG-TERM TESTING QUESTIONNAIRE

Test user: _____

What features have you used in the phone?

- ☐ calling
- ☐ voice mail
- ☐ games
- ☐ downloading games
- ☐ contacts / phonebook
- ☐ Gallery
- ☐ calendar
- ☐ calculator
- ☐ alarm clock
- ☐ WAP/browser
- ☐ SMS
- ☐ MMS – multimedia messages
- ☐ speed dials
- ☐ Bluetooth, with what? _____
- ☐ still camera
- ☐ video camera
- ☐ profiles
- ☐ something else, what? _____

When using the phone, did you find something very well designed or intuitive? What?

_____

When using the phone, did you find something specifically difficult or troublesome? What?

_____

What do you think about the navigation key in the phone?

_____

Have you learned some new functionality by yourself during this 6 weeks period? What?

_____

What should be added/changed in the UI to make the phone a good WCDMA phone?

_____

Do you consider the phone easy or difficult to use? Easy ☐☐☐☐☐ Difficult

Is the phone easier to use than your previous phone? Easier ☐☐☐☐☐ More difficult