

# Creating Heuristics for the Evaluation of Mobile Devices

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## Abstract

With the growing popularity and ubiquity of mobile technology, it has become increasingly important that mobile devices can be used by as wide a variety of people as possible. Usability heuristics are a useful tool in evaluating the ease of use of computing devices but have been designed with desktop computers and web applications in mind. This paper describes how usability heuristics have been created specifically for mobile devices.

The paper gives a brief history and discussion of mobile devices, usability and usability testing. Using the knowledge gathered from the review of literature and information gathered from the analysis of interviews conducted with users of personal digital assistants (PDAs), a host of concepts relating to users concerns and difficulties were identified. These concepts were condensed and refined and from them heuristics were created to address each concept. The heuristics were tested in an initial study and improved in light of the study's results to version 1.1. The heuristics were then tested by means of a comparative study of two mobile phones; the Motorola V3i and the Samsung D600.

From the comparative study the heuristics were found to produce meaningful results with the Motorola V3i being identified as the more usable phone according to the Mobile Device Heuristics v1.1. Further revisions to the heuristics are recommended including validation of the usability problems identified. It has been recommended that the process is repeated using information gathered from users of a wider range of mobile devices.

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# 1 Introduction

Over the last decade we have started to carry more technology with us. Devices which were once of interest only to gadget aficionados are now commonplace in many walks of life and have even become fashionable.

In a survey conducted by Mobile Life (2008) it was found that 94% of British youngsters and 95% of British adults owned or had access to a mobile phone; in fact, 17% had two or more. It is not only mobile phones that have become very popular, 85% of British youngsters and 59% of British adults also owned or had access to an MP3 player (Mobile Life, 2008).

These types of mobile devices have become incredibly popular and it is important that everyone must be able to use them. The designers of these devices are responsible for making these devices usable by as many people possible.

How can designers ensure their product is usable? The answer in part is through testing the devices to identify usability problems; once these problems are identified they can attempt to fix them. Popular techniques for testing usability appear to make the assumption that the device being tested has the traditional components of a computing system; a keyboard, mouse and a large visual display. Most mobile devices however do not have these features or have much smaller versions. Why then should we evaluate their usability with the same standards?

In this project I shall aim to produce a set of standards specifically to test the usability of mobile devices. These shall take the form of a set of usability heuristics which will be used to perform heuristic evaluations.

## 1.1 Motivation for the Project

The topic of usability evaluation and mobile devices was brought to my attention during a lecture on usability evaluation methods; the point was made that Nielsen's heuristics were not relevant when evaluating mobile phones and an interesting project may be to create some for the purpose. This sparked an interest in the

subject, and I have decided to undertake this project for a number of reasons; to further my experience with usability, because the topic has not been fully explored, because no-one has made mobile usability heuristics from scratch, and to see if I can.

## **1.2 Scope**

The devices hereafter regarded as mobile are defined by the physical size of the interface and the portability of the device. Laptop computers may be considered mobile computing devices, but are impractical to use while walking or using one-handed for example. For the scope of this project three main types of mobile device shall be used, these are: mobile phones, personal media players and personal digital assistants (PDAs). These three types of mobile device were chosen for their ubiquity and the variety of their common interfaces.

Although popular, mobile gaming devices or handheld games consoles are deliberately excluded from this study because of the relatively small number of devices that have a substantial interface out with the games they play. Such devices include the Sony PSP, the Nintendo DS and the Game Boy series of consoles.

### **1.2.1 Who Will Benefit?**

The target audience for these heuristics are the designers of mobile devices and anyone with an interest in usability. The aim is not to dismiss all other usability evaluation techniques, but to give those who need to evaluate mobile devices another tool for their toolbox.

## **1.3 Research Questions**

The specific research questions I wish to answer are as follows:

1. Is it possible to create heuristics for mobile devices?
2. Can someone use these heuristics to evaluate the usability of mobile devices?
3. Are these heuristics better than existing methods?

After the project's completion, the extent to which these questions have been answered shall be discussed.

## **1.4 Answering the Questions**

In order to answer these research questions I will undertake a piece of work to gather information on the subject, discover the usability concerns of mobile devices and use the knowledge gained to create and test usability heuristics.

### **1.4.1 Review of Literature**

I will research the history of the devices I am producing heuristics to evaluate and how the way we interact with these devices has changed. I shall also research the topic of usability, how it is changing and how usability is currently evaluated.

### **1.4.2 Data Gathering**

In preparation of creating the heuristics I will gather data on the usability concerns of mobile devices. To do this I will analyse interviews conducted with users of mobile devices, identify problems they have and features they find easy to use.

### **1.4.3 Creation of Heuristics**

Using information gathered from the analysis of interviews I will create a structured list of usability heuristics. To test the heuristics I will then use them to evaluate a range of devices and record any difficulties people have performing the evaluations.

### **1.4.4 Revision of Heuristics & Testing**

Based on the results from testing the heuristics they shall be revised. Using the revised heuristics I shall perform a comparative study on two devices to test whether the heuristics can discover which device is the most usable.

### **1.4.5 Discussion & Conclusion**

Once the mobile device heuristics have been created and tested I shall discuss the process and findings of the work and examine how successfully the research questions have been answered.

## **1.5 A Start**

The first step in this process is to research the topics to be discussed in the report. I shall begin with a look at the history of mobile technology and usability.

## 2 Literature Review

In this section I shall research and examine information that is relevant and necessary to my understanding of the subjects to be discussed in the process of creating usability heuristics for mobile devices. The subjects I shall research are mobile devices, usability and usability evaluation.

### 2.1 Mobile Devices, a Brief History

In this section I will give a brief history of a selection of mobile devices and describe how development of the technology has led to the need for a change in the way we interact with these devices. This section is not intended to document the entire history of specific devices but will cover examples representative of technology at the time.

#### 2.1.1 The Personal Digital Assistant (PDA)

The Psion Organiser is an early pocket computer launched in 1984; it was the first in a series of hand held computers and features an alphabetic keyboard and a single line LCD screen, Figure 2.1 shows the first Psion Organiser. Its successor the Organiser II was launched in 1986 and featured a host of improvements over the previous model, including more memory and a larger display. Psion released several iterations of their personal organiser up until 2000 (Litchfield, 2000).

The first PDAs in the form we recognise now were released in 1993. The AT&T EO Communicator 440 and the more successful Apple Newton were introduced in 1993; both featuring handwriting recognition and a host of other features (Kahney, 2002). The Newton and the EO 440 had a touch screen interface with very few physical buttons; selections are



**Figure 2.1: Psion Organiser**  
(<http://members.surfeu.at/org2/psion1/>)

made on the screen with a stylus. The stylus is also used to input text, either through handwriting recognition or on-screen keyboard. Figure 2.4 shows an Apple Newton with its stylus.



**Figure 2.4: Apple Newton & Stylus**  
(<http://www.jonholato.com>)

A name that has become synonymous with PDAs is that of the manufacturer Palm. Palm introduced their first PDAs in 1996, the Pilot 1000 (Figure 2.3) and the Pilot 5000 which featured more memory. The Palm Pilot was the first device of its kind which straight out of the box; could synchronise data with both Windows and Macintosh desktop computers of that time. The Palm Pilot 1000 featured a date book, an address book, a to-do list, a memo pad, calculator, security and the ability to “HotSync” (Kairer, 2006). The Pilot 1000



**Figure 2.3: Palm Pilot 1000**  
(<http://www.palminfocenter.com/>)

(Figure 2.3) used Graffiti text entry software similar to the Apple Newton. Graffiti claimed to enable users to enter data at up to 30 words a minute with 100% accuracy; the method of entry was really a gesture based system which bore a resemblance to writing roman capital letters (Figure 2.2). In an empirical study by MacKenzie & Zang (1997), Graffiti was found to be “easy” and “immediate” in its usability and after one minute, about 86% accuracy was attainable, five minutes improves to about 97% and after a week of non use, the participants still maintained 97% accuracy. MacKenzie &

Zang predicted that with continuous use, very high levels of accuracy (99%) appeared possible. Palm continued to develop its platform and in 1998 they launched the Palm III organiser which continued to use Graffiti technology, it was complemented on its sturdier case, larger storage space and ability to transfer data via IR (Gadgeteer, 1998). The Palm



**Figure 2.2: Graffiti stroke alphabet (MacKenzie & Zang, 1997)**

IIIxe also launched alongside a palm portable keyboard for more conventional data

entry. In 2005 Palm released its current top of the range PDA, the TX. The TX features improved functionality over its predecessors, it has the capability to handle Microsoft Office documents, photos and mp3 audio. It features a large colour display and Wi-Fi connectivity; useful for the devices email client and web browser (MobileTechReview, 2005). The TX uses an evolution of the original Graffiti text input system called Graffiti2, although users can opt to use an on-screen keyboard or number pad for data entry; these are operated using a stylus.

In some modern PDAs some manufacturers, such as Blackberry have reverted to the use of soft keys and scroll wheels or thumb wheels for navigation and often feature full QWERTY keyboards.

### 2.1.2 Personal Media Players

Sony launched the Walkman (Figure 2.5) in 1979, although portable cassette tape players existed at the time they were mostly used for dictation by reporters and featured a microphone. Critics were sceptical, thinking there was no need for such a device and they would fail to sell (Hormby, 2006). The Walkman allowed people to listen to their own music on the go and was the first of a breed of lightweight and compact personal audio devices. As the compact disk (CD) became a popular medium for music distribution, Sony launched the CD Walkman or Discman in 1984 (Sony, n.d.) CDs hold around 20 regularly sized songs per disk, still a relatively small



Figure 2.5: Sony Walkman (<http://lowendmac.com/>)

number of tracks and easily navigated by skipping backwards and forwards through disc. The MD Walkman was released in 1992 and played Mini-disks, Mini-disks as the name may suggest, are smaller than CDs and allowed users to carry more music (Sony, n.d.). The capacity of Mini-disks grew but the interface of Mini-disk players still remained rather primitive.

In the early 21<sup>st</sup> Century compressed digital sound formats started to gain popularity. Music could now be ripped or copied from audio CDs and downloaded directly from the Internet in file formats such as, Apples' AAC, Microsofts' WMV and the most popular file format, the mp3 (MPEG Layer 3). To play these files on the move the

first mp3 player was created in March 1998 by Saehan and it was called the MPMan (Van Buskirk, 2005). The company Diamond released another mp3 player later the same year called the Rio PMP300; neither of these however were particularly popular with the general public.



**Figure 2.6: 1st Generation Apple iPod (<http://lowendmac.com/>)**

On the 23<sup>rd</sup> October 2001 Apple launched the first generation of their iPod (Shown in Figure 2.6); the iPod had a five gigabyte hard drive which facilitated the storage of thousand songs. The device has become a great success for the company; this success has been attributed to many factors. Apple launched the iTunes Music Store in 2003 which enabled users of the iPod to purchase legal music easily from the Internet and have it seamlessly synchronised with their personal audio device, this infrastructure has seen iTunes become the number two music retailer in the United States as of January 2008; Based on data from market research firm the NPD Group's MusicWatch survey (Apple, 2008). Another factor which is thought to have contributed to the early iPods success and the success of future generations of the device is its user interface. The large capacity of the iPod meant the user had the potential to search through thousands of tracks; using traditional skipping methods just weren't feasible and Apple developed a solution for this:

“Unlike most other players, the iPod did not use controls that were better suited to the Sony Walkman in 1979 than a MP3 player with a capacity of thousands of songs. Instead of using skip buttons, a user could spin a wheel on the front of the device to scroll through a list of songs to find the song the user wanted to play. The same wheel was also used to control the menus of the system. As a result, it was much easier to navigate through the iPod's playlist than the comparable Nomad or Compaq MP3 players.” (Hornby & Knight, 2007)

The evolution of Apples' iPod continued with a variety of different versions, as the technology of the device evolved so did the interface. Most iPods retained their navigation wheel with the exception of the smaller shuffle; these feature buttons to skip between tracks and to pause. The menu, skip tracks and play/pause buttons on

the iPod were first moved above the scroll wheel and then into the scroll wheel itself (Hormby & Knight, 2007).



**Figure 2.7: iPod Touch**  
(<http://www.apple.com/>)

An iteration in the functionality of the iPod occurred in September 2004 with the inclusion of a colour screen and the ability to browse albums of photos, along with more battery life and a larger hard drive. Apple upgraded the iPod with possibly the most significant feature yet in October 2005 when it released the Video iPod which was capable of playing mp4 video files, purchasable of course, from iTunes. Apple in September 2007 launched a new line-up of iPods, including the iPod touch, seen in Figure 2.7. The iPod Touch features the same multi-touch screen as the iPhone (discussed in section 2.1.3) and marks the end

for the full sized iPods click wheel, the last iPod to feature the click wheel was sold as the iPod Classic, the iPod Nano still retained its click wheel and gained a larger screen and video playback capabilities (Hormby & Knight, 2007). The iPod Touch allows the user to browse the iTunes store using wireless Internet and download songs directly to the device (Multi-Touch Technology, 2007).

Other notable personal media devices include Microsofts Zune and the latest Sony Walkman.

### 2.1.3 Mobile Phones

The first call made from a mobile phone was made in 1973 by Motorola employee Dr Martin Cooper; he is widely regarded as the inventor of the mobile phone. One of the first commercial mobile phones on the market was the Motorola DynaTAC 8000X, available in 1983. The phone was sought after and was an expensive piece of technology, costing \$3,995 in 1983 (Sheils, 2003). The 8000X was self contained and truly portable, competing models at the time (such as the 4500x)



**Figure 2.8: Dr Martin Cooper Re-enacts the 1st mobile phone call**  
(<http://news.bbc.co.uk>)

were adapted from car phones and were akin to and resembled a large acid car battery with a car phone attached to the top. Figure 2.8 shows Dr Martin Cooper re-enacting the first call he made from a mobile phone.

From that first mobile handheld, mobile phones have become increasingly smaller and more light weight, the technology used for communication has improved and with more advanced battery technology; users can talk for longer and spend less time charging their phones batteries. Through this development, alternate media of communication have emerged. SMS (Short Messaging Service) or text messaging has proved surprisingly popular. An SMS message allows a user to send a message of 160 characters per page to another mobile phone or some computers and automated systems. To allow the input of text for naming contacts and writing text messages most modern mobile phones have an alphabetical keyboard included in their numeric keypad. The keyboards mode is usually context sensitive, depending



**Figure 2.9: Conventional mobile phone keypad layout**

on the type of input required it will choose text or numbers e.g. when writing a text message, by default the keypad will input text and when entering a phone number, enter digits. The keypad layout can be seen in Figure 2.9. In an attempt to make text input faster, most manufacturers have included a predictive text system to make it faster and easier to type text on numeric keypads (Nuance Communications, 2007). These systems allow users to type words by pressing a button once to select any of the character associated with that key, as the user types the rest of the word the device predicts what word the user is meaning to type. For example, Philip would be entered by pressing 744547.

Feature convergence has been an overwhelming trend with mobile phones over the last dozen years, whereby mobile phones adopt the features of other dedicated devices. This trend started with the introduction of digital cameras; first pioneered by Philippe Kahn in 1997 as a way to share photos of his new child with work colleagues (Weekend America, 2007). Technology has now progressed to include video cameras in mobile phones with the infrastructures to have video calls over 3G networks and share videos using Multimedia Messaging Service (MMS) technology. With the development of larger capacity and smaller sized storage media such as



**Figure 2.10: Sony NWZ-A829**  
(<http://www.engadget.com/>)

flash memory; integrating competent music players into mobile phones has become feasible. Sony Ericsson produce a range of mobile phones marketed as Walkman phones, with emphasis on the music playing capabilities of the device. One of the latest Sony Walkman Phone model, NWZ-A829 (Figure 2.10) features sixteen gigabytes of flash storage (Miller, 2008). With the addition of digital cameras users can send MMS or picture messages and the format was extended to send video messages. Through high

bandwidth 3G networks and with a capable handset, it is possible to have a real-time video call with a person using another video phone; although possible, mobile video calls have remained relatively unpopular; this may be because people feel they don't require this type of interaction, the technology is available but it is not commonly used. If one were to use a mobile phone to have a video conversation, the phone would have to be held in front of the users face; this could be quite distracting when doing something as simple as walking along a busy street avoiding people and inanimate objects.

Mobile phones are being used more often to browse the web; WAP (Wireless Application Protocol) browsers enable users to browse a simplified version of the web coded in a separate standard to the majority of the Internet. This platform was found to be rather restrictive to the users and problematic from a developers' point of view, Nielsen (2000) reported:

“Following a UK field study, 70% of users decided not to continue using WAP. Currently, its services are poorly designed, have insufficient task analysis, and abuse existing non-mobile design guidelines. WAP's killer app is killing time; m-commerce's prospects are dim for the next several years.”

There are however a new generation of mobile phones that are capable of browsing the Internet similar to a full sized computers browser. Such a device that has proved popular is the iPhone (Figure 2.11) from Apple Inc. (Ricker, 2007). The iPhone has a large touch screen interface which removes the need for a dedicated hardware keypad in favour of a larger screen size. The iPhone includes a host of features from



**Figure 2.11: Apple iPhone**  
(<http://sudarshanapte.wordpress.com/>)

the companies' popular iPod series, the iPhone has the capability to play audio and video, capture and browse pictures and of course surf the web. The interface mated to these varied and numerous functions as well as the physical hardware is critically acclaimed, Tognazzini (2007) states "*Traditional cell phones are dull, limited, and at end-of-life. iPhone is glorious, and it is only the beginning*". The iPhone operates almost entirely from its touch screen, the only hard button is the home button which returns the user to the home screen. The touch screen enables the interface to position buttons anywhere on the screen, allowing for great flexibility. The iPhone makes use of a multi-touch interface, not only allowing users to tap the touch

screen to perform an action; but using gestures such as swiping a finger across an object to delete it, or scrolling through pictures by swiping a finger left or right and the iPhones' interface lets the user zoom in and out on pictures using a pinch gesture. Apple have also included an orientation-sensor so the device knows which way up it is being held, this enables the iPhones' screen to change layout depending on the orientation of the screen. It puts this to use in its web browsing application allowing the user to view websites in both orientations. The latest iteration of the iPhone series incorporates 3G technology, a missing feature slated on the original model. Using an iPhone on the 3G network with the upgraded software the 3G iPhone features; provides a welcome boost of speed, enabling greater capabilities. These capabilities include maps with built-in GPS to allow real-time navigation and searching, email calendar and contacts with remote synchronisation, custom applications and the ability to download music directly to the iPhone.

This evolution of the mobile phone interface is in my opinion driven by the enhanced feature set of modern mobile devices. In 1973 when Martin Cooper made the first mobile phone call; a 14 button keypad and no status display was sufficient, today however complex mobile phones must facilitate taking pictures, storing and accessing large amounts of information and even browsing the Internet.

## 2.1.4 Future Predictions

By observing the trends in technology in recent history as documented in section 2.1 it is possible to make assumptions regarding the future of mobile technology. It is a constant that devices as they are developed reduce in size; it is reasonable to assume future devices will only become smaller or more likely the technology included in the devices will become smaller and easier to integrate into a slender device. The use of multi-touch in Apples iPhone may indicate a more wide spread adoption of this technology in mobile technology, its large screen is already becoming a common feature in other smart phones. On the whole we shall see the introduction of more portable devices with increased functionality, and a web browsing experience comparable to that of a normal desktop computer.

## 2.2 From Usability to User Experience

Here we will discuss what is meant by usability, why it is important and how its success is measured.

### 2.2.1 What is Usability?

The term usability refers to something as being usable, which is defined in the Oxford English Dictionary as “*able to be used*”. In the International Organisation for Standardisation standard: ISO 9241-11, regarding “Ergonomic requirements for office work with visual display terminals” (1998), usability is defined as “*the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*”. In 1993 Nielsen wrote about Usability Engineering and briefly defined usability as “*...a quality attribute that assesses how easy user interfaces are to use*”. Nielsen described more specific qualities of usability as:

- “Learnability: How easy is it for users to accomplish basic tasks the first time they encounter the design?”
- Efficiency: Once users have learned the design, how quickly can they perform tasks?
- Memorability: When users return to the design after a period of not using it, how easily can they re-establish proficiency?
- Errors: How many errors do users make, how severe are these errors, and how easily can they recover from the errors?

- Satisfaction: How pleasant is it to use the design?"

Nielsen then went on to elaborate on his five qualities, mentioning utility. Utility, Nielsen argues is as important as usability, this meaning the product must fulfil the users needs and do what they want it to do, *"it matters little that something is easy, if it is not what you want"* (Nielsen, 1993). Utility however is unavoidably linked to usability; if the product is capable of performing how the user wants but they are unable to make it do so because of a difficult user interface, the product is of little worth.

## 2.2.2 Why is Usability Important?

As previously mentioned, usability is inevitably linked to the function of a system, be it application based, web based or indeed mobile, all these varying contexts share the same characteristic; if they cannot be used it doesn't matter if the system does what it was designed for (and vice versa). Niensens' model of system acceptability is shown in Figure 2.12;

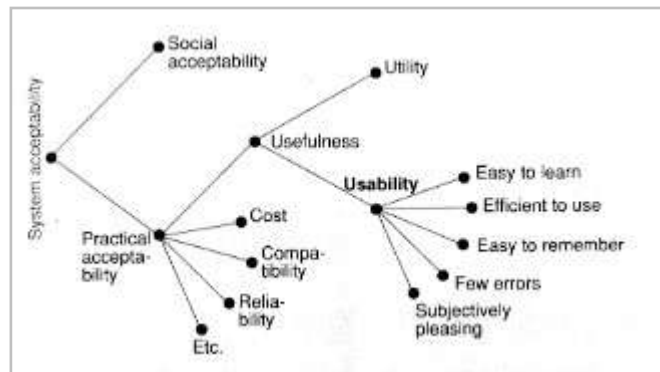


Figure 2.12: System Acceptability (Nielsen, 1993)

it shows how usability is linked to other attributes of the system, putting it on par with utility.

## 2.2.3 User Experience

Nielsens fifth point "satisfaction" is an interesting one; the notion of satisfaction when using a system may have been the first indication of the thinking that the users experience may affect the usability of a system. Although Neilson has revised his definitions little since their conception, some have elaborated on what defines a product as usable. Some new thinking in this field is often referred to as user experience (often abbreviated UX).

The Nielsen Norman Group (n.d.) defines user experience in the following way:

"User experience encompasses all aspects of the end-user's interaction with the company, its services, and its products. The first requirement for

an exemplary user experience is to meet the exact needs of the customer, without fuss or bother. Next comes simplicity and elegance that produce products that are a joy to own, a joy to use. True user experience goes far beyond giving customers what they say they want, or providing checklist features. In order to achieve high-quality user experience in a company's offerings there must be a seamless merging of the services of multiple disciplines, including engineering, marketing, graphical and industrial design, and interface design.”

This is a rather broad definition which is difficult to use.

People have tried to define user experience in a number of ways, but the general concept is that it encompasses the users' whole experience of using the product. This is particularly relevant with regards to mobile devices as the interface extends beyond the screen to the physical object.

In terms of user experience it seems that aesthetics, among other attributes, play a role in the users emotional experience when interacting with a product and providing an increased sense of user satisfaction. Norman (2002) describes this when he said “*attractive things work better*”. The emotional response of users to an attractive design may encourage users to engage more with the system and even forgive small grievances with the device.

There has been a lot of debate on the role of aesthetics when related to usability and user experience. Tractinsky et al (2000) made the statement “*What is beautiful is usable*” based somewhat on the psychological stereotype that “*What is beautiful is good*” (Dion et al, 1972), they tested and substantiated this theory using an experiment to measure perceived and actual usability across a range of aesthetically pleasing interfaces. However further study by Hassenzahl (2004) does not support this and indeed he concludes that “*what is judged to be more beautiful is not necessarily perceived as more usable*”, Hassenzahl performed two studies using MP3 player skins. The author of this study mentions that beauty is a driving force to become an owner of an object and that beauty is a prerequisite for bonding with an object. These conclusions are however a little dismissive of the link between usability and aesthetics.

Lindgaard (2007) explores the link between aesthetics and emotion; he states that *“To the extent that aesthetics is a pleasant experience or an experience that leads to pleasure, it implies a relationship to emotion”*, the author then points out that if a users (emotional) first impression is negative in terms of aesthetics and content, they will use negative usability flaws to confirm their initial response and (in the case of a website) leave the site. By contrast, Lindgaard says a visually appealing site will be forgiven minor or even major usability flaws because the first impression was positive. The author then speculates that interactive technology that “feels good” or “feels right” will put the user at ease and in turn may increase user performance and satisfaction.

Returning to user satisfaction; the international standard ISO 9241-11 (1998) describes user satisfaction in terms of attitude and degree of comfort and measures it on a 7 or 10 point scale. Lindgaard (2007) explains that these terms do not capture the user experience and in an attempt to better describe user satisfaction, identified five factors that contribute to user satisfaction. These are: aesthetics, emotion, likeability, expectation and usability. Although the author agreed these were a good approximation, further work was needed to refine the factors, this work is currently being written up for publication.

Due to the lack of a concrete definition, rather than define user experience, I shall consider relevant attributes of user experience when describing and assessing usability.

Usability then, refers to how easy a device is to use, especially to novice users. Considerations must be made for how positive the users’ experience of using the device is i.e. user satisfaction.

## **2.3 Evaluation**

The objective of evaluation is to measure, using certain techniques, how usable a system is and to identify problems and areas to improve. Evaluation is used to gauge a users response or predicted response to interaction with the system and provide feedback to designers on how to improve the system. There are numerous methods for evaluating usability; combinations of these are often used. The methods of evaluation used depend on a number of factors, these include:

- the techniques ability to detect certain types of problems
- financial and time constraints
- the accuracy and quality of the results
- usefulness of results and who can understand the results
- the generality of the results – the extent to which the results are representative of all users

(Lang, 2003).

I shall discuss the heuristic evaluation technique, outlining the process involved and benefits and shortcomings of the technique.

### **2.3.1 Heuristic Evaluation**

Heuristic evaluation is a discount usability engineering method for quick, cheap, and easy evaluation of a user interface design (Nielsen, 2005). The development of heuristic evaluation is credited to Jakob Nielsen and Rolf Molich. The process of heuristic evaluation involves “*having a small set of evaluators examine the interface and judge its compliance with recognized usability principles*” (Nielsen, 1993). These usability principles are a set of heuristics or guidelines developed originally by Nielsen, although others are available. The evaluators navigate through the interface several times, comparing its’ features to the list of heuristics. Evaluators may yield more representative results by using a usage scenario produced from task analysis of actual users, e.g. in a mobile phone this may involve making a call to a contact saved in an address book or sending an SMS (Nielsen, 1993; Doubleday et al, 1997). The interface is inspected by each evaluator individually and at the end of the respective evaluations the results are discussed, this ensures a fair and unbiased evaluation. The evaluations typically last one to two hours, in cases an observer is used to gather and collate findings from each individual evaluation. The process is performed by a nominal number of three to five evaluators, studies have shown results do not increase with larger numbers (Nielsen, 1993).

The benefits of heuristic evaluation compared to other methods include time and therefore also cost effectiveness. Doubleday et al (1997) observed during a comparison of heuristic evaluation and end user testing of the INTUITIVE system, a heuristic evaluation took 33.5 hours compared to 125 hours for end user testing. Heuristic evaluation can also be used in cases where observation of end users is

difficult or not practical; such as the evaluation of devices with small screens.

Doubleday et al (1997) also make observation that heuristic evaluation goes some way to identifying the cause of usability problems as opposed to only the symptom and furthermore can suggest a possible solution for the problem.

Heuristic evaluation however is largely dependent on the quality of the judgements of the evaluators, making it strongly advisable to perform evaluations with the recommended number of people. Quality of the information received is also likely dependant on the experience of the evaluators and by removing users from the evaluation, some results may be false positives i.e. problems that do not affect the users.

Heuristic evaluation is only one tool in the tool box for usability evaluation, there are several other techniques which may provide more in-depth and complimentary results. These shall not be discussed in detail here but Figure 2.13 provides a summary of usability evaluation techniques, each have their own advantages and disadvantages. Which technique to use in a given situation is dependent on many factors not excluding time, budget, resources and type of interface to be evaluated.

<i>Method Name</i>	<i>Lifecycle Stage</i>	<i>Users Needed</i>	<i>Main Advantage</i>	<i>Main Disadvantage</i>
Heuristic evaluation	Early design, "inner cycle" of iterative design	None	Finds individual usability problems. Can address expert user issues.	Does not involve real users, so does not find "surprises" relating to their needs.
Performance measures	Competitive analysis, final testing	At least 10	Hard numbers. Results easy to compare.	Does not find individual usability problems.
Thinking aloud	Iterative design, formative evaluation	3-5	Pinpoints user misconceptions. Cheap test.	Unnatural for users. Hard for expert users to verbalize.
Observation	Task analysis, follow-up studies	3 or more	Ecological validity; reveals users' real tasks. Suggests functions and features.	Appointments hard to set up. No experimenter control.
Questionnaires	Task analysis, follow-up studies	At least 30	Finds subjective user preferences. Easy to repeat.	Pilot work needed (to prevent misunderstandings).
Interviews	Task analysis	5	Flexible, in-depth attitude and experience probing.	Time consuming. Hard to analyze and compare.
Focus groups	Task analysis, user involvement	6-9 per group	Spontaneous reactions and group dynamics.	Hard to analyze. Low validity
Logging actual use	Final testing, follow-up studies	At least 20	Finds highly used (or unused) features. Can run continuously.	Analysis programs needed for huge mass of data. Violation of users' privacy.
User feedback	Follow-up studies	Hundreds	Tracks changes in user requirements and views.	Special organization needed to handle replies.

**Figure 2.13: Summary of Evaluation Techniques (Nielsen, 1993)**

## **2.4 What Next?**

An amount of background information on mobile phones, PDAs, portable media players, usability and user experience has been presented and discussed. This is the first step to creating the heuristics, the next however is to gather data from users.

### **3 Data Analysis**

When creating heuristics for people evaluating or producing mobile devices, we shall be advising them what features and characteristics are successful and those that are not. In order to inform others, these things must first be discovered and understood. It is necessary to ascertain which features and characteristics of mobile devices users like and those they do not. In order to do this users will be asked what it is that they like about their devices, what it is they do not like and what they would like to change.

#### **3.1 Method**

To discover what users think of their mobile devices I shall analyse a series of interviews. These interviews were not carried out by myself but by an interviewer researching the use of PDAs. The interviews are semi-structured which allows the interviewer to pursue points of interest that arise. The researcher interviewed fourteen people who owned or used PDAs, they were asked around ten to fifteen questions on what they used their PDA for, how they used its functionality, their feelings about it and their general good and bad points. These questions include: *“How do you feel about using it in front of other people?”*, *“Could you talk to me about your likes and dislikes about it?”*, *“How do you feel about using it outside the work environment, in front of other people?”* and *“Imagine that you have to describe on the phone to a colleague something that you're doing on it, show me a function that you use as part of your routine, but talk me through it, step by step, as if you were talking to someone on the phone that couldn't see what you were doing”*.

To produce some useful information from these interviews the transcripts have been carefully analysed and common themes, likes and dislikes of the users have been identified. The transcripts however, are altogether almost 40,000 words in length. To manage the amount of data involved I have used a software tool specifically designed for the analysis of qualitative data, this tool is NVivo 7, created by QSR International.

### 3.1.1 NVivo & Coding

NVivo allows researchers to import transcribed interviews in a digital format and process these resources in a number of ways. Their product overview says, “If you need to handle very rich information, where deep levels of analysis on both small and large volumes of data are required, NVivo is your solution. It removes many of the manual tasks associated with analysis, like classifying, sorting and arranging information, so you have more time to explore trends, build and test theories and ultimately arrive at answers to questions” (QSR International, 2008). The most important task when using NVivo to analyse data is coding. Coding involves creating codes which represent trends, concepts, points of interest etc. and associating parts of the text with these codes, these are referred to as “nodes” within the NVivo software. An example of coding may be; the analyst will notice a trend that people prefer devices with larger screens; the analyst then creates a node called “Screen Size” and codes or associates the relevant part of the text with that node. After coding the entire project it will be possible to look at the codes and identify common themes and concepts within the interviews.

### 3.2 Analysis of Interview Data

After analysing the fourteen interviews forty one codes have been identified. The codes are named according to themes that have been picked up in the text, although some may appear similar, their contexts in the text or their subtle differences warrant a separate code.

After analysing the interview data using NVivo, there were 41 codes, these are listed in Table 3.1.

Table 3.1

**Table 3.1: 41 Codes produced from NVivo analysis**

Ability to Back-Up	Aesthetics	Battery Life	Boredom
Connectivity	Cost	Customisation	Device Size
Easy to Access Information	Easy to Access Popular Features	Easy to Use Buttons	Ergonomics
Features	Feels Nice	Fits in Your Pocket	Flexibility
Fun to Use	Handwriting Recognition	Input	Integration & Synchronisation
Memory & Storage	Navigation	New Gadget	Opportunistic Use

Out-of-the-Box Usability	Perceived Usability	Personal Image	Practice Makes Perfect
Pride to Own	Reliability	Reliance on the Device	Reminders
Screen Size	Security	Sharing Information	Shortcuts
Simplicity	Socially Intrusive	Speed	Sturdiness
Value of Information			

Each code, a description of their concept and a sample of associated text from the interviews are as follows:

### 3.2.1 Ability to Back-Up

This code concerns a devices ability to back-up the data it contains. Speaking of why they prefer electronic organisers to paper diaries, interviewee K.H. says *“why this is better, I suppose... is that-er [it] is backed up...”* and speaking of the purpose for buying a PDA, interviewee M.K. said *“I guess my main purpose was to keep my addresses backed up”*. Backing-up information that is important or very inconvenient to lose is important to users.

### 3.2.2 Aesthetics

Concerns how attractive the device looks, this concept is important to these devices and can be a deciding factor when purchasing, M.K. said *“I think the design is actually very nice, I mean, the reason I got a palm is because actually I thought the design was very very sleek”*. A.C. also said, *“I like it. I think it's nice, and slim, and shiny, solid, you know, it feels good, it feels nicely built”*.

### 3.2.3 Battery Life

This was possibly the biggest complaint of those interviewed, E.H. complained *“I think sometimes it seems as if the battery has a bit of a life of its own, and for ages it will be ninety percent charged, and then the next time you want to use it, when you really want to use it, you find it's at thirty five percent and it's saying the battery is low”*. A device is rendered unusable if it has no power and this is a major concern for users and even to be given reliable indication of the batteries' status allows them to make assumptions on its lifespan.

### **3.2.4 Boredom**

This observation relates to the interviewees using the device when they are bored; when asked if they played games with their PDA, S.D. replied, *“Little bit. Usually when I'm bored sitting in an airport”*. This type of use is important and very common.

### **3.2.5 Connectivity**

This code concerns a devices ability to connect or interact with other devices. It was found to be of importance by D.I., *“The reason why I bought it is because it has blue tooth capability, and it has Wi-Fi, Wireless networking... The blue tooth is great, because it can talk to my mobile phone. So I can basically dial up my ISP and I can get hold of emails”*. Difficulties with connectivity present a possible usability problem.

### **3.2.6 Cost**

The price of the device must justify its functionality and desirability, C.H. said, *“I spent something like three hundred pounds on it, and I guess, if it does me for ten years... [...] it's just a very cost effective way of ...of doing a lot of the things”*.

### **3.2.7 Customisation**

Concerns a users ability to customise the design, software layout or functionality of the device, L.A. discussed customising their hardware *“You can get a little card, which goes into the top of it, which you can plug into an overhead video projector, and then you can use it like you would a laptop. You get a little piece of software which converts your PowerPoint presentation from the computer a pc, into a format which this thing can understand, download it to this thing, plug it into the projector and then you get a little remote control device which you can use to flick between the presentations. Which is great, it means I don't have to carry laptops to lectures”*

### **3.2.8 Device Size**

The matter of device size was a very commonly recurring subject in the interviews. A.R. said, *“I like the... the size of it, and obviously it would be nice if it were a little smaller, and a little less weighty, so that it... it would fit more comfortably on a trouser pocket, for example, rather than a white coat pocket. And I think that that increase in portability might actually make it a little more easy to use on a day-to-day basis”*. The usability of mobile devices extends beyond the software interface and the physical size of the device is an important part of this.

### **3.2.9 Easy Access to Information**

This concerns the access, or ease of access to information such as files, pictures, music, video etc. D.I. complained, *“I find sometimes it is difficult to find files out with the kind of usual, so... outside the notes or word. Erm... it sometimes can be a little difficult to find a photograph or whatever you've decide to put on. So that sometimes is a little bit frustrating, I sometimes have to really stop and try and think how I got that file the last time. And the same for moving things around within the internal memory versus the storage card, and things like that”*. Finding the things you want in a maze of menus and folders is a major usability problem.

### **3.2.10 Easy Access to Popular Features**

The interviewees thought it important to have easy access to the features they use most often A.S. said, *“I like the layout, I think it's very easy to... to... manoeuvre your way around, very easy to find your way around, the... the software is such that... it's very easy to find all the things that I tend to use it for”*.

### **3.2.11 Easy to Use Buttons**

As an important input mechanism, buttons must be easy to use, M.K. said *“I like that it doesn't have a puny, stupid little keyboard, which you can't type on”*, M.A. also said *“But I use the main four buttons on here, the... calendar, the address book, the... those two I use all the time”*.

### **3.2.12 Ergonomics**

The ergonomics of mobile devices are important; the entire device is held and operated in the hand so it must sit well and be easily operated with the fingers etc. A.B. said *“It does actually fit into your hand. And it's a very nice... natural way to hold it, to... to write on it”*. A.C. while talking about her PDA commented, *“I like it. I think it's nice, and slim, and shiny, solid, you know, it feels good, it feels nicely built”*.

### **3.2.13 Features**

This code refers to technological features on mobile devices such as calculators or mobile phone functionality. Those interviewed had different feelings about feature convergence on mobile devices, A.B. said *“My ultimate would be, er... having a mobile phone that did what that did, rather than having to have my PDA and my mobile phone I would like one... one... gadget, one device that does it”* however A.C.

was more wary of these features saying, *“Features get stuffed into technology, don't they? For instance, even my telephone has a calculator in it, can you believe it? We get duplications of features across technologies and very often I find that those extra add-ons are really not very useful”*. However users perceive these integrations, it is clearly a subject that matters to them.

#### **3.2.14 Feels Nice**

This code refers to the interviewees having a sensation of pleasure related to holding the device, rather than it simply being ergonomic such as a hammer may be. E.H. said *“There's nothing extra, there's nothing fiddly, it's just really streamlined and nice, feels nice in your hand”*. A device feeling nice in the hand could well be a deciding factor in its sale.

#### **3.2.15 Fits In Your Pocket**

This code was included in response to the overwhelming number of times the interviewees used the specific phrase, “in my pocket”. Participants valued the fact that they could carry the device in either their trouser, jacket or shirt pocket. This relates to the devices size and also its weight, shape and general portability. When asked how they carried their PDA, A.R. replied *“Just in my pocket! Just stick in my pocket! It's pretty small, so yeah”*, E.H. said, *“The size I think is fantastic, it's so miniaturised, it fits in my pocket, I can carry it with me everywhere”*. K.H. also remarked, *“It's slim, so it'll fit in a pocket, er, fit in a bag. It's very light, it... that is one of its main attractions, really. Its' slimness, it's lightweight”*.

#### **3.2.16 Flexibility**

This code refers to the flexibility or multitude of uses the technology offers. D.I. was asked about their reasons for purchasing a PDA and they said, *“Instead of carrying a big FiloFax round, something a lot more neat, easy to carry and a lot more flexible”*.

#### **3.2.17 Fun to Use**

Certain participants found it pleasurable to use the devices; A.B. said *“They've great fun with the drawing packages. Again they love the fact that you can just scribble on the screen and it appears, and so on”*, A.C. said, *“I played around with someone else who had a PDA, we had a bit of fun sending messages to each other across the room”*.

### **3.2.18 Handwriting Recognition**

This was a subject that interviewees talked a lot about. There were mixed feelings among the users but most, at best tolerated handwriting recognition. D.I. said “*I found graphite (handwriting tool) incredibly difficult to use and frustrating*”, E.H. said, “*The only thing that I don't think is good is the handwriting recognition. I tried that for quite a while, trying to get it to persevere, trying to... kind of two or three weeks of writing everything in and it's... it's not great. I've gone back to the keyboard*” and also “*What I really want is something that I can just... be on the phone and I can just jot down things and it'll recognise it and transfer it into text*”.

### **3.2.19 Input**

Input devices and technologies are important to the users experience with the device and the interviewees held strong opinions on some of these. M.A. said, “*I find any of the predictive stuff in the phone inevitably wants to say words that I don't want to say (laughs) an I've never really mastered that*”, M.K. also mentioned “*I've used things with the, er... sort of standard keyboard, but far too small to do efficient typing, I found that absolutely irritating*”.

### **3.2.20 Integration & Synchronisation**

This code refers to a devices ability to integrate and synchronise with other devices, primarily desktop computers. Users found this feature useful for updating calendars etc and found problems with this system extremely irritating. G.R. said, “*I guess the biggest dislike is eh... still the poor synchronisation between the PDAs and my desktop system*”, M.K. however had a positive experience of synchronisation on their device, “*It does what it's meant to do. It's hassle free, er... You can back it up by pressing one button, and just spend half a minute drinking some coffee and it's done*”.

### **3.2.21 Memory & Storage**

As mobile devices become more advanced, the space requirements of the software and documents grows also. Problems with storage space can lead to a poor user experience; I.P. said, “*If you wanna put stuff onto the actual memory it fills up very quickly, and you have to use the expansion slot*”. K.H. also found transferring documents to memory valuable “*Memory card is very useful on this one as well. Erm... it's just for transferring data between things, not because I ever have that*

*much added stuff on it, but for transferring documents or things, er... that should be quite useful*.

### **3.2.22 Navigation**

Navigating a menu structure and applications was a concern of the interviewees, K.H. complained, *"It's a pain in the neck flicking from one week to another, even then you can't see the detail of what you are meant to be doing, it's an absolute pain"*.

### **3.2.23 New Gadget**

This concept concerns the users feeling that they want, or enjoy the device because it is a "new gadget" and a new technology they can get excited about or play with. This can be a powerful deciding factor in selling such devices, K.H. said, *"I just decided I quite fancied one, so I just went and bought one, without any real understanding of why I wanted it"*, D.I. also said *"I do quite like technology, and I do enjoy technological advances and seeing things that erm... five years ago would never even dreamt of, or I would never have dreamt of, seeing as reality. And so... I have to say that when I first got it I was actually very excited about it"*. However M.K disagrees but still finds the device useful saying, *"I'm not a gadget man. I don't like gadgets for gadgets' sake. And... and I found that my PDA is practical"*.

### **3.2.24 Opportunistic Use**

A theme that emerged from the interviews was that users often used their devices in an opportunistic way, making notes when something arose or producing a phone number etc. C.H. found this type of use valuable, *"You get ideas on the train, waiting for a taxi, or something like that, you are in the back of a taxi, you can put things down"*, they also said *"So, its role really is a way of recording instantaneous ideas, either vocally, because it's got a.. It's got a recorder as well, you can take a note, a memo to yourself"*. E.H. also found this useful, *"It's where the most important thing, where it momentarily is useful."What's the number of such and such", I've got it here, and it's there. Erm, and it's quite handy just as simple as a calendar, for bringing it up "is the 16th of June a Tuesday or a Wednesday?" it's a Wednesday"*.

### **3.2.25 Out-of-the-box Usability**

Interviewees found it important to be able to use their devices straight away, or straight out-of-the-box. A.C. said, *"Out-of-the-box usability was absolutely first class."*

*You know, er, I would say within... within five minutes of getting the device out of the box, my first PDA, the thing was working". I.P. also found the device easy to use in a short amount of time, "I think the training and the... the... learning curve, if you want to call it that, for learning how to use one of these, is really very short, and people can be up and running within a matter of hours, just through practice. I don't think it needs a lot of study. They're really quite intuitive and... common sense. If you can use a computer you can use one of these".*

### **3.2.26 Perceived Usability**

This concept concerns how a user perceives the possible usability of the device, this was a problem for L.A., they said *"I've never been a fan of them for that kind of thing, erm... And when I've seen other people using them for that kind of thing as well, it just looks really clumsy. Erm... It takes me two seconds to write something on my diary and it takes them a couple of minutes"*.

### **3.2.27 Personal Image**

Interviewees were conscious of their personal image while using or carrying these devices, specifically they were concerned about looking like a "computer geek", S.D. said, *"I also am very against wearing it on your hips so everybody can see you carry these things, it makes you look like a computer geek (laughs). Which I am, so I try to hide that to a certain extent"*, L.A. also said, *"I would normally not carry around in my pocket, er... and I would probably feel a bit of a fool carrying it on my belt or anything like that"*.

### **3.2.28 Practice Makes Perfect**

Many interviewees were at first not proficient with the use of their PDAs but said as they practiced using it, or got the hang of it, they found the device easier to use. D.I. said, *"I sometimes struggle a bit with that. Erm... But I'm getting better as I've kind of got more practice with it, I think. Erm... I think that's the major complaint that I have, I think sometimes"*, and also said, *"It's the same as everything, it's the same as your computer at home, or your video recorder. It's just question I think of getting practice with them"*.

### **3.2.29 Pride to Own**

Some interviewees take pride in owning a piece of expensive technology, A.S. said, *"I'm very proud of it, I like my PDA"* and E.H. said, *"You know, it's quite nice to produce my PDA and tap and things and "oh, you've got one of those, oh, that's quite nice", so I take it on holiday"*.

### **3.2.30 Reliance on the Device**

Because the device has a lot of capability users develop a heavy reliance on the device to organise their lives or to stay in contact with other people. A.S. said, *"I do rely on it, to a certain extent, in that it's quite frustrating if I forget it, or if I leave it somewhere which isn't immediately accessible"*, C.H. is also reliant on their device, they said, *"If I were, say, twenty miles down the road and I'd forgotten it, I would turn the car around and go back and get it. But if I was on a train, I would say, well, yea, I can survive with a day without it, it's not a problem, I'll just use bits of paper or... I'll go to directory inquiries, or... Phone somebody who knows somebody else's number. I might delay one or two tasks, until the following day when I have all the information"*.

### **3.2.31 Reliability**

Reliability is a concept that seems to be linked to reliance on the device and indeed it makes the subject all the more important. As people rely more and more heavily on a device, the importance of its reliability grows significantly. D.I. illustrates this, *"You want it to be a hundred percent reliable, because it's got your life on it, you know. And... and I think that's why a lot of people do have... kind of fall out with them, or drop out of using them. It's because they get frustrated by the technical difficulties"*. E.H. also worries about the devices reliability, *"I still have a slight nagging doubt that it's not completely secure, I worry that I've just lost my entire diary for the next year (laughs)"*.

### **3.2.32 Reminders**

Certain interviewees used their devices to remind themselves of information or events, A.C. said *"I do rely on it. So I always want to check when I'm at home what I've got first thing the next morning, that sort of thing"* and when asked what they use their device for, A.S. said *"Just to er.. organise my thoughts, and organise the things that I have to do, I can no longer rely on my memory to remind me of multiple things"*

*during the day, or during the course of a week, or a number of weeks, erm... and therefore having something like the PDA, erm... it's extremely valuable".*

### **3.2.33 Screen Size**

Possibly the most notable and influential difference between a mobile device and a traditional computer is the vastly smaller screen. Screens are needed for the display of visual information, and their size can limit the amount they can display. This is a problem for A.B.; he said *"I've tried to use some of the... mind mapping software. But the interfaces are too... The interfaces are... the screen is not big enough, and the fact that you are using the little... the pen, the stylus and that, it's, it's... I think they try to make software that does... I think... they try to develop software for it that the interface doesn't support"*. C.H. also finds the screen size restricting; they say *"I don't use any of the Excels or anything like that. It's not big enough, really. The screen just isn't big enough to look at any spreadsheet of any size"*, G.R. however is pleased with the size of his display, *"I've got a phone which is a PDA, it's got a nice big screen on it, I can see all my appointments easily enough, and I can make changes easily enough, using the keys if I want to"*.

### **3.2.34 Security**

Storing large amounts of personal information on a small device can be a problem if the device is lost or stolen; security measures help limit this vulnerability. I.P. discussed his devices security, *"I like the security aspects of it, that I can put a pin number or use the finger print reader, so even if we have patient confidential data on here, you know, if it gets lost someone else can't read it without putting in the pin code or the blue... er... the finger print reader"*.

### **3.2.35 Sharing Information**

As social animals, people like to communicate and share information with each other. Devices designed to facilitate this have added value, D.I said, *"My husband and I have got the same PDA, we beam things to one another, erm, we both synchronise our erm, diaries, with our desktop computers, and things"*, also I.P. said, *"I can take my PDA with images from five or six patients on it and show them to the surgeons or the radiologists, and say: "look, this is what I found, what do you think of this, what do you think this shows?", that would be very useful"*.

### **3.2.36 Shortcuts**

This code refers to navigation shortcuts to functions etc. that users may use frequently or find useful, while walking through a task on their device, E.H. mentioned, *“There’s a short-cut here going into tasks”* and while discussing their likes and dislikes of their device, A.S. said, *“The quick access buttons on the front for things like addresses, erm... calendars, note books, things like that, er... all really adds to the... the convenience of using the PDA”*.

### **3.2.37 Simplicity**

Some of the interviewees seen their device as simple, and took some value in this. E.H. said, *“It’d be simple to use, it’s just... functionality is there, somebody has just worked out... There’s nothing extra, there’s nothing fiddly”* and A.B. said, *“It doesn’t pretend to be anything more than it actually is. Er... It’s just a good, simple organiser”*.

### **3.2.38 Socially Intrusive**

Mobile devices have the potential to be seen as rude or intrusive in certain situations for example on a bus or in a meeting, either through their alerts or through their use. Talking about using their PDA in public, P.C. said, *“I think it’s less intrusive than say, someone talking on a phone. So if you’re in a public place it’s less intrusive than someone speaking on a phone. I have no hang-ups at all about using it on a public place”*.

### **3.2.39 Speed**

This code refers to the speed or responsiveness of a device or its software, both in starting up and in operation. A.C. was impressed with the start-up speed of his device when he said, *“Another thing that’s impressed me a lot, was the fact that it is instantly on when you press the button. I think we are very used with computers to the overhead of switching the device on. There isn’t an overhead here. I reckon it’s quicker for me to find today, in my diary, than it is for you to open yours to find the page”*. A slow device can also cause confusion when the device and its navigation stick or don’t behave in a uniform way, A.S. was walking through a task on their PDA when: *“Uh, that’s strange! Now, normally that would drop down and give me.... uh! There we go!”*.

### **3.2.40 Sturdiness**

As people often pay a significant amount of money for their mobile devices, they expect them to stand up to general wear and tear and the little knocks and bumps that this implies. G.R. was disappointed when he said, *“I mean I sat down one day and when I got up the screen was broken. That's, obviously, that's a major hindrance, and they are quite expensive to replace [...] That was very unfortunate, I mean, I didn't hear it break or anything like that, and it wasn't in a back pocket or anything, it was actually inside the jacket, in the inside pocket, so got up and the next time I looked at it was broken”*.

### **3.2.41 Value of Information**

As we have seen, people can become very reliant on their mobile device and input a large amount of personal information. Users value the information held by these devices, whether it be pictures, diaries or contacts etc. K.H. said, *“The device itself is not important, it's the content that is important. And if the content is actually...is elsewhere... Then... that is what I am worried about”*. H.D. also remarked, *“If I thought I'd lost it, I would be upset about the data on it, not the actual machine”*.

## **3.3 What Next?**

The next step is to consolidate the findings from the analysis into a more manageable set, in preparation for the creation of heuristics.

## 4 Information Refinement

There are now 41 themes on which to base the heuristics, however 41 heuristics are too many and the concepts must first be refined a little more; some are quite similar and should be consolidated into single codes. To make the results more manageable they have been sorted into groups of similar codes, these groups will then form the basis of the heuristics.

### 4.1 Method

To group the codes in a logical way I have performed a card sort. A card sort is normally used to help organise the navigation structure of websites, as part of a re-design or conception. Card sorts involve a number of people (e.g. usually users of the site if in a company intranet) which are tasked with sorting cards into groups that make sense to them. These cards each have one concept (or code in our case) written on the card and a short description of what the concept means (Figure 4.1), each card also has a number on the back to aid documentation.



Figure 4.1: Named & blank cards

The participants are then left to sort the cards on their own or in a small group with limited interference from the organiser. The organiser may be required to answer questions from the participants, but not interfere with their decisions (Spencer, 2004). Once the participants have sorted the cards into groups, they name the groups by selecting a card from the piles that best represents the group or by writing a name on a blank card (Figure 4.2). After the participants completed the card sort the groups and the cards they contain were documented and also photograph was taken of the sort to capture any other information not documented, such as the order and proximity of the groups.

## 4.2 Card Sort Results

Card sorts were performed with four participants, the sorts were completed separately by single participants. The investigation involved both male and female participants who study or studied different topics in computer science, under graduates, post graduates and professionals.

### 4.2.1 Sort 1

These are the results of the first card sort:

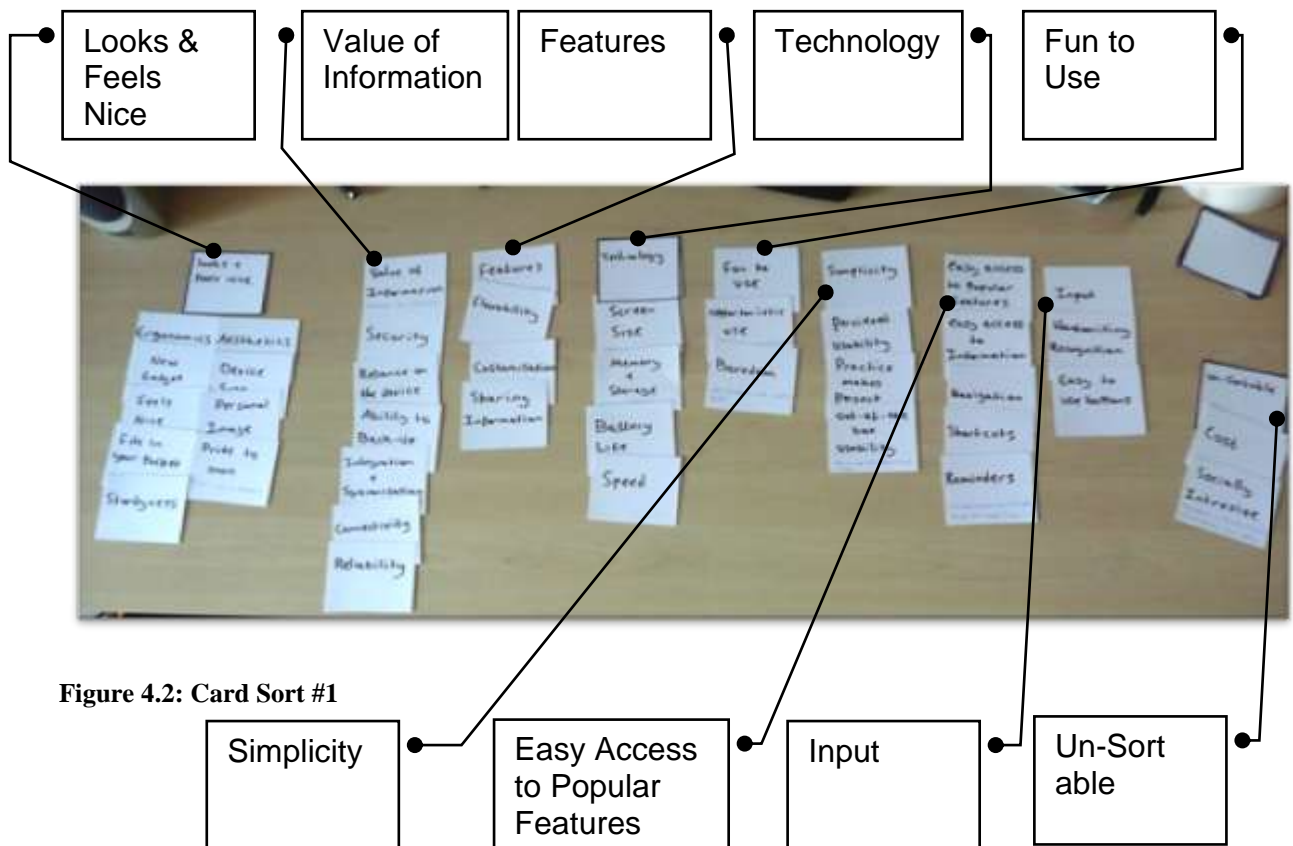


Figure 4.2: Card Sort #1

The participant in sort one identified 9 groups of cards, they used six original cards as headings and created two of their own, including an “un-sortable” group.



### 4.2.3 Sort 3

These are the results from the third card sort:

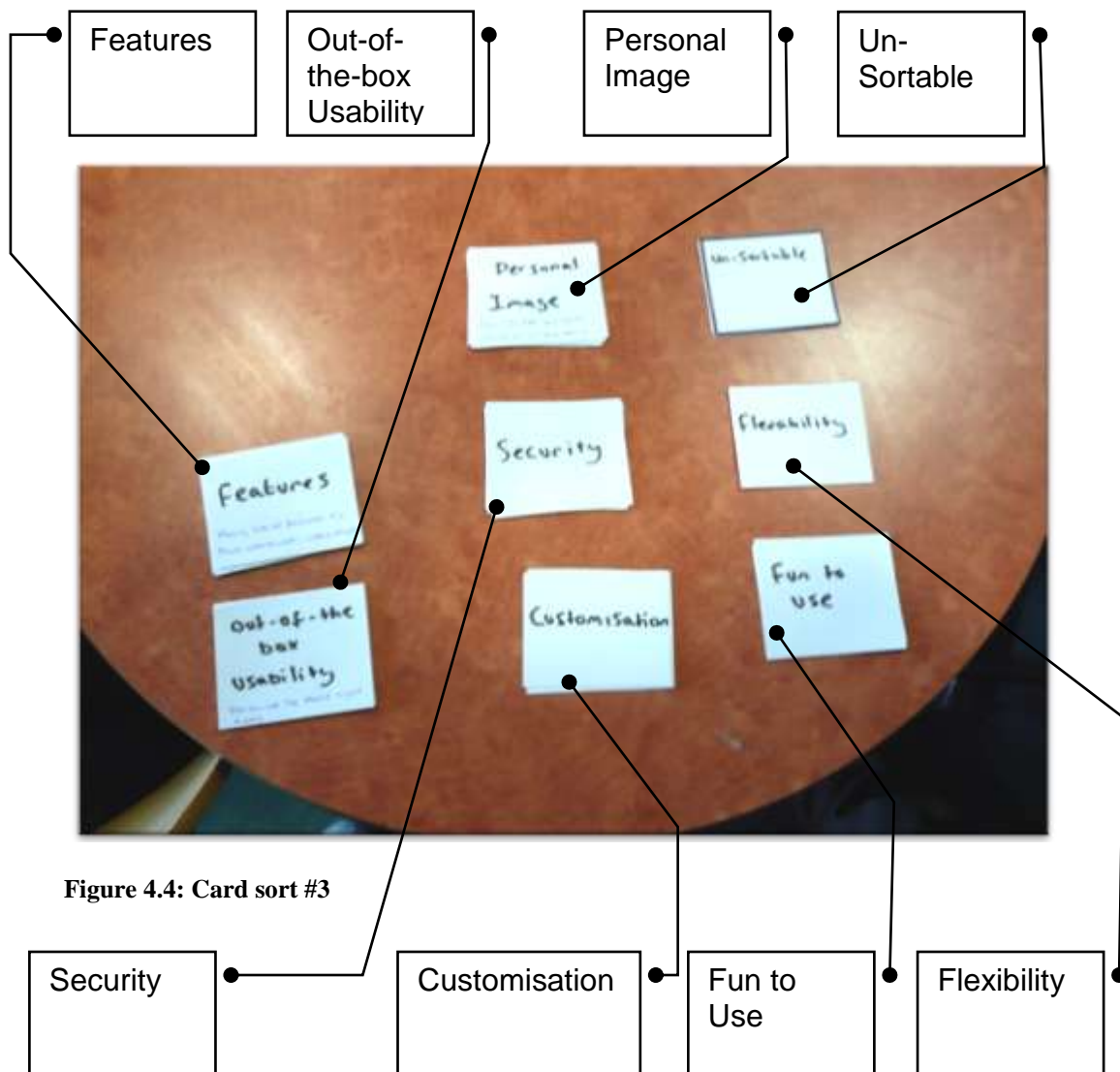
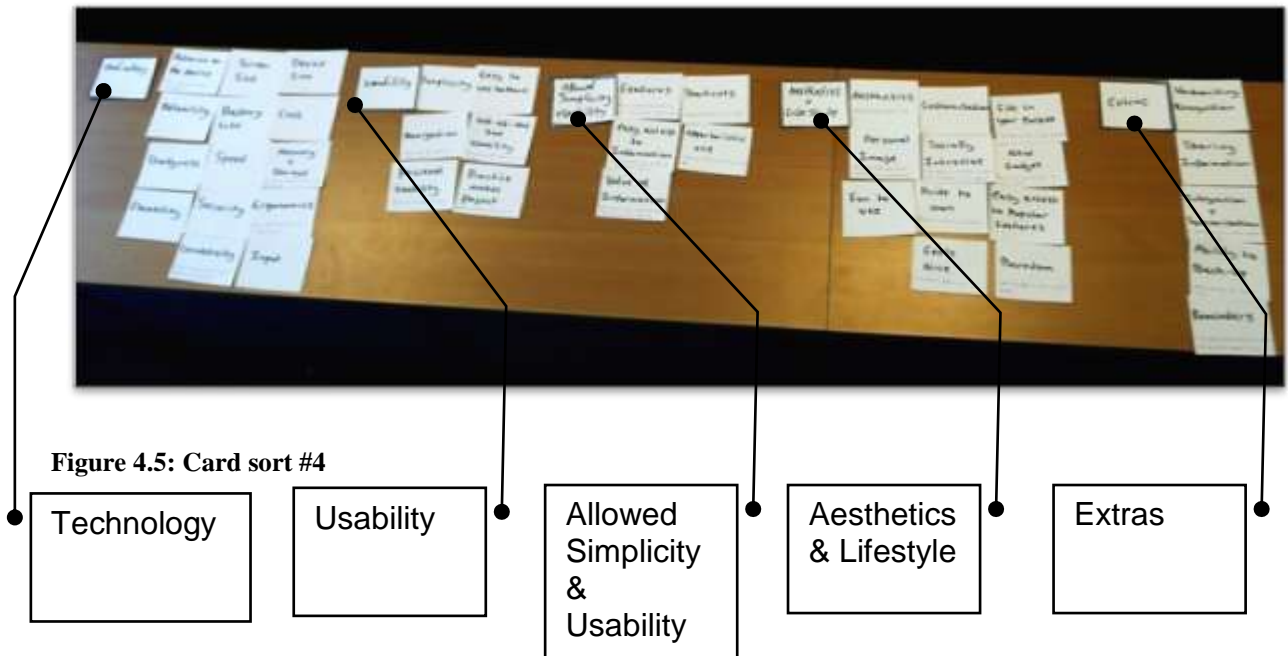


Figure 4.4: Card sort #3

The participant in sort three arranged the cards into 8 groups, they used eight existing cards and did not create any new group names. The participant arranged the cards into piles, they had a different sorting technique to the others, they shuffled through the deck rather than spreading the cards over the table (Figure 4.4). This may have been due to space constraints.

#### 4.2.4 Sort 4

These are the results from the fourth card sort:



The participant in sort four identified 5 groups; they used none of the original cards and created 5 new cards to name their groups. Participant 5 also organised their groups in order of importance, from left to right.

#### 4.2.5 Notes on Card Sort Process

Participants generally performed well in the card sort process, the initial intimidation of a large stack of cards subsided and participants were happy to finish the task. The task took on average 30 – 35 minutes and the participants sorted the cards in an iterative way, establishing groups and moving cards among different groups as trends emerged. All participants reviewed their final groups and some made last minute changes.

Some participants felt there were cards that would suit more than one of their groups, perhaps this is the cause of the low number of groups in sort 2 (Figure 4.3). When asked some of the participants found the cards cost and speed the most difficult to place. It is encouraging to note there were very few cards in un-sortable piles and only half the participants used this group.

### 4.3 Consolidation

Card sorts have been performed to consolidate the 41 codes and we now have four sets of sort results. Although the codes have been sorted into groups by the participants, each sort has a different number of groups and many different group names. To complete the consolidation of codes the information gathered must be analysed from it must be produced a number of uniform groups of codes, in accordance with patterns found in the four card sorts.

To help manage the analysis of this information, a tool in the form of a Microsoft Excel spreadsheet has been used. This spreadsheet was created by Donna Maurer for analysis of card sorts and published through Rosenfeld Media (Maurer, 2008). To facilitate analysis of the results they must first be entered into the spreadsheet, and so must the cards. The cards were all numbered prior to the card sorts and their groupings were noted using this unique identifier. The cards numbers and names were entered into the spreadsheet, along with the results from the card sorts in the relevant sheets. Once the sort data has been entered it is possible to view all the results in a summary table, with this table it is possible to sort the cards and sorts in different ways to observe trends such as similarities and differences in the data

Card no	Card name	Sort1	Sort2	Sort3	Sort4
1	Flexibility	Features	Features	Flexibility	Technology
2	Personal Image	Looks & Feels Nice	Fun to Use	Personal Image	Aesthetics & Lifestyle
3	Fits in Your Pocket	Looks & Feels Nice	Features	Personal Image	Aesthetics & Lifestyle
4	Device Size	Looks & Feels Nice	Physical Characteristics	Features	Technology
5	Customisation	Features	Features	Customisation	Aesthetics & Lifestyle
6	Easy to Use Buttons	Input	Features	Features	Usability
7	Feels Nice	Looks & Feels Nice	Fun to Use	Personal Image	Aesthetics & Lifestyle
8	Features	Features	Features	Features	Allowed Simplicity & Usability
9	Ergonomics	Looks & Feels Nice	Fun to Use	Personal Image	Technology
10	Ability to Backup	Value of Information	Features	Features	Extras
11	Cost	Unsortable	Physical Characteristics	Personal Image	Technology
12	Shortcuts	Easy Access to Popular Features	Fun to Use	Customisation	Allowed Simplicity & Usability
13	Input	Input	Physical Characteristics	Un-Sortable	Technology
14	Sharing Information	Features	Features	Security	Extras
15	Security	Value of Information	Physical Characteristics	Security	Technology
16	Screen Size	Technology	Physical Characteristics	Features	Technology
17	Out-of-the-box usability	Simplicity	Features	Out-of-the-box Usability	Usability
18	Easy Access to Popular Features	Easy Access to Popular Features	Features	Fun to Use	Aesthetics & Lifestyle

Figure 4.6: A sample from analysis spreadsheet summary table

(Figure 4.6).

### 4.3.1 Group Standardisation

Although the codes have been sorted into groups by the participants there are 24 separate groups, these must be standardised, i.e. the groups identified by the participants with the same, or very similar basic concept must be given a common name (Figure 4.7). For example; the groups Flexibility and Customisation are similar concepts so they shall both be known as Flexibility. Groups may also form part of a larger more popular group which some participants have identified as involving those groups, for example; the recently standardised Flexibility group becomes part of the Features group.



Figure 4.7: Standardisation of Groups

After standardisation there are 6 individual groups of codes:

- Aesthetics, Ergonomics & Image
- Device
- Easy Access
- Features
- Usability
- Value of Information

The standardised groups and the general groups they contain are detailed below:

#### 4.3.1.1 Aesthetics, Ergonomics and Image

This standardized group contains the general groups “Looks & Feels Nice”, “Fun to Use”, “Personal Image”, “Aesthetics & Lifestyle” and “Physical Characteristics”. The group refers to the look of the device, how pleasant it feels to hold and use and the image portrayed by using the device.

#### 4.3.1.2 Device

This group contains only one code: “Technology”. The “Technology” group was a common group used in half of the card sorts. Device refers to physical technological attributes of the device.

#### 4.3.1.3 Easy Access

The general groups “Easy Access to Popular Features” and “Allowed Simplicity and Usability” are now known as Easy Access, these groups involved the same concept of easy access to information.

#### 4.3.1.4 Features

“Features” was a common general group; it has now encapsulated “Flexibility”, “Customisation” and “Extras”. This group concerns devices software or (programme) features.

#### 4.3.1.5 Usability

The general groups “Input”, “Simplicity”, “Out-of-the-Box Usability” and “Usability” are now all known as Usability. This group encapsulates learning and using the devices interface.

#### 4.3.1.6 Value of Information

This group contains the general groups “Value of Information” and “Security”. The group concerns the value users place on their information stored on a device and keeping the information safe.

### **4.3.2 Grouped Codes**

There are now 6 standardized groups, the next step is to examine the data from the sorts and decide in which of the 6 groups each of the 41 codes belong. The card sort analysis spreadsheet allows analysts to view the agreement between all the codes and the groups in a matrix and gives this agreement as a percentage. The agreement table can be seen in Table 4.1.

**Table 4.1: Agreement between groups and codes**

Card no	Card name	Aesthetics, Ergonomics & Image	Device	Easy Access	Features	Usability	Value of Information
1	Flexibility		25%		75%		
2	Personal Image	100%					
3	Fits in Your Pocket	75%			25%		
4	Device Size	50%	25%		25%		
5	Customisation	25%			75%		
6	Easy to Use Buttons				50%	50%	
7	Feels Nice	100%					
8	Features			25%	75%		
9	Ergonomics	75%	25%				
10	Ability to Backup				75%		25%
11	Cost	50%	25%				
12	Shortcuts	25%		50%	25%		
13	Input	25%	25%			25%	
14	Sharing Information				75%		25%
15	Security	25%	25%				50%
16	Screen Size	25%	50%		25%		
17	Out-of-the-box usability				25%	75%	
18	Easy Access to Popular Features	50%		25%	25%		
19	Perceived Usability	25%				75%	
20	Connectivity		25%		25%		50%
21	Practice Makes Perfect	25%			25%	50%	
22	Easy Access to Information	25%		50%	25%		
23	Reminders	25%		25%	25%		25%
24	Reliance on the Device	25%	25%			25%	25%
25	Battery Life	25%	50%			25%	
26	Opportunistic Use	50%		25%	25%		
27	New Gadget	100%					
28	Socially Intrusive	50%			25%		
29	Simplicity	25%				75%	
30	Sturdyness	50%	25%		25%		
31	Speed	25%	50%			25%	
32	Handwriting Recognition				50%	25%	25%
33	Memory & Storage	25%	50%		25%		
34	Navigation			25%	50%	25%	
35	Fun to Use	100%					
36	Reliability	25%	25%			25%	25%
37	Pride to Own	100%					
38	Integration & Synchronisation				75%		25%
39	Aesthetics	100%					
40	Boredom	75%					
41	Value of Information	25%		25%			25%

The parent group of the codes is determined by the percentage agreement of the code, any code which shows 50% or more in a group belongs to that group, e.g. the code “Personal Image” belongs to the group “Aesthetics, Ergonomics & Image” as it displays 100% agreement. The code “Device Size” belongs to the same group as it displays 50% agreement. The vast majority of codes show an agreement to one specific group; there are however some exceptions. The code “Easy to Use Buttons” shows 50% in two groups, because it shows more similarity with the codes in the group “Usability” than “Features” it will belong to that group. The code “Reminders” showed an agreement of 25% in 4 different groups; it bears the most resemblance to codes in “Easy Access” and will belong to that group. The codes “Reliance on the Device” and “Reliability” showed an agreement of 25% in 4 different groups but bear a strong resemblance to codes in the group “Value of Information” so they will belong

to that group. The lack of strong agreement with these cards may be due to unclear labels or descriptions on the codes cards in the card sort. The codes “Input” and “Value of Information” have no strong agreement due to belonging to an “Un-Sortable” group in the card sorts. “Input” shall belong to the group “Usability” and “Value of Information” shall belong to the group which bears its name.

The process of consolidation and the codes’ final groups can be seen in Figure 4.8.

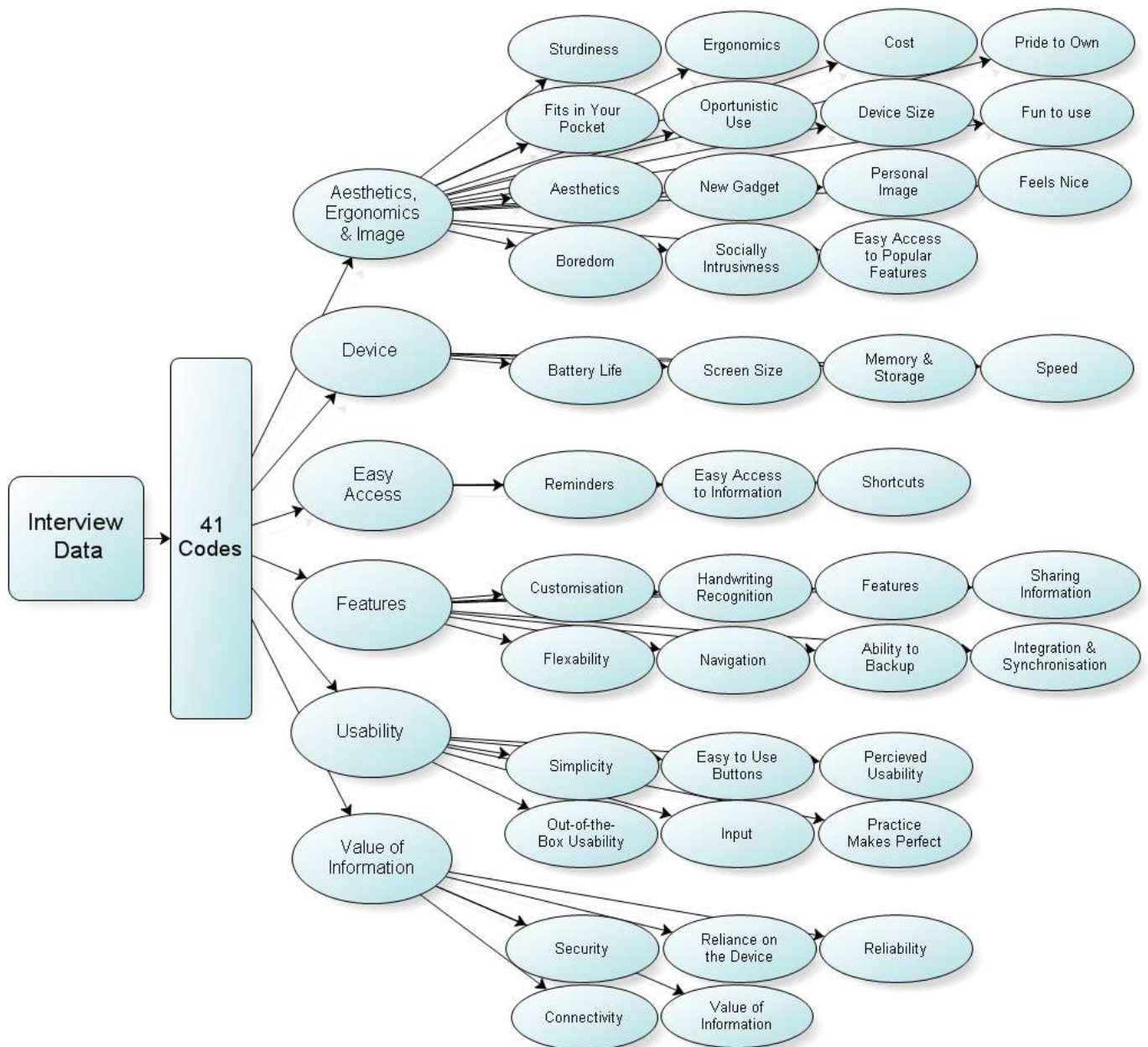


Figure 4.8: Analysis and consolidation of codes

#### **4.4 What Next?**

We now have 41 codes which have been sorted into logical categories; the next step is to produce guidelines for testing devices against these.

## **5 Piloting the Heuristics**

There are now six categories which contain the forty one codes. These codes were taken directly from interviews with users; for this reason these are things they care about. Now we know the things users care about, we must be able to test a device and find out to what extent it fulfils the users needs.

### **5.1 From Codes to Heuristics**

To produce the mobile heuristics, the themes from the codes have been formed into a number of open questions. Those evaluating the devices shall answer the questions on a scale of one to five, depending on how successfully the device has performed on that particular question.

#### **5.1.1 Heuristics**

As the codes have been sorted into logical groups, occasionally it will be possible to address more than one code in a single question. The heuristics were made into questions the participants can answer and revised until they were suitable for their first iteration. The 27 heuristics created from the 41 codes are listed below.

##### **5.1.1.1 Usability**

- How simple is the device to use?
- Rate how easy to use the buttons are.
- How easy to learn is the device?
- Rate how easy it is to input information using the device.
- To what extent does the device look easy to use?

##### **5.1.1.2 Features**

- How easily can you customise the device?
- Rate the ease with which you can share information with others and connect to other devices.
- How easily can you navigate within the device?
- If the device has handwriting recognition; rate its effectiveness.
- Rate the flexibility of the device.

- How useful do you find the features of the device?

#### 5.1.1.3 Easy Access

- If there are shortcuts to the devices features, rate the usefulness of these.
- How effective are the devices reminders?
- How easy is it to access information on the device? E.g. audio, pictures, documents

#### 5.1.1.4 Value of Information

- Rate how secure your information is on the device.
- Rate reliability of the device.
- How easily can you back up information on the device?

#### 5.1.1.5 Aesthetics, Ergonomics & Image

- Rate how easily you can access the things you use the most often
- Rate how much fun this is to use and how it can relieve your boredom.
- How proud do you feel to own this gadget?
- Rate how people see you while using this device in public.
- To what extent does the device fit in your hand and how does it feel?
- How well does the device fit in your pocket?

#### 5.1.1.6 Device

- Rate how much storage space the device has.
- Rate the responsiveness of the device.
- How well does the size of the screen cater for your usage of the device?
- Rate the battery life of the device and the accuracy of the battery life indicator.

The first draft of the heuristics is complete, to examine their validity, ensure they are usable by those that may use them to analyse devices, and to establish if they give us useful data, the heuristics must be tested. Based on their performance in this test they shall be refined. An initial study involving 6 participants has been performed to ensure people understand the questions and can use them

## 5.2 Initial Study

This study involved 6 people independently evaluating their own mobile phones using version 1.0 of the Mobile Device Heuristics.

### 5.2.1 Method

The participants were asked to evaluate their own mobile phones as they were guaranteed to have a great deal of experience using the devices. This means inexperience would not be a factor influencing the participants' experience of the test. The participants were given sheets with the 27 heuristics and could answer the questions on a rating from 1 to 5; 1 being the most negative answer and 5 being most positive. There was an option to select N/A if the question did not apply or could not be answered. In addition to the questions the participants were given instructions on answering the questions. On the front of the sheets, the standardised instructions were as follows:

*“There are 27 questions; please read them thoroughly and answer by circling the one option you think is most appropriate. If this question does not apply, circle N/A. Please make a note of the device info in the space provided. If you are unsure of the wording of the questions, or have any queries about the questions or the process, please ask.*

*If you have notes, comments, or want to re-arrange anything; feel free to write or draw on the sheets. Remember, it is the device and the questions that are being evaluated, not you!”*

Below the standardised instructions was a space to record what device the participants were evaluating, this was under “Some Device Info” and the fields recorded were “Manufacturer”, “Model” and “Type / Description”.

### 5.3 Is This Useful?

The data from each of the six evaluation sheets was recorded in an Excel Spreadsheet. Answers to each of the 27 questions from the 6 participants were recorded. These are presented in Table 5.1; the bold headings in grey backgrounds show names of the sections and the sum of the answers in that section for the given participant. Answers are rated from 1 – 5 with the option to answer N/A.

**Table 5.1: Results from initial study of Mobile Device Heuristics 1.0**

<b>Heuristic / Participant</b>	<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>	<b>P5</b>	<b>P6</b>
<b>Usability</b>	<b>19</b>	<b>18</b>	<b>24</b>	<b>18</b>	<b>18</b>	<b>18</b>
How simple is the device to use?	4	4	5	4	4	3

Rate how easy to use the buttons are.	4	3	5	3	4	4
How easy to learn is the device?	5	4	5	4	4	3
Rate how easy it is to input information using the device.	2	3	4	3	3	4
To what extent does the device look easy to use?	4	4	5	4	3	4
<b>Features</b>	<b>16</b>	<b>20</b>	<b>21</b>	<b>17</b>	<b>19</b>	<b>19</b>
How easily can you customise the device?	3	5	4	3	3	4
Rate the ease with which you can share information with others and connect to other devices.	2	2	5	3	4	4
How easily can you navigate within the device?	4	3	4	4	5	5
If the device has handwriting recognition; rate its effectiveness.	N/A	N/A	N/A	N/A	N/A	N/A
Rate the flexibility of the device.	3	5	4	3	3	2
How useful do you find the features of the device?	4	5	4	4	4	4
<b>Easy Access</b>	<b>12</b>	<b>11</b>	<b>12</b>	<b>11</b>	<b>13</b>	<b>11</b>
If there are shortcuts to the devices features, rate the usefulness of these.	4	2	4	4	5	4
How effective are the devices reminders?	3	4	3	3	3	4
How easy is it to access information on the device? E.g. audio, pictures, documents	5	5	5	4	5	3
<b>Value of Information</b>	<b>4</b>	<b>12</b>	<b>11</b>	<b>11</b>	<b>8</b>	<b>12</b>
Rate how secure you information is on the device	1	4	4	4	3	2
Rate the reliability of the device.	2	5	4	4	3	5
How easily can you back up information on the device?	1	3	3	3	2	5
<b>Aesthetics, Ergonomics &amp; Image</b>	<b>25</b>	<b>23</b>	<b>22</b>	<b>23</b>	<b>22</b>	<b>22</b>
Rate how easily you can access the things you use the most often	5	5	4	4	5	4
Rate how much fun this is to use and how it can relieve your boredom.	2	3	4	4	5	3
How proud do you feel to own this gadget?	5	5	3	3	3	4
Rate how people see you while using this device in public.	3	3	3	3	3	4
To what extent does the device fit in your hand and how does it feel?	5	3	4	4	3	4
How well does the device fit in your pocket?	5	4	4	5	3	3
<b>Device</b>	<b>11</b>	<b>15</b>	<b>14</b>	<b>16</b>	<b>11</b>	<b>17</b>
Rate how much storage space the device has.	2	5	2	4	4	4
Rate the responsiveness of the device.	2	2	4	4	3	4
How well does the size of the screen cater for your usage of the device?	5	5	4	4	3	5
Rate the battery life of the device and the accuracy of the battery life indicator.	2	3	4	4	1	4

The data retrieved has been inspected and it appears to be useful; it is clear in the study which device was rated the most useful and in particular in which sections. It is

possible to ascertain a devices strengths and shortcomings by examining which sections they score highest and lowest in.

## **5.4 User Reaction**

On the whole the reaction to the initial study was optimistic. Participants were positive and in some cases eager to evaluate using the heuristics. Most questions were answered without obvious problems and the heuristics seemed quite self explanatory and easy to understand. There were however several comments on the heuristics and a few recurring themes and problems.

Some participants were intimidated by the apparent large number of questions; once the evaluation was underway however, the participants made no further complaint. Any reduction in the number of questions however may be beneficial. One of the participants commented on the placement of the question on navigation in the Features section, this question may be better placed in Usability or Easy Access.

### **5.4.1 Wording & Questions**

In all 6 tests the question on handwriting recognition was answered N/A. It is very likely this feature will not be present in many devices that are evaluated, and its absence will not necessarily have a negative effect on usability; because of this the question shall be removed. The topic of handwriting recognition falls within the scope of the question on input in the Usability section; therefore if the feature is present it shall be evaluated. The question “How proud do you feel to own this gadget” has been reworded as “How proud do you feel to use this gadget” to better suit evaluation as the participant probably will not own the device.

The “Some Device Info” section at the start of the evaluation sheets was mostly self explanatory but participants were confused by the “Type / Description” field, and wrote irrelevant information, some left it blank and others asked what it meant. This must be reworded for clarity.

### **5.4.2 User Queries**

The most common question asked by participants was regarding the question on flexibility. Four out of the six participants asked what was meant by flexibility; this was answered in the case of their mobile phone as generally “*to what extent can you*

*use it for other things as opposed to using it as a phone*". This question must be reworded to better reflect its meaning.

Although the participants evaluated their devices by answering the questions and rating their answers; they often also gave an explanation of why they were rating the device as such. These comments have extremely important information which is lost if not recorded. Although participants freely discussed why they rated the devices as such, they may be more reluctant to make a written note after each question.

From an evaluation perspective, the answers to the heuristics may prove easier to evaluate if the questions on the sheets were numbered accordingly.

## **5.5 Revision of Heuristics**

The heuristics have been revised to reflect the problems found in the initial study, the changes are detailed below.

The questions concerning ergonomics have been removed from *aesthetics, ergonomics and image*, and added to the *usability* section. This gives a better balance to the heuristics as the *aesthetics, ergonomics and image* section was rather heavy. The revised sections are now named, *usability & ergonomics* and *aesthetics & image*.

As the question on handwriting recognition in the *features* section was deemed unnecessary and would be covered in the question regarding input; this question has been removed. The question on navigation has been removed from the *features* section and added to *easy access* where it appears more logically placed. The question regarding shortcuts has been changed from "If there are shortcuts to the devices features, rate the usefulness of these" to "Rate the usefulness of shortcuts to the devices features". This question was changed as although none of the participants in the initial study answered N/A, the question was previously worded to give the impression that it was optional and this is not the case.

### **5.5.1 Mobile Device Heuristics 1.1**

These are the 26 Mobile Device Heuristics revised to version 1.1. changes are noted where appropriate.

#### 5.5.1.1 Usability & Ergonomics<sup>1</sup>

- How simple is the device to use?
- Rate how easy to use the buttons are.
- How easy to learn is the device?
- Rate how easy it is to input information using the device.
- To what extent does the device look easy to use?<sup>2</sup>
- To what extent does the device fit in your hand and how does it feel?<sup>3</sup>
- How well does the device fit in your pocket?<sup>4</sup>

#### 5.5.1.2 Features<sup>5</sup>

- How easily can you customise the device?
- Rate the ease with which you can share information with others and connect to other devices.
- Rate the flexibility of the device: to what extent can you use it for other things.<sup>6</sup>
- How useful do you find the features of the device?

#### 5.5.1.3 Easy Access

- Rate the usefulness of shortcuts to the devices features.<sup>7</sup>
- How effective are the devices reminders?
- How easy is it to access information on the device? E.g. audio, pictures, documents
- How easily can you navigate within the device?<sup>8</sup>

#### 5.5.1.4 Value of Information

- Rate how secure your information is on the device.
- Rate reliability of the device.
- How easily can you back up information on the device?

#### 5.5.1.5 Aesthetics & Image<sup>9</sup>

- Rate how easily you can access the things you use the most often
- Rate how much fun this is to use and how it can relieve your boredom.

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<sup>1</sup> Section renamed from *Usability*

<sup>2</sup> Question moved from *Aesthetics, Ergonomics & Image*

<sup>3</sup> Question moved from *Aesthetics, Ergonomics & Image*

<sup>4</sup> Question moved from *Aesthetics, Ergonomics & Image*

<sup>5</sup> Question on handwriting recognition removed

<sup>6</sup> Question reworded

<sup>7</sup> Question reworded

<sup>8</sup> Moved from *Features*

<sup>9</sup> Renamed from *Aesthetics, Ergonomics & Image*

- How proud do you feel to use this gadget?<sup>10</sup>
- Rate how people see you while using this device in public.

#### 5.5.1.6 Device

- Rate how much storage space the device has.
- Rate the responsiveness of the device.
- How well does the size of the screen cater for your usage of the device?
- Rate the battery life of the device and the accuracy of the battery life indicator.

## 5.6 What Next?

Now we have improved the heuristics based on the pilot study, we will use the revised heuristics v1.1 in a meaningful study.

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<sup>10</sup> Question Reworded

## 6 Comparative Study

This comparative study has compared two different phones. This study should ascertain whether the heuristics produce meaningful results. Two mobile phones were compared using the mobile device heuristics to discover which is rated more usable according to the results. This test should discover whether the heuristics produce meaningful results and shall further evaluate the heuristics. Multiple participants have performed the test; in addition to evaluating the devices they have also given feedback and criticism on the process.



Figure 6.2: Motorola V3i



Figure 6.1: Samsung D600

The devices selected for the study are the Motorola V3i (Figure 6.2) and the Samsung D600 (Figure 6.1). The devices were produced by different manufacturers but at similar times. The phones are of a similar specification: both have the ability to take pictures and record video files, Bluetooth connectivity, WAP internet browsers, a variety of games and applications, the ability to send SMS and MMS messages, play audio files and of course; make phone calls.

The V3i is a *flip* or *clamshell* style phone; this form factor (Business Dictionary, 2008) allows the device to remain compact when folded over but gives a larger surface area when opened, in the case of the V3i this means it has a relatively large screen and buttons. The D600 is a *slide* style phone, this type of device has front and back parts, these slide apart vertically or horizontally to reveal more of the device, usually

a keypad. This form factor is another space saving and often aesthetic feature; in the case of the D600, it slides open vertically to reveal a keypad.

There is a standard and consistent structure and method in the study, each participant was given the same information, completed the same tasks and asked the same questions. The study was conducted with multiple participants, each participant evaluated both phones. Once all participants have evaluated both phones an average result can be taken from the findings, to ascertain which device has performed best in the study.

## **6.1 Method**

In this study the Motorola V3i shall be referred to as “device 1” and the Samsung D600 shall be referred to as “device 2”.

Participants performed the study individually with a researcher; the method of study is as follows:

1. Participants are informed of the study; they are told it is a comparative study of two mobile phones using a set of heuristics in the form of questions. The purpose of the study is to test the heuristics and use them to compare the devices.
2. The participant is given device 1, which is turned off.
3. Participants are then told to familiarise themselves with the device and given 2 minutes to do this.
4. The participant is given a sheet with standardised instructions to complete a task. The time taken to complete the task and each of the bullet points is recorded. The task is as follows:

Using the device you have been given:

- Make a phone call to “John Smith”; he is stored in the devices phone book.
- Send John Smith an SMS telling him your favourite colour.
- Take a picture of the researcher.

- Send the picture you have taken to the researcher.
  - Finally, set a reminder on the phone to wake yourself at 7.00am tomorrow morning.
5. Participants are given a Mobile Device Heuristics v1.1 sheet to complete; regarding device 1. (The participants are allowed to keep device 1 at hand for reference when completing the heuristics.)
  6. Participants are given device 2, which is turned off.
  7. Repeat steps 3 – 6 for device 2.
  8. Participants are given a Mobile Device Heuristics v1.1 sheets to complete regarding device 2. (The participants are allowed to keep device 2 at hand for reference when completing the heuristics.)
  9. Participants are then asked questions intended to gather any other information:
    - Did you encounter any problems while completing the tasks?
    - Did you encounter any problems while using the heuristics?
    - Was there anything that I missed that you feel is important or interesting?
  10. Participants are thanked for their participation and time.

## **6.2 Results**

The comparative study was conducted with 3 participants. The data from the 3 sets of evaluations has been recorded in an Excel spreadsheet. Answers from each of the questions were recorded on a scale of 1 – 5. Treating these results as though they are on an interval scale, the answers were grouped by section and plotted on line charts for comparison.

The charts for both devices are displayed below for comparison and interpretation of the results. The users rating is plotted on the vertical axis and the question number

is plotted on the horizontal axis, each participants ratings are plotted as a series of points and joined by a line.

### 6.2.1 Usability & Ergonomics

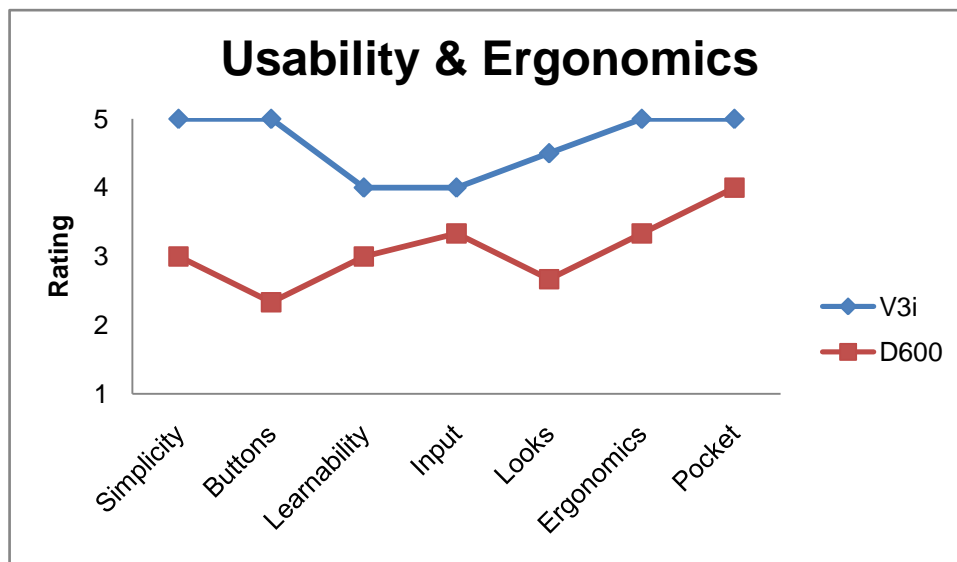


Figure 6.3: Usability & Ergonomics Line Chart

When we compare the plotting for the V3i and the D600 in Figure 6.3, we see that the V3i is rated higher than the D600; in general all ratings for the V3i are clearly higher than the D600.

We can interpret that in the *usability & ergonomics* section, the V3i (device 1) is the most usable.

## 6.2.2 Features

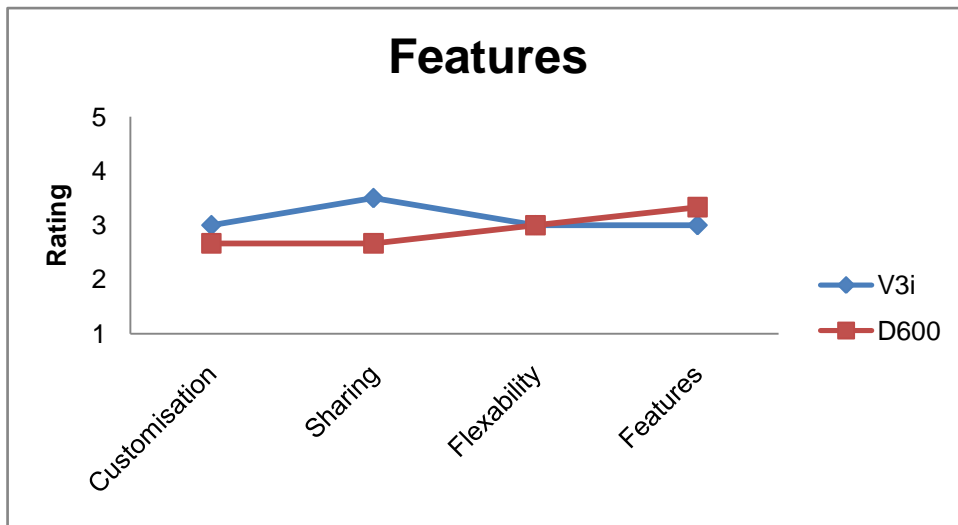


Figure 6.4: Features Line Chart

When looking at Figure 6.4, the V3i appears to have been rated slightly more positively than the D600; although the difference is quite small. Both devices have similar ratings but the V3is' line is higher in the first two questions.

We can interpret that in the *features* section, the V3i (device 1) is the most usable by a small margin.

### 6.2.3 Easy Access

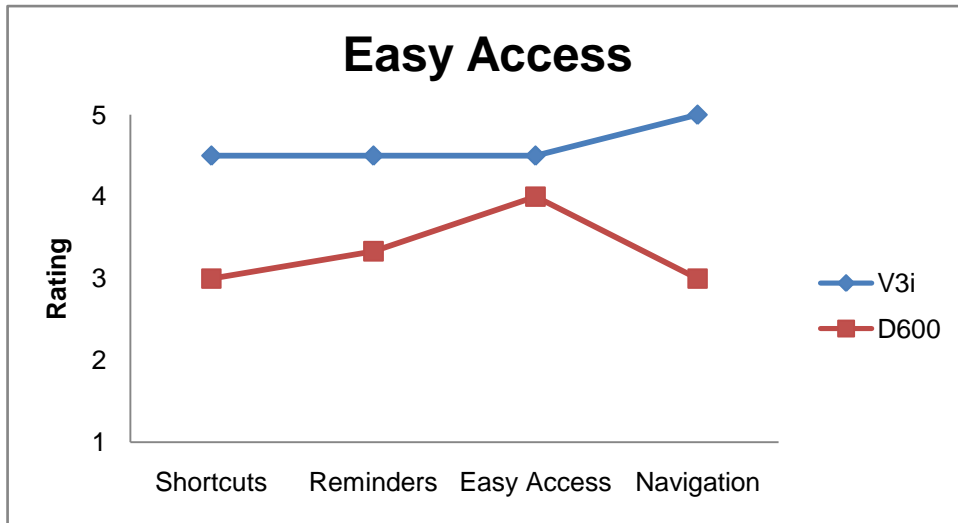
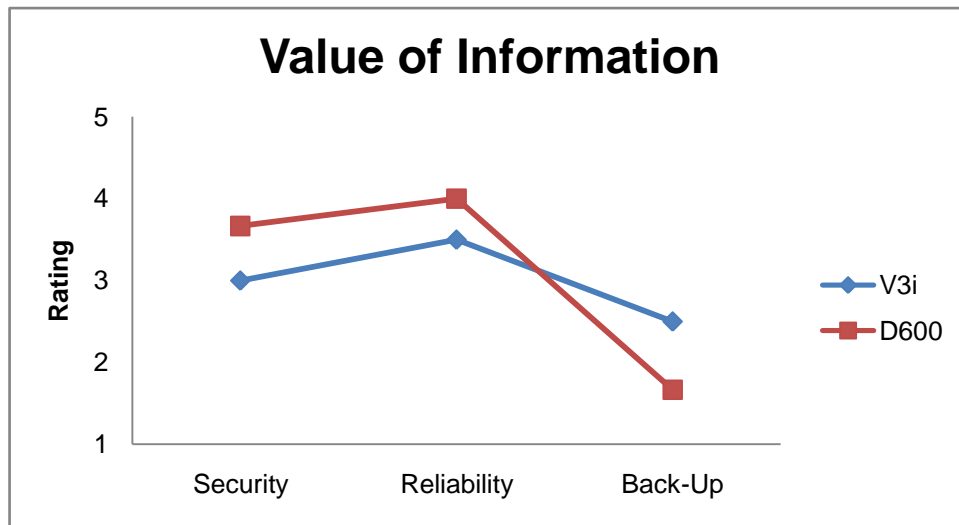


Figure 6.5: Easy Access Line Chart

Through comparison of the plots in Figure 6.5 it is clear that the v3i (device 1) has been rated more positively than the D600 (device 2). The ratings for each question are clearly higher in the V3is' plot than the D600s' plot.

We may interpret that in the *easy access* section, the V3i (device 1) has been rated more usable than the D600 (device 2).

## 6.2.4 Value of Information



**Figure 6.6: Value of Information Line Chart**

On inspection of Figure 6.6 we can interpret that the D600 is rated marginally higher than the V3i. The D600 scores higher than the V3i in two questions but much lower in the third, the D600 however appears to rate higher than the V3i.

Therefore in the *value of information* section we can conclude the D600 (device 2) is more usable than the V3i (device 1).

## 6.2.5 Aesthetics & Image

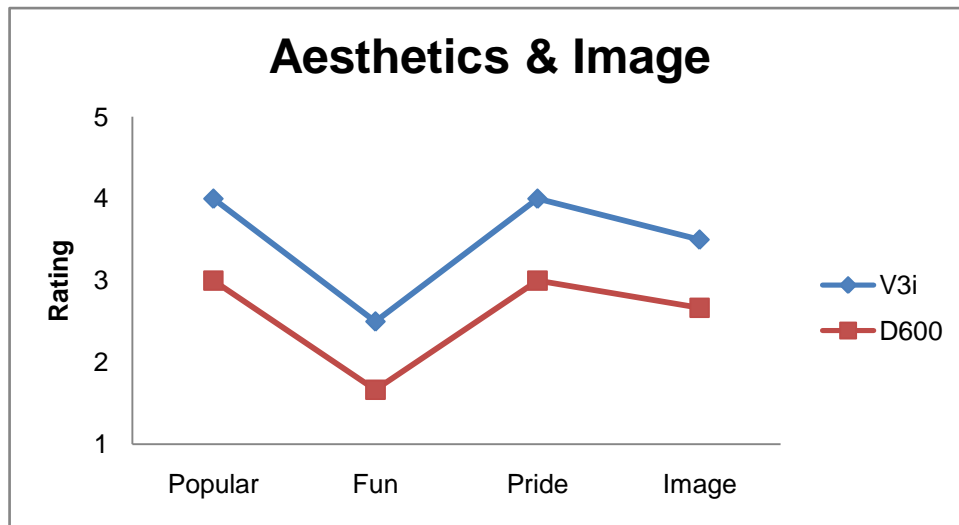


Figure 6.7: Aesthetics & Image Line Chart

Through comparison of plots in Figure 6.7 it is clear that the V3i is rated more positively than the D600. Ratings for the V3i are consistently higher than the D600.

We can conclude that in the section *aesthetics & image*, the V3i (device 1) is the more usable device.

## 6.2.6 Device

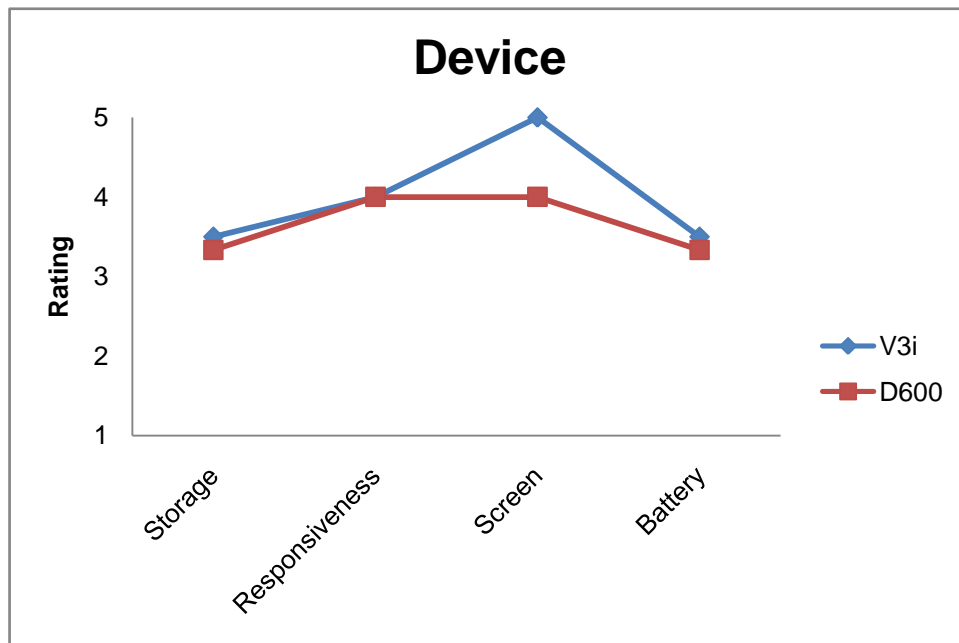


Figure 6.8: Device Line Chart

On inspection of Figure 6.8 it appears that the V3i is rated higher than the D600, although for the question on responsiveness each device were rated the same, the V3is' screen was rated much higher than the D600.

We may interpret that in the *device* section, the V3i (device 1) is slightly more usable than the D600 (device 2).

## 6.2.7 In Summary

When device 1, the Motorola V3i and device 2, the Samsung D600 were compared using the Mobile Device Heuristics v1.1; it was found that the Motorola V3i was rated more usable in *usability & ergonomics, features, easy access, aesthetics & image and device* and the Samsung D600 more usable in *value of information*. The most usable device on average in the comparative study therefore is the Motorola V3i.

## 6.2.8 User Comments

In addition to completing the heuristic evaluation; users were also asked a few questions regarding the study and the devices.

In response to the question "Did you encounter any problems while completing the tasks?" participant 1 mentioned that they could not type the word "red" on the D600

using the predictive text system and instead had to type the word 'blue' which it understood. In response to the same question, participants 2 and 3 said they could not complete the file transfer part of the task; one could not work out how to transfer the file using Bluetooth and the second could not get their device to find the other.

When asked "Did you encounter any problems while using the heuristics?" no one reported any difficulties.

In response to the question "Was there anything that I missed that you feel is important or interesting", there were no problems, once participant did however recommend counting the number of times they swore at the device while completing the tasks as a useful usability metric.

### **6.3 Conclusion**

This comparative study was performed to ascertain whether the heuristics produced meaningful results. It is my opinion that the heuristics do indeed produce meaningful results, as it is possible to interpret in a comparative study which device was deemed more usable by a number of participants. As a standalone evaluation by a number of participants it is possible to identify the devices strengths and weaknesses according to the defined sections.

### **6.4 What Next?**

The heuristics shall not be revised any further in this project although further work and revisions will be recommend and the process reflected upon.

## **7 Discussion & Reflection**

The research and development of the mobile device heuristics within the scope of this project has been completed; there shall be no further revision of the heuristics. In this section I shall discuss and reflect on the process of creating and testing the heuristics and comment on its success.

### **7.1 Research Questions**

To measure the success of the project I can evaluate whether the research questions set in section 1.3. have been answered.

The specific research questions I set out to answer are as follows:

1. Is it possible to create heuristics for mobile devices?
2. Can someone use these heuristics to evaluate the usability of mobile devices?
3. Are these heuristics better than existing methods?

The answer to question 1 is yes, it is possible to create heuristics for mobile devices. This was demonstrated in the report and proof exists in the form of the Mobile Device Heuristics v1.0 and v1.1.

Question 2 has been answered in both the pilot study and the comparative study. On both occasions a selection of participants were able to evaluate a range of mobile phones and the results produced were meaningful. The heuristics themselves do indeed appear to be usable and give an indication of how usable the devices were rated.

The answer to question 3 is not clear, and how to fully answer this is debatable. The fact is usability problems identified by the mobile device heuristics have not been validated as true usability problems; therefore it cannot be said if they are better than existing methods. The problem is however; to what standard should the heuristics be measured? If the mobile heuristics find different usability problems to Nielsen's heuristics for example, which can be said to be wrong or right if all or some of both

sets of problems are useful? If a designer finds a certain evaluation method to be more successful than another, is that then the best method? The nature of the problems found by evaluation methods may also differ, depending also on how severe the problem is *perceived* to be. To answer question 3 and ascertain whether the heuristics are any better than existing methods, it seems logical that they should be used in the design process of a mobile device and feedback from those developing the device would be a measure of their success.

## **7.2 Project Review**

While producing this piece of work I have expanded my knowledge on a number of subjects and gained a number of new skills. I will comment on the success of each of the major sections and discuss the experience of completing these.

### **7.2.1 Research**

I have undertaken research into mobile devices and usability, chapter 2 has described the evolution of mobile devices, and how the need for richer interaction has grown with this development. I have discussed usability and how the field has moved to encompass the users' complete experience of using a product; studied as user experience.

While producing a review of the history of mobile devices and discussing usability in chapter 2, I have greatly improved my research skills. I have become more capable of researching a desired topic, by finding a number of sources from different individuals and organisations using different methods and sources, judging which of these are most relevant and reliable and presenting my findings in a way that makes sense. I was surprised when writing chapter 2 how time consuming the research process was at first, the experience was akin to swimming through treacle; there was a lot of effort involved but I never seemed to get anywhere. During this research process I was required to read many large articles bordering several areas of expertise such as psychology; these were at times complex and intimidating, and a lack of progress proved frustrating. Progress and understanding of these fields however improved over time and with practice and patience. I found the lecture by the library staff on research very helpful and also the guidance of my supervisor. At the end of the chapter on research it was satisfying to have produced the piece of

work and I looked forward to using the knowledge I gained when producing the heuristics.

While researching the subject of usability I discovered the extent to which the field is moving towards a more holistic view of usability, namely user experience. The principals of user experience have featured in the decisions I have made when producing the mobile heuristics. User experience featured for example when deciding to code parts of the interview text. Parts of the text concerning how the users reported the device felt, were coded; this lead to a question in version 1.1 of the heuristics evaluating, to what extent the device fits in the users hand and how it feels.

From this research I have formed some opinions and increased my interest in the field of user experience, this knowledge should prove valuable in my future career. I have also developed a greater understanding of the history of mobile devices and noticed trends in their evolution. Based on these trends I have formed opinions on where mobile technology is heading, in terms of the technology, its popularity and how we will interact with future mobile technology.

### **7.2.2 Information Analysis**

Taking into account the information gathered from my research, I analysed a series of transcripts from interviews with PDA users. This analysis involved highlighting points of relevance and recurring themes and creating an overall picture of users concerns, with the goal of using them to produce guidelines for evaluation.

Having the interview transcripts was of great assistance to the project, freeing up time to be spent in the interpretation and analysis of the results. In order to evaluate the large amount of data contained in the PDA interview manuscripts, I learnt to use the QSR NVivo qualitative data analysis software. This software was instrumental in my analysis of the PDA data, greatly assisting the management of the analysis.

Starting the analysis of a large amount of information using NVivo was intimidating, and I was unsure of the concepts used. When starting to code I was unsure whether to create codes based on what I expected to find or read the interviews and create codes based on points of interest and recurring themes. In the end I chose the latter, this helped increase my confidence and coding proficiency. If I were to use the

NVivo software in the future, I would adopt the same strategy. Although NVivo was a valuable tool enabling fast coding of the interview texts, I underestimated the amount of time required to code all the transcripts, though the project did not suffer because of this. It was a recurring trend in this project that the time spent preparing for and analysing studies, was greater than time spent performing them.

Once I was familiar with the concepts in NVivo, I was able to use its modelling software to produce a large complex model showing the hierarchy of the groups of codes, making it possible to trace how each code was sorted. A complex model created to show the analysis and consolidation of codes can be seen in Figure 4.8. on page 41.

As a consequence of this data analysis task I have am more confident and competent in the analysis of qualitative data and have interpreted the findings of the analysis. Experience of qualitative data analysis is a valuable skill, one that may prove useful in my future career.

### **7.2.3 Card Sorting, Consolidation and Producing Heuristics**

After analysing the interview data there were 41 codes on which to base the heuristics. It was necessary however to sort these codes into logical groups to make producing a manageable number of heuristics less complex.

To sort the codes a card sort was used. The card sort involved a number of participants sorting cards, each representing a code. I was quite confident of my ability to successfully perform the card sorts with participants, I invested a considerable amount of time into preparation for the sorts, creating the cards, researching the technique and arranging meetings with the participants. I also learnt to prepare for documentation of the sorts by numbering each of the cards for quickly recording the groupings and taking a photograph of the sort in case the data was lost and to record the proximity of the groups. In preparation for the card sorts I consulted a number of resources regarding the proper procedure, but also for guidance on the interpretation of the results. Using a card sort analysis template I learnt how to use the card sort data to produce meaningful groups, part of this process required the consolidation of the groups. The consolidation of codes was the most difficult stage in this process; it required me to use my knowledge of the grouping and the card sort process to give standard names to groups which

appeared to be of the same concept. There were no rigid guidelines for this part and required me to trust my own interpretations and decisions, I was nervous of this at first with the rest of the procedure being quite structured and controlled but several revisions of the groups reinforced my confidence in the decisions.

If I were to perform a card sort in the future I would be confident of my ability to do so and would change little if any of the process.

Having the 41 codes sorted into 6 groups, the next step was to create heuristics in the form of questions designed to test how a device fulfils each particular need of the user. At the start of the project it was unclear exactly how I would create these questions, this was an intimidating point to work towards and I was somewhat nervous of this unknown. As the data was analysed and sorted however, by studying the grouped codes it was clear that it would be possible to create questions within each group to address the concerns raised by one or more codes. Questions were at first created to address one code within a section, the question was then re-worded to address another code if possible; the other groups were then addressed in this way. It was satisfying to watch the problem unravel as more questions were produced and the number of codes to be addressed grew smaller; after all the codes were included it was a wonderful feeling to draft the first version of the heuristics.

Creating the heuristics v1.0 was a major milestone in the process and it was exciting to see the process produce the guidelines that had been in planning for several months.

#### **7.2.4 Empirical Studies**

After creating the version 1 heuristics, it was beneficial to develop the questions further. In order to do this they were tested using a pilot study to discover immediate and obvious problems with the applicability and wording of the questions. I designed a study in which participants performed a heuristic evaluation of their own mobile phone using the v1.0 mobile device heuristics. I did not find creating, preparing for and documenting the study as difficult as I anticipated, but it still required a great deal of planning and thought. Along with the heuristics questions, the participants were given standardised instructions; these were carefully thought out to minimise the help they needed to complete the task. Each evaluation in the study was arranged and performed separately with 6 participants. The pilot study was the second test I

performed involving a number of participants, the confidence gained from the card sorts helped this process. Seeing other people use the heuristics for the first time on actual mobile devices was quite rewarding, and the feedback I received was informative and positive.

Based on the feedback results from this pilot study, the heuristics were revised to version 1.1. There were some questions that in practice were not easily answered and some that were worded ambiguously, these were changed along with some restructuring of the questions and version 1.1 of the heuristics was created. It was enjoyable at this point to get some user feedback and new opinions on the project. I had anticipated some of the problems encountered by users in the tests but most I had not.

In order to ascertain whether an evaluation using the heuristics could produce meaningful results, I conducted a comparative study of two mobile phones. The devices selected were of the same age, the Motorola V3i and the Samsung D600. Both happened to be devices I had access to and deemed interesting subjects for the study because of their similar age and features, but different form factors and interfaces. These devices are examples of how each manufacturer had tackled the problems of condensing a complex computer with cameras, wireless transfer etc. into a handheld device. It would have been preferable also to perform comparative studies on portable media devices such as the iPod and Zune, PDAs and contemporary smart phones such as the iPhone but due to a lack of access to these devices at the time, this was not possible. Although it is disappointing not to have performed studies on these devices, I was pleased with having performed the study on the mobile phones and with the results from the study.

The study itself was again arranged and performed with separate participants, the methodology in this study was very much more structured than the first, with each participant having to use each phone to complete set tasks. These tasks were created in order to explore the functionality of the phones and to give a good overall idea of the user interface and its navigation. Although these tasks gave the participants a good general experience of the phones, I believe that the studies would have provided better results if participants had more time to familiarise themselves with the devices, perhaps using them over a longer period of time to get a feel for what it means to live with the device. The interpretation of the data from the

study was quite difficult, or rather how to present the information in an accurate way that allowed visual comparison. Early attempts were not representative of the nature of the data but with guidance from my supervisor I was able to present the information as a series of line charts on which were plotted the average answer of each question in a given section of the questions. It was satisfying to see the comparison charts adding a visual aspect to the results and more substance to the project.

I have demonstrated that the heuristics themselves appear to be usable, after the comparative study of the heuristics users were found to have no problems answering the questions. By examining the results of the study I was able to conclude that in an evaluation using the heuristics, the Motorola V3i is rated more usable than the Samsung D600. From personal experience of using both these devices for a period of time I was not surprised at the result from the study and indeed the result increased my confidence in the heuristics. It is a concern however that there is no structured method to collect comments made by the participants in relation to the devices, perhaps addressing topics that aren't covered by (at least this version of) the heuristics. This valuable qualitative information may be lost if not properly recorded. This may be addressed in the method of the evaluations rather than the heuristics themselves; perhaps a short interview may provide some more insight. How these insights could be integrated with the results from the heuristic evaluation in terms of the line charts is uncertain and open for discussion, although the method for displaying the results may vary from study to study, the line charts are useful for comparing sets of data but may not be suitable in a study of a different nature.

I have conducted a vaguely similar smaller study before this project, but never one in which I was solely responsible for the questions posed and data gathered. The experience gained preparing for, conducting and documenting these studies was both interesting and valuable, the techniques and experiences I have learned could be applied directly to studies I may conduct in the future. I have a better idea of the timescale required for the preparation, execution and analysis of such a study. In both studies a conscious effort was made to ensure that each participant was given exactly the same information and the process completed was as similar as possible. If I were to perform this type of study again I would use a larger number of participants, I felt that the 3 participants in the comparative study was not ideal but it

was not possible to complete any more at the time, the recommended range for a heuristic evaluation is 3 - 5.

The results from the comparative study were encouraging, and I felt an amount of satisfaction and relief to see the heuristics producing meaningful results after such a long and difficult process.

### **7.2.5 Documentation & Project in General**

The writing of this report is the largest and most demanding technical document I have undertaken. In the process of writing this report I have learned how to explain the processes of my work and present these explanations in a structured way, by efficiently using the tools available. Though I have certainly had experience with office software, (Microsoft Word XP and in latter stages Office 2007) writing this report however has given me the opportunity to use some of the features of the software that I had not previously made use of. An example is the internal labelling and referencing feature, allowing the addition of captions and numbers to figures and tables. This automatically updates numbers and makes it easy to insert references to objects. Knowledge of these features will be very useful when producing future documents.

When first trying to document the work I had completed, I found it difficult to include the level of detail required and the reasoning behind some of my decisions. Through practice I found it useful to ask myself questions about the work and try and answer these in order to show my working out, e.g. why have I done this? How have I done this? And what will I do next? I have as a result of this become better at documenting and explaining my work and critically analysing what I have produced.

This project has been produced with the best of my knowledge gained from my education at Napier University, gleaned from relevant modules. I am however still a student of the topics I have addressed in this project and have much to learn on these before acquiring all the knowledge on the subject, if such a thing is possible. As far as user experience is concerned I have just scratched the surface of a field that is constantly changing and whose scope has not been fully discovered. I shall continue to pursue my interest in the fields of usability and user experience with the hope it shall enlighten some of the designs I may create in the future. The mobile world too is rapidly expanding with advances in technology and as demand to carry

the world in your pocket increases, it seems that mobile technology is a field I shall inevitably be involved with in ways I may not yet imagine.

The time available to complete this project at first seemed extensive but as the time available was broken down and measured against the work to be completed it was soon apparent that time was valuable and very quickly diminishing. Even when seemingly trivial tasks were timetabled, the notion of Parkinson's Law seems quite valid, "*Work expands so as to fill the time available for its completion*". It has however surprised me as to how productive I can be with the right motivation or if time demands it; often however the anticipation of the end result was more than enough motivation. The experience of planning a (in my view) large project like this has been valuable, I feel I am better able to estimate how much work such a project requires and the relevant timescale needed to complete the work to a certain standard. These skills are essential in order to perform well in a professional environment.

It would be possible to continue the development of this project over the same period of time again and no doubt more; the project at its current state however is as complete as time and scope has allowed. Because of this I have mixed feelings towards the outcome of the project, I am very proud of the effort I have put into this piece of work and indeed its result but am also slightly disappointed not to have developed and tested the heuristics even further. Nonetheless I am rather proud of and pleased with the outcome of this report as a technical exercise and a journey. I have invested many hours of effort in this project and it has been very rewarding to see the outcomes in the form of the heuristics and the results of the studies and also to see the project's completion.

## 8 Conclusion

The sudden ubiquity of mobile devices and mobile phones in particular creates some concerns with the usability of these devices, especially considering the considerable technological advances in recent years; meaning our mobile phone is no longer simply a tool for making a phone call. The explosion of functionality in these devices is staggering and with one device trying to be many devices it runs the risk of being none of these. Evaluating how well devices juggle these multiple personalities is a complex task, but this paper has attempted to provide one tool of many to help designers test the usability of their devices. A more specialised tool developed specifically for the job. The result of this is the mobile device heuristics v1.1.

This project has at the very least shown that heuristic evaluation could be a valuable tool in evaluating the usability of mobile devices. It has explored the creation of an entirely new set of heuristics specifically for mobile devices, based on research rather than existing heuristics and is the first attempt at this I have seen.

The mobile device heuristics were created from users observations and with a mind to evaluate how devices fulfil their needs. They take into account the physical device and how users interact with the device as a whole, not only the elements on screen. A large amount of qualitative data was gathered from the analysis of interviews with users of PDAs. This data was refined and distilled through a process of card sorting with multiple participants, to ensure the codes identified in the data were grouped in a way that made sense to the users. The grouped codes were then consolidated into 6 categories which formed the basic structure of the heuristics. Within these 6 categories questions were created to address all the codes within each category. The first draft of heuristics was then tested with a pilot study and refined according to the study's results.

The more extensive comparative study of the Motorola V3i and the Samsung D600 using the heuristics was successful and produced meaningful results which were presented for comparison and analysis in the form of line charts. Although the heuristics were produced from data gathered on the use of PDAs it has been shown

in the pilot study and the comparative study that they are capable of evaluating mobile phones, a platform on which they were not based but one which they have been designed to accommodate. It is logical then to assume that the heuristics performance could be improved across all mobile platforms if data were gathered from users of mobile phones, portable media players, smart phones and portable email devices.

Although I was able to draw conclusions from the comparative study, the findings of the heuristic evaluations however have not been validated as true usability problems and it is not clear how this would be achieved. The results of the heuristics appear to be relevant and useful however confirmation of this may come from their use by professionals. These professionals would use them in a process to develop mobile devices; as an evaluation tool to improve a prototype.

Of the 3 research questions posed at the start of the project, question 1 and question 2 have been answered, question 3 however has not. This can be used as a measure of the projects success. From the analysis of these results discussed in section 7.1 we can conclude that the project has been successful in creating heuristics for mobile devices and also proving that someone can use the heuristics to evaluate the usability of mobile devices. The project has not addressed however whether these heuristics are better than existing methods. The standard to which the heuristics are to be measured is also not clear; it would seem sensible to compare their results with that of Nielsen's heuristics but it is debatable if the results can be compared.

In light of the points considered, the creation of heuristics for the evaluation of mobile devices to an extent has been a success. The guidelines however are in need of further testing and revision to prove and improve their validity and usefulness. This project has created a point on which to build and shall hopefully inspire some thought on the subject of creating usability evaluation methods for complex modern mobile devices.

In the expanding area of mobile technology the rapid ubiquity and technological development of the mobile phone poses some interesting questions and problems, how we interact with these devices and how we shall interact with future devices is an interesting cause for thought.

## 8.1 Further Work

If the scope of this project were larger, the timeframe more extensive or if further work were to be undertaken on this subject; there are a number of points I would recommend.

The creation of the mobile heuristics in this fashion would benefit from a range of interviews as a source of information, interviews concerning more types of mobile devices such as mobile phones, portable media players and smart phones.

A possible source of information that may prove useful may include intelligence gathered through the ethnographic study of users of mobile devices. Nielsen (2001) makes the point "*pay attention to what users do, not what they say*", this concerns the argument that users may not know what they want. An ethnographic study may learn better what problems users have although it may prove impractical.

Perhaps a more useful way of testing the heuristics (as an extension of the 2<sup>nd</sup> study) would involve giving the participants one of the devices and asking them to complete the tasks at intervals during their normal day, possibly through notification by text message, phone call etc. The participant would then at the end of their day, complete a heuristic evaluation of that device and give notes to the researcher. This method would be repeated another day with the second device. Testing in this way (if practical) may give a more realistic result, as people use their mobile devices in different locations and times.

Given more time it may have been valuable or at least interesting, to create a web application that would allow people to evaluate their devices online and compare them to others. Over time this application would collect evaluations on the same phones and develop a large amount of data on these. i.e. every time a user evaluates a V3i, their ratings are added to the V3i average. As other devices are evaluated their scores are added to the charts for comparison.

## References

- Apple Inc (2008). iTunes Now Number Two Music Retailer in the US. Retrieved March 6 2008 from <http://www.apple.com/pr/library/2008/02/26itunes.html>
- Dion, K., Berscheid, E., Walster, E., (1972). What is beautiful is good. *Journal of Personality and Social Psychology* 24 (3), 285-290
- Doubleday, A., Ryan, M., Springett, M. & Sutcliffe, A. (1997). A comparison of usability techniques for evaluating design [Electronic version]. Proceedings of the conference on Designing interactive systems: processes, practices, methods, and techniques. Amsterdam
- Form factor. BusinessDictionary.com. Retrieved November 24, 2008, from BusinessDictionary.com website: <http://www.businessdictionary.com/definition/form-factor.html>
- Hassenzahl, Marc (2004). The interplay of Beauty, Goodness, and Usability in Interactive Products, *Human-Computer Interaction*, 19:4, 319 – 349
- Hormby, T & Knight D (2007). A History of the iPod: 2000 to 2004. Retrieved February 29 2008 from <http://www.lowendmac.com/orchard/05/origin-of-the-ipod.html>
- Hormby, T. (2006). The Story Behind the Sony Walkman. Retrieved February 29 2008 from <http://lowendmac.com/orchard/06/sony-Walkman-origin.html>
- ISO (1998). ISO 9241: *Ergonomic requirements for office work with visual display terminals (VDTs) - Part 11: Guidance on usability*. International Organisation for Standardization. Geneva, Switzerland.
- Kahney, L. (2002). Apple's Newton Just Won't Drop. Retrieved March 6 2008 from <http://www.wired.com/gadgets/mac/commentary/cultofmac/2002/08/54580>
- Kairer, R. (2006). Palm Pilot 1000 Retrospective. Retrieved November 4 2008 from <http://www.palminfocenter.com/news/8493/pilot-1000-retrospective/>
- Lang, T. (2003). Comparing website usability evaluation methods and learnings from usability evaluation methods. Retrieved April 10 2008 from [http://www.peakusability.com.au/pdf/website\\_accessibility.pdf](http://www.peakusability.com.au/pdf/website_accessibility.pdf)
- Lindgaard, G (2007). Aesthetics, Visual Appeal, Usability and User Satisfaction: What Do the User's Eyes Tell the User's Brain? *Australian Journal of Emerging Technologies and Society* Vol. 5, No. 1, 2007, pp:1-14
- Litchfield, S. (2000). The History of Psion. Retrieved February 21, 2008 from <http://3lib.ukonline.co.uk/historyofpsion.htm>.
- Maurer, D. (2008). Card Sort Analysis Spreadsheet. Retrieved October 29 2008 from [http://www.rosenfeldmedia.com/books/cardsorting/blog/card\\_sort\\_analysis\\_spreadsheet/](http://www.rosenfeldmedia.com/books/cardsorting/blog/card_sort_analysis_spreadsheet/)
- Miller, P. (2008). Sony debuts A820, A720 and S710F series Walkman players in the States. Retrieved March 6 2008 from <http://www.engadget.com/2008/02/26/sony-debuts-a820-a720-and-s710f-series-Walkman-players-in-the-s/>
- Mobile Life (2008) Mobile Life Report 2008: The Connected World. Retrieved

December 1 2008 from <http://mobilelife2008.co.uk/>

MobileTechReview (2005). PDA Reviews: Palm T|X. Retrieved November 4 2008 from <http://www.mobiletechreview.com/Palm-TX.htm>

Multi-Touch Technology (2007). iPod Touch. Retrieved March 13 2008 from <http://www.multitouchtechnology.com/ipod/ipod-touch/>

Nielsen Norman Group (n.d.) Strategies to enhance the user experience. User Experience – Our Definition. Retrieved May 7 2008 from <http://www.nngroup.com/about/userexperience.html>

Nielsen, J. (1993). Usability Engineering. Boston: Academic.

Nielsen, J. (2002). First Rule of Usability? Don't Listen to Users. AlertBox. Retrieved November 25 2008 from <http://www.useit.com/alertbox/20010805.html>

Nielsen, J. (2003). Usability 101: Introduction to Usability. Jakob Nielsen's Alertbox. Retrieved April 24 2008 from <http://www.useit.com/alertbox/20030825.html>

Norman, D. A. (2002). Emotion and design: Attractive things work better. *Interactions Magazine*, ix (4), 36-42 [Electronic version] retrieved April 24 2008 from [http://www.jnd.org/dn.mss/emotion\\_design.html](http://www.jnd.org/dn.mss/emotion_design.html)

Nuance Communications (2007). Learn To Use T9®. Retrieved March 13 2008 from <http://www.t9.com/learn/>

QSR International. (2008). Product Overview. Retrieved October 26 2008 from [http://www.qsrinternational.com/products\\_nvivo.aspx](http://www.qsrinternational.com/products_nvivo.aspx)

Ricker, T. for Engadget (2007). Can Apple Meet iPhone Demand? Retrieved March 13 2008 from <http://www.engadget.com/2007/07/03/can-apple-meet-iphone-demand/>

Sheils, M. (2003). A Chat With The Man Behind Mobiles. Retrieved February 23 2008 from <http://news.bbc.co.uk/1/hi/uk/2963619.stm>.

Sony (n.d.) Corporate History. Retrieved February 29 2008 from <http://www.sony.net/SonyInfo/CorporateInfo/History/history.html>

Spencer, D. (2004). Card sorting: a definitive guide. Retrieved October 19 from [http://www.boxesandarrows.com/view/card\\_sorting\\_a\\_definitive\\_guide](http://www.boxesandarrows.com/view/card_sorting_a_definitive_guide)

The Gadgeteer (1998). Palm III Hands on Review. Retrieved November 4 2008 from [http://the-gadgeteer.com//review/palm\\_iii\\_review](http://the-gadgeteer.com//review/palm_iii_review)

Tognazzini, B. (2007). The iPhone User Experience: A First Look. Retrieved March 13 2008 from <http://www.asktog.com/columns/070iPhoneFirstLook.html>

Tractinsky, N., Katz, A. S., & Ikar, D. (2000). What is beautiful is usable. *Interacting with Computers*, 13, 127–145

Weekend America (2007). Father of the Camera Phone. Retrieved March 6 2008 from [http://weekendamerica.publicradio.org/programs/2007/01/06/father\\_of\\_the\\_camera.html](http://weekendamerica.publicradio.org/programs/2007/01/06/father_of_the_camera.html)

## Appendix 1 - Project Overview

## Appendix 2 - Second Formal Review Output

## Appendix 3 – Project Management

## Appendix 4 – Evidence