CHAPTER 1
POSSIBILITIES

OVERVIEW

KEY POINTS

- 'Mobile' means more than 'mobile phone': handhelds, wearables, badges, RFID tags and even implants will play an important part in the future.
- The emerging technologies offer interesting interaction possibilities involving audio, touch and gestures.
- There are competing visions of what mobiles should do and be – are they for communication or information? Fashion or utility?
- While some feel that these small devices have 'impoverished interfaces' the bigger problem is the impoverished designs being developed.
- Interaction design is about finding the right ways to deploy the dazzling new technological capabilities to meet real user needs.
- Without effective interaction design, there will be negative emotional, economic and ethical impacts.

1.1 INTRODUCTION

For two billion people, the mobile phone (or 'cellphone') is an essential part of everyday life. It's a business tool to clinch important deals; a 'remote control' for the real world, helping us cope with daily travel delay frustrations; a 'relationship appliance' to say goodnight to loved ones when away from home; a community device to organize political demonstrations.

This most pervasive of devices has been used in times of great tragedy and personal loss – who can forget reports of poignant emergency last calls and texts; in joy and excitement; and, more banally, in many simple moments of commuter boredom. It's a device that is truly a *personal* technology, helping people to feel safer, less lonely, more human.

The statistics associated with the uptake and use of mobile phones are staggering. Many European countries have a penetration rate approaching 100% and, in places like Italy and Finland, it's not uncommon to find people who have several handsets. Mobile ownership certainly outstrips personal computer ownership dramatically, despite the technology being relatively new. While in 1993 there were fewer than 10 million subscribers worldwide, by mid-2003 there were 10 times this number in China alone. In the same year, on average, Singaporean users sent and received over 200 text messages a month, contributing to the worldwide traffic of many billions of text messages monthly.

BOX 1.1 HOW TIMES HAVE CHANGED

While today, anybody and everybody, at least in the Western world, can be a mobile user, things were very different half a century ago, as Jon Agar notes (Agar, 2004):

In 1954, the Marquis of Donegal heard that the Duke of Edinburgh possessed a mobile radio set with which he phoned through to Buckingham Palace – and anyone else on the network – while driving in London. The Marquis was more than a little jealous, and enquired of the Postmaster General whether he, too, could have such a telephone. The polite but firm reply was 'no'. In the mid-1950s, if you were the husband of the Queen you could have a mobile telephone connection to the public network. But if you were a mere marquis, you could go whistle. ■

Despite this satisfying success story, there have been some disappointments in the way other aspects of the mobile market have developed over recent years. While the first quarter of 2005 saw a further 180 million-plus telephone handset sales, *just* – the 'just' emphasizing how spectacular telephone sales were – three million people bought a handheld computer. On top of this, the mobile telephone industry's pleasure in money made from basic services is tempered by unenthusiastic consumer responses to some advanced devices and services. Even with a great deal of marketing, early attempts to convert users to technologies such as WAP, video calling, and a whole host of mobile payment schemes, flopped.

Why are basic mobile devices (phones) and services (voice and messaging) so successful, while the uptake of the more advanced gadgets and applications is frustratingly sluggish? Answer: the former meet basic human desires in simple, direct ways.

So, what's the trick to spotting and developing successful future mobile user experiences – ones that really connect with what people want, and operate in straightforward, satisfying ways? Answer: interaction design, the focus of this book.

As a practice, interaction design owes much to the long-established discipline of Human–Computer Interaction (HCI) and the associated usability industry. Through the efforts of researchers and practitioners, over the past several decades, methods, tools and techniques have evolved to help designers identify the needs of their users and to develop systems that support their goals in effective and efficient ways.

Interaction design, though, extends the mainstream practices. It goes further, being concerned more about crafting a poetic 'customer experience' rather than prosaically delivering 'ease-of-use' (Thomas and Macredie, 2002). As an interaction designer you have to have passion and heart: whereas usability is often seen as a privative – something you notice only when it is not there – interaction design is about making a statement.

Terry Winograd, a pioneer of HCI, compares interaction designers to architects. The job is about building spaces – or, as he dubs them, *interspaces* – for people to coexist and communicate (Winograd, 1997). Now, think about some of the great buildings around the world – wonderful cathedrals like St Paul's in London or Gaudi's Sagrada Familia Church in Barcelona, and dazzling modern-day constructions like the Guggenheim Museum in Bilbao. Or consider more private places – your favorite holiday retreat and home itself. The architects of these buildings clearly thought about how to make sure they are workable and functional, helping inhabitants carry out their worship, visits, jobs, holidays or domestic lives. But what makes these sorts of places truly successful is not just their basic 'usability'. These places inspire, excite, lift the spirits or provide comfort.

BOX 1.2 MOBILE LIFE

Over the past few years there have been many news media stories highlighting impacts of emerging mobile-phone based technologies on societies and individuals. Here are just a few examples:

'Photo lead in credit card fraud – A photograph taken by a quick-thinking passer-by on his mobile phone could help trace a gang of credit card fraudsters.' (*BBC News Online*, 19 September 2003)

'Don't smoke, light up a mobile phone, it's safer – The next time you feel the urge to indulge your craving for nicotine try lighting your mobile, not literally though. British psychologists say those desperate to kick their weed could soon resort to a small program on their cell phones or PDA which would display a series of dots on the screen. Looking at the flickering images, or conjuring up different mental pictures, can help stop ➤

cigarette cravings, claim scientists at the British Association's science festival in Salford, Greater Manchester.' (*The Economic Times*, India, 13 September 2003)

'Mobiles ''betray'' cheating Italians – A new survey published by Italy's largest private investigation company says that in nearly 90% of cases, it is the mobile phone which reveals or betrays extramarital activities.' (*BBC News Online*, 15 September 2003)

'U r sakd – Accident Group's 2,500 staff received a series of text messages on their mobile phones, telling them to call a number. There, a recorded message from the company's insolvency administrators at PricewaterhouseCoopers informed them that ''All staff who are being retained will be contacted today. If you have not been spoken to you are therefore being made redundant''.' (*Economist Magazine*, 5 June 2003) ■

This book is about shifting the mobile design perspective away from 'smart' phones, to people who are smart, creative, busy, or plain bored. Our aim is to help you to overcome the frustrations of the previous disappointing handheld 'revolution' by providing the billions of potential mobile users with future products and services that can change their (or even the) world.

In the rest of this chapter, we set the scene by first considering different perspectives on what mobile devices are, or should be. Then, we look at the evolving diversity of mobile interaction technologies. If you are a designer used to working with conventional interactive systems (say a website developer), you might feel the mobile environment is rather impoverished in comparison; we aim to alter your perspective.

While some might feel the technology itself reduces the range of user experiences, we believe the bigger problem is poor design choices; so, to end, we highlight some of the reasons for and implications of bad mobile design, hopefully motivating you to read the rest of the book.

1.2 WHAT ARE MOBILE DEVICES?

There's no doubt, then, that we are in the era of the mobile and will see an increasingly dazzling and sometimes bewildering diversity of devices and services. Indeed, if you ask the question 'what is a mobile?', even today, the answer isn't straightforward.

We could describe them in terms of the types of function they provide: some allow you to organize your appointments and to-do lists; with others you can create Multimedia Messages (MMS), a picture with a soundclip, perhaps, to send to a friend; many provide desktop-type applications – like word-processing – viewed through a small screen. Full-color games are possible with a range of handsets, and there's a potential market of medical devices that could monitor your vital life signs day by day. Of course, devices that allow many or all of such functions are possible, too.

EXERCISE 1.1 MY MOBILE IS . . . ?

Get a group of friends or colleagues to complete this sentence: ''*My mobile is* . . . ''.

What sorts of answer did you get? Classify them in terms of function (keeping in touch, checking the news, etc.), context of use (home, work, leisure, etc.), and emotional issues (attachment to the device, frustrations it causes, and so on). ■

Another way of distinguishing the different types of device is by form factor and the physical elements users can interact with. They range in size from handheld devices to jewel-sized sensors and badge-shaped displays. Most have physical buttons you can press and many have touch-sensitive displays. Then there's usually a stylus, cursor control pad or wheel for pointing to and selecting from the information displayed. Less conventionally, some devices are beginning to have position, movement and tilt sensors; even squeezing is being considered as an interaction method.

Some users are more attached to their mobiles than others. Most see their mobiles as an accessory they carry around – another portable object like a wallet or paperback book; in contrast, others, like the well-known 'Cyborg', Kevin Warwick, see the future of mobiles as lying *beneath* the skin, through the use of surgically implanted devices (Warwick, 2002).

BOX 1.3 IMPLANTING YOUR MOBILE?

An interview with Kevin Warwick

Kevin Warwick, professor of cybernetics at Reading University, UK, shocked the scientific establishment in the late 1990s by implanting microprocessor circuitry in his arm. Since that time, he has continued to experiment on 'upgrading the human' through implants.

MJ: Your use of implants, to many, seems at best hyper-futuristic, at worst quite strange. Will the types of approach you use ever become mainstream?

KW: I used to work for British Telecom [the major telecoms provider in the UK] and in the 1970s we were looking at mobile telephony, but the mainstream management view was that the technology would never be used pervasively. Now, 30 years on, everyone has a mobile.

MJ: So where are we with implants in development terms? ➤

KW: Well, implants are already used to help people overcome some disabilities – cochlear implants to help those with impaired hearing are good examples. For the more radical work – such as that we've pioneered to explore the possibility of people communicating directly using their nervous systems – we are many decades or more years off before it becomes widely viable.

MJ: . . . and when implanting technology does become easy, what will be the 'killer apps'? What will be the SMS of implants?

KW: Enhancing communication and relationships. My wife and I took part in an experiment where her nervous system and mine were directly connected with implants in each of us transmitting and receiving nerve pulses from each other. We'd just finished the 'official', independently observed test, when I felt a little pulse of electricity in my arm. I knew my wife was sending me a signal – it was a 'wow' moment. Imagine if we could move on from simple dots-and-dashes and send thoughts and feelings.

MJ: Some of the things you're proposing could be done without implants – think about a phone you squeeze, and someone else holding their device feels your touch. Why, then, are you so interested in embedding these devices into the body itself?

KW: Because I want to see how the nervous system accommodates, adapts (or rejects) the new possibilities. We know the brain is very good at adapting to new configurations – people who have suffered strokes, for example, can recover some of their abilities by the brain effectively rewiring itself. How, then, will the brain cope if we wire in extra sensors, providing it with new inputs – say, infrared – for instance?

MJ: This book is about mobile interaction design – for your special type of mobile device, what's the process you use?

KW: I'm a cybernetics professor – for me it is about fusing technology and humanity. So, unlike traditional human–computer interaction design, we are not 'user-centered': it is *not* all about the human. Rather, we think about how the technology and human can work together. We start, then, often by thinking about the technology and how to apply it to enhance the human experience. I think there's a big danger of focusing too much on what people think they want or need – sometimes, only when they experience a new technology can they articulate its value to them and help shape its development. Of course, we also work with a wide range of people who bring other perspectives, from bio-ethicists to anthropologists and neurosurgeons.

MJ: You see a positive future for implants, but is there a darker side to the technology?

KW: Of course you could construe all manners of frightening future scenarios: people with implants might get viruses – not biological but digital ones; hackers could tap into your nervous system, and so on. The constructive thing to do, though – and this applies to more conventional development – is to start thinking through the human and social implications from the start, designing in an attempt to ensure positive outcomes. ■

Wearable computing researchers are also beginning to see their devices as *part of* them, rather than *apart from* them. Take Thad Starner and his co-researchers at Georgia Tech. His team are developing wearable systems with tiny head-mounted displays embedded in a prescription set of glasses, a simplified keyboard and a backpack containing a fully featured computer (Starner, 2003). Less extreme wearables include wristwatch-come-web browsers and badges that are mini public information displays (Falk and Björk, 1999). (See Color Plate 1.)

For other devices, their mobility comes not from the people carrying them but by virtue of being embedded in a vehicle – car navigation systems are increasingly popular, and luxury models can offer small-screen, passenger Internet access systems.

In this book, there is an emphasis on handheld, small-screen devices like PDAs and mobile phones. However, many of the issues and ideas we discuss are just as relevant to the larger devices, like tablet-sized PCs, and the more diminutive ones, like tiny button-sized gadgets.

But let's not get carried away and overwhelmed by the range of devices, functions and application areas (dozens of new ones are being envisaged every day, after all). Let's step back and consider what users might want out of a mobile – the role they should play.

1.2.1 COMMUNICATION OR INFORMATION DEVICE?

Until the end of the 1990s, there were two types of handheld device that supported quite different sets of user needs. There were the mobile phones, for keeping in touch, and PDAs or handhelds, for information management.

Communication-oriented mobile devices have been around somewhat longer than the information-focused ones. Predecessors of modern mobile phones first emerged when Bell Labs launched its radio telephone service in 1946. Then, the devices were vehicle-bound, used by dispatch drivers, doctors and other emergency service personnel. Thirty years later, in 1975, Martin Cooper of Motorola was granted a patent for the cellular handset technology that has enabled mass use of wireless communications.

John Sculley first applied the term Personal Digital Assistant (PDA) in 1992 when talking about the Apple Newton, a hand-sized information organizer. However, small computer-like devices were widely available eight years earlier in 1984 when Psion launched the successful handheld Organizer. Over the 20 succeeding years, many other manufacturers, like Palm with its PalmPilot range and Microsoft with a 'pocket' version of its operating system, have entered the market, providing devices that have offered a range of information processing facilities from simple diary and contact management through to spreadsheet applications. Medical professionals, traveling salespeople, and others who have to spend a large part of their time away from a conventional office have been enthusiastic early adopters of these developments; indeed, there are even books – such as *Handheld Computers for Doctors* (Al-Ubaydli, 2003) – aimed at helping these users get the most out of their devices.

The barriers between the two mobile species began to break down from around 1997 onwards. Mobile phones started to offer access to web-like information using a variety of innovations, the best known being the Wireless Application Protocol – used in Europe and North America – and i-mode which dominated Japan. In addition, like all computing devices, their processors became faster and faster and their onboard storage capacities ever faster. To make use of such resources, manufacturers competed to provide additional features like diaries, games and even text editors. Some phones – the Communicator series from Nokia and the advanced Sony Ericsson devices are good examples – support many of the functions found in PDAs.

Meanwhile, as phones became more like PDAs, handhelds sprouted stubby aerials and gained wireless communication card slots, so users could communicate with each other, placing calls and sending text messages as well as connecting wirelessly with information services.

The trend, then, is clear: increasingly, people will be able to carry mobile devices that are both communication and sophisticated information devices. Indeed, many of the mobile devices people buy will have such abilities built in as standard. But will their owners actually use them both to communicate – by voice, messaging and other emerging services – and to manage and access information?

Lots of commentators certainly see a future full of satisfied handheld users, talking, messaging, playing games, and accessing the net. In a book about Nokia's approach to designing usable phones, Turkka Keinonen sees it this way:

Mobile phones used to be functionally direct replacements of their wired forebears. Now they have suddenly become platforms for entertainment and commerce and tools for information management and media consumption. (Lindholm *et al.*, 2003, p. 6)

Others, though, feel the research community and mobile industry are focusing too heavily on developing services that provide mobile users with 'content'. Richard Harper, an influential communications researcher, puts it this way (Harper, 2003):

. . . mobile devices will be first and foremost about offering users the ability to keep in touch with friends, family and colleagues, and that this will take precedence over technologies and applications that will offer information access and use.

He argues that the communication potential of devices has hardly begun to be tapped:

If one thinks about human communication in the [sic] general, one will note that exchanges between people are not all the same, as if a hello were the same as a summons, as if a whisper from a lover is the same as a bellow from the boss. Yet if one looks at current communications applications and protocols one will see there are few alternatives made available to the user, and people cannot vary the way they call their friends, partners or colleagues, except perhaps through the use of text.

EXERCISE 1.2 ENHANCING EXPRESSIVENESS

What features might a future mobile device have to help users express themselves more fully when communicating with another person in another location? Discuss the pros and cons of each proposal. ■

Harper worries that as people, in his view, will carry mobiles mainly for communication, the drive to provide information-centered products might have a damaging impact on the overall usefulness and acceptance:

Many information delivering services and products, for example, require larger screens than most current GSM devices do, and this may lead to expanding the form factor to a level that makes constant carrying difficult or at least irritating and burdensome.

Unlike others, then, Harper sees the brightest future of mobiles lying in a device that is specialized in providing users with ways to communicate, with revenues from such services vastly outselling the information-based ones.

1.2.2 APPLIANCE OR SWISS ARMY KNIFE?

Perhaps, though, the real issue is not whether mobile devices should focus mainly on communication or information processing. There is a broader concern – should one device try to do everything for a user or should there be specialized tools, each carefully crafted to support a particular type of activity?

This is the debate over the value of an 'appliance attitude' in mobile design. Should we focus on simple, activity-centered devices – ones that might well combine task-specific communication and information facilities – or look to providing a 'Swiss Army Knife' that has every communication and information management feature a manufacturer can pack into it?

Kitchen toasters have a simple purpose – to quickly tan pieces of bread, transforming them into something appetizing for breakfast. They are focused-function, easy-to-use appliances. Often, they are put to work with other appliances – a bread-making machine to provide a fresh, warm loaf in the morning; an electric carving knife for slicing pieces into just the right thickness.

In contrast, the Swiss Army Knife – a pocket-sized device with a set of retractable tools, from blades to tweezers – is not an appliance; it is trying hard to be a do-it-all, multi-purpose gadget. Don Norman sees it this way:

Sure, it is fun to look at, sure it is handy if you are off in the wilderness and it is the only tool you have, but of all the umpteen things it does, none of them are done particularly well. (Norman, 1999, p. 71)

Some techno-prophets, like Norman, foresee a future where the computer becomes less like a Swiss Army Knife and more like a toaster – a future where it evolves into an appliance; an information appliance, that is.

In Norman's vision, we will surround ourselves with many such devices, just as we currently fill our homes and offices with books, lights, notepads and picture frames. Each appliance will help users do a specific activity – like writing, their hobby, or communicating – and they will support these in simple, direct ways. The tools will also be able to effortlessly communicate with the others:

. . . use an appliance for one activity, then point it at a target appliance and push the 'send' button: whoosh, the information is transmitted to the other. (Norman, 1999, p. 52)

At first glance, the simplifying appliance attitude seems particularly well suited to small, mobile devices. Multitudes of features frustrate users even when they use a PC with a high-resolution display, full keyboard and mouse; in the mobile context, each additional function might be a further ingredient for disappointing user experiences. Then, there's the design liberation offered by the vision of devices working together. No need to worry that the handheld has a small display – just find a nearby large screen for a more comfortable read.

However, an important objection to this sleek simplicity is the possibility that users will be overwhelmed by the number of appliances they will need to support their everyday tasks. For mobiles, the problem seems even more pressing – just how many gadgets will people be able to carry around with them on a daily basis? Norman suggests that when traveling, there will be a preference for a Swiss Army Knife, all-in-one, computing device, such as a portable PC, trading off its convenience against lower usability.

It is probably too early to dismiss the notion of mobile appliances, though, and to assume people will only ever want to carry around one device. Look inside the bag you carry to work – it might well contain a book or magazine (a reading appliance), a phone (a communication appliance), pictures of your favorite people (a photo appliance) and a notepad (a writing appliance). Technological developments – making mobiles lighter, foldable and flexible – could make the appliance approach tenable.

Returning to the present, however, we see that most mobile devices are certainly not appliances; they are do-everything, solve-it-all, shrunk-down personal computers. Industry bodies, manufacturers and service providers don't appear to see this as a problem; indeed, all seem to be proud of the complex miniatures they are producing, convinced that users want to carry around one device to fit all the different tasks they face each day. Take this statement from the International Telecommunications Union, quoted in an *Economist Magazine* article, which discusses advanced, third-generation (3G) products:

The 3G device will function as a phone, a computer, a television, a pager, a video-conferencing centre, a newspaper, a diary and even a credit card ... it will support not only voice communications but also real-time video and full-scale multimedia ... It will also function as a portable address book and agenda, containing all the information about meetings and contacts ... It will automatically search the Internet for relevant news and information on pre-selected subjects, book your next holiday for you online and download a bedtime story for your child, complete with moving pictures. It will even be able to pay for goods when you shop via wireless electronic funds transfer. In short, the new mobile handset will become the single, indispensable 'life tool', carried everywhere by everyone, just like a wallet or purse is today. (Economist, 2004b)

The market has, though, shown some signs of appliance-flavored thinking with devices which are optimized for particular types of activity. The BlackBerry, for instance, is focused on keeping professionals in touch with their email and important data. Meanwhile, several phone manufacturers are producing entertainment-style appliances, optimized for image capture, games and music enjoyment. The notion of using mobile devices together with other pieces of technology is also being put into practice – for example, there are set-top boxes to receive data from mobile phones and display it on the television screen.

Of the two early and classic handheld computer types – Palm's PalmPilot and Microsoft's Windows CE/PocketPC devices – the former had a greater appliance feel to it, supporting frequent short bursts of activity, such as looking up a telephone number or jotting down a note. The instantaneous, unobtrusive qualities that characterize information appliances were pursued throughout the product's development (Bergman and Haitani, 2000). Meanwhile, the Microsoft approach has tended towards replicating the flavor of their desktop products in shrunk-down form; as one of the designers puts it:

Windows is installed on a great number of PCs, both in the office and home environments. It makes sense to leverage familiar design in new emerging platforms. (Zuberec, 2000, p. 128)

While there is limited evidence of appliance thinking in the commercial world, research labs are testing a range of possibilities. Consider, for example, Cameo, designed for professionals who take care of elderly people living independently in the community (Andersson, 2002). The device supports six functions, including handling of alarm alerts sent from the carer's clients, taking photos of the client's environment to inform the wider care team, and a memo recorder.

1.2.3 CHERISHED DEVICE OR COMMODITY TOOL?

Most users have very little emotional attachment to their toaster or dishwasher – they are, after all, just appliances: tools to get a job done. Lots of mobile users, though, really care about the devices they carry around with them, their choice of device reflecting something about who they are, or want to be.

Designers have recognized this, particularly in the styling of the physical features of the devices they build. As an extreme example, take Vertu, which markets itself as a luxury mobile communications company. It handcrafts handsets using precious metals, jewels and distinct design. Such attention to detail comes at a price – in 2005, their range retailed at between $9000 and $30 000 (Vertu). The company's products appeal to those concerned with making an *haute-couture* statement that they feel reflects their high status. In contrast to the short life most mobiles have, the company expects people to hold on to their expensive model for many years, valuing them as they would a precision-made watch. The phone is engineered so that new developments in technology can be accommodated without having to dispose of the handheld entirely.

It seems that the biggest challenge watchmakers at the higher end of the business face today is to sustain the emotional attachment people have for their watches. There are hints that many people could (or already have) become just as emotionally attached to their sleek new GPS-enabled, tune-playing, video-showing, time-managing camera-phones as they once were to their wristwatches. (Cukier, 2005)

Right at the other end of the market are the disposable phones. Just buy it, use up the pre-paid credit and throw it away. These phones are simple and functional, with the only user interface being a touchpad for dialing calls.

Between Vertu and the throwaways, there are many mainstream devices designed with an eye to image, style and fashion. One of Nokia's early imaging phones (the 7600) was marketed on its website in this way:

Introducing a bold icon for the age of mobility. The distinctly new-paradigm Nokia 7600 imaging phone is a synchronous blend of torqued curves and the latest technology. It's compact, futuristic, and conveniently contoured to fit your palm. (Nokia, a)

BOX 1.4 **JUST ANOTHER TOOL? PICK-UP-AND-USE MOBILES**

Not all mobiles are well-loved, personal devices with one long-term user who wants to personalize and adapt it to suit their specific needs and image. Some are mobile equivalents of familiar walk-up-and-use technologies like cash-dispensing machines and public transport ticket vending devices. ➤

FIGURE 1.1

MyGROCER showing small screen display attached to shopping cart

An obvious place for these pick-up-and-use technologies is supermarkets. The MyGROCER system (Kourouthanasis and Roussos, 2003), for example, illustrated in Figure 1.1, uses a PDA-type device built into a shopping cart, helping the user navigate to grocery promotions and to keep track of their purchases. Less sophisticated versions of this approach are now in common use in supermarkets around the world. Researchers have also taken mobile systems into museums and art galleries, with visitors being handed devices to use for the duration of their visit. ■

1.3 IMPOVERISHED OR EXTRAORDINARY INTERFACES?

It is all too easy to despair at the seemingly limited interaction abilities a mobile device has. The tiny, fiddly keypad; the low-resolution, small screen – surely, such input and output technologies will always mean these devices will be the impoverished relations of the richly expressive desktops? If you are a designer who has worked with conventional technologies – perhaps used to producing slick websites for large-screen viewing – you might well feel handhelds offer you little room to develop creative interactions your users will find fulfilling.

This sort of thinking needs to be challenged. The much-reduced physical size of the devices does seem to be a big limitation on the possibilities for rich interaction, but there are technology developments that will allow designers to effectively address the mobile context.

While we emphasize the importance of understanding users throughout the book – their needs, capabilities and limitations – paradoxically, a look here at input and output technologies nicely highlights the importance of this human-centered style. We will see how insights into aspects of human nature, from basic physiology through to social protocols, can lead to more effective technologies for the device and user to communicate.

By facing the challenge to build extraordinary interfaces that go beyond the normal and expected, highly usable input and output approaches will emerge. Already, some interesting new ways of increasing the bandwidth between user and device have been demonstrated in research labs.

But let's begin by considering the two much-derided interaction 'failings' of small devices – their tiny keypads and Post-it note-sized screens. How can a small handheld device allow the user to interact in ways they are familiar with on their PC, that is, by pressing discrete keys to input characters and having a large display area? Two interesting technologies, the first a commercial design, the second coming out of a HCI research lab, illustrate imaginative ways of making up for the physical lack of space for a keypad and a display.

1.3.1 THE FASTAP KEYPAD

Standard mobile phones use the ISO keypad layout – 12 keys, 10 for the numbers 0–9, the other two for the characters * and #. Eight of the numeral keys also each have three alphabetic characters associated with them (e.g., '2' has 'abc' and '6' has 'mno').

Entering more than a few words with such a condensed keypad can be very laborious. The basic entry technique is called multi-tap. For each character, the user has to potentially press a key several times to select the actual input they want. For instance, entering 'CAN' would involve pressing key '2' three times for 'C', pressing it once again for 'A', and finally hitting '6' twice for 'N'. Clearly, such an approach slows a user down – one study, for example, showed that compared with a conventional keyboard, where people can achieve 60 or more words per minute (wpm), multi-tap reduces this sprinting pace to an ambling 21 wpm for experts (Silfverberg *et al.*, 2000).

Basic multi-tapping was enhanced significantly with the introduction of the dictionary-based, predictive text method patented by Tegic, known as T9. Users press keys just once and the system, using a dictionary lookup, presents the most likely word(s) as the input progresses. Silfverberg's comparison with multi-tap showed that it has the potential to allow a user to double their text entry speed to 40 wpm.

Instead of relying on user effort as in the multi-tap case, or the sort of clever software processing that T9 uses, the Fastap keypad manages to squeeze a full alphanumeric keyboard with 50 independent keys in a third of the space of a business card (Levy, 2002). That's 3.3 keys per square centimeter while other similar-sized keypads provide around 1.2.

The approach actually involves two keypads, one raised above the other (see Figure 1.2). The upper provides mainly for alphabetic input, while the lower provides for digits. The keys are positioned so each has a similar amount of space to a conventional, full-size keyboard, leading, it's claimed, to increased comfort. While users are typing, they do not have to worry about pressing a key exactly. If they hit several keys in one go, a technique called 'passive chording' allows the system to unambiguously work out what entry a user intended. In passing, note that *active* chording has been used for entering text while mobile, too. Here the user has to press *groups* of keys – a chord – simultaneously to enter text. The Twiddler (see Figure 1.3) uses 12 keys in its chording system, for instance.

Cockburn and Siresena (2003) wanted to find out how this new keypad compared with the text entry performance of multi-tap and T9 systems. They did this by carrying out a controlled, scientific experiment (we will explore this type of evaluation method and alternatives in Chapter 7).

FIGURE 1.2

Fastap keypad

The first time users tried the different methods, Fastap was the most successful. With Fastap, they could enter a text message at an average rate of 6.3 wpm; in contrast, not all could complete the task using multi-tap or T9 and the input rates dropped to 3.6 and 3.9 wpm, respectively. The technique had the advantage of requiring no training, and when users were asked about the schemes they were more satisfied with the novel approach. They also liked the 'modeless' style of data entry: that is, they didn't have to work in different ways depending on whether they were entering numbers or words. Modes in interactive systems are known to cause people difficulties. We will look at the issues of mobiles and modes in more detail in Chapter 8.

1.3.2 PEEPHOLE DISPLAYS

While the Fastap keypad makes the physical keypad seem much larger than it really is, the Peephole display does the same for a handheld's screen area. Instead of trying to clutter the small screen with information, with this approach the display acts as a small window – the peephole – onto a much larger display area (Yee, 2003).

The handheld is given positional sensors that tell the system where the device is, relative to the user. The user moves the device around, left and right, up and down, and as the position of the handheld changes, the display is updated to show another portion of the bigger picture. This virtual,

FIGURE 1.3

The Twiddler – active chording for text entry (Lyons *et al.*, 2004)

large-scale display might be showing a map, a list of names in an address book, or a figure the user wants to draw.

Figure 1.4 shows one of the prototypes in use, providing what is dubbed a personal information space. The user can move the device to view different parts of a sort of virtual desktop, with different applications and information being placed around the user.

1.3.3 ACCOMMODATING HUMAN CAPABILITIES AND LIMITATIONS

Sit in a café and watch how people interact with each other and the world around them. The PC's interface abilities, envied by handheld developers who see it as highly expressive, looks completely unsophisticated and simple in comparison. Yes, people do write things down for others to read – a waiter writing a bill, for example – and they show each other documents: "would you like to see

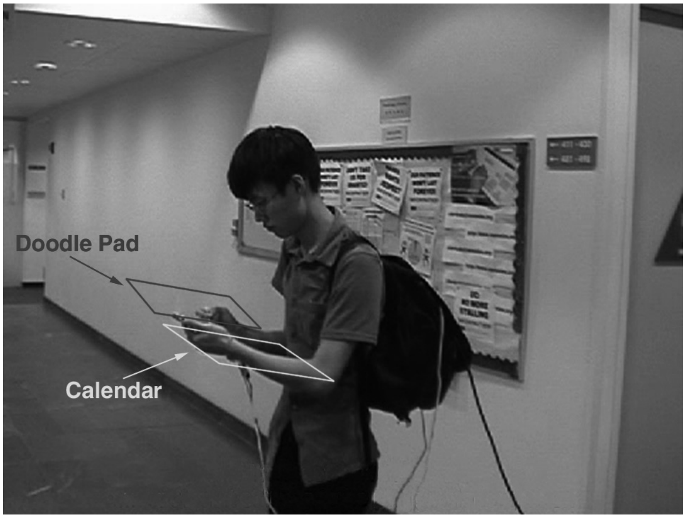

FIGURE 1.4

Peepholes in action – accessing a large personal information space via a small window. Image shows user operating a PDA. Moving the device to their right allows them to access a Doodle Pad application; to their left is a calendar application

the wine menu, ma'm?''. But much more nuanced interplays are occurring, too. ''Touch that bottle of red wine – is it the right temperature?'' ''What did my partner's sigh mean?'' ''Such a dramatic hand movement over on Table 5, what's going on?''.

Some HCI researchers have long wanted to endow the computer systems they envision with similarly 'natural' ways of communicating. Despite the ability of people to sense and express themselves in many ways, there's been a great deal of frustration with machines that can only respond to discrete inputs – on the whole, that means key pushes – and present information predominantly in a visual form, with a few beeps or, at most, a sequence of notes.

Handhelds are proving to be both an outlet and an additional motivation for novel interaction research – for these gadgets, advanced approaches are seen not as luxury added extras, but as necessities. Extending the repertoire of input and output forms – or modalities, as they are called – is seen as a way of allowing the user and device to communicate more completely and in ways that better fit with mobile demands. When someone is walking around a new town, hurriedly trying to locate a meeting place, they will probably want to pay attention to street signs, traffic and landmarks and not have to exert all their mental abilities on interacting with their handheld.

As we will see below, there is a wide range of developments in mobile interaction techniques that are trying to better exploit users' capabilities. Some address human auditory (hearing) abilities, others haptic (touch and movement sensing) abilities. Then there's increasing interest in exploiting people's gestural skills, such as the expressive movements users can make with their hands or head; and the ways in which users can deploy multiple means to express their needs are also being accommodated.

Auditory Interfaces

If you listen to a piece of music, your brain has the ability to accurately distinguish between subtle variations in the intensity, pitch, duration and quality (or timbre) of the notes you hear. For some time, researchers have explored using such cues to enhance the user experience, particularly in terms of the feedback an interactive system gives about the effect of something a user has done.

Auditory icons, such as familiar, natural sounds, were proposed by Bill Gaver to supplement visual cues (Gaver, 1989). A file dropped into the trashcan, then, would not only disappear but cause a metallic, crashing sound to be played. Moving a document over your desktop becomes more realistic as you hear a shuffling sound and see the icon shift position.

Earcons are also non-speech sounds but are synthetic, systematic sequences designed to convey structural information about an interface, such as what part of a menu hierarchy a user is currently perusing (Blattner *et al.*, 1989).

In the new, mobile context, the sophisticated hi-fi abilities of some phones are already important: many users enjoy downloading ringtone melodies and there are 'Top 10′ style ringtone charts that track the most popular. (In June 2005, a quirky mobile ringtone 'sung' by a frog topped the pop music charts, displacing Coldplay! The mobile's influence on everyday life continues to surprise.) But, from an interaction design perspective, auditory input–output is also very attractive.

Stephen Brewster and his team at Glasgow University, for example, are looking at additional interactive uses of the sound channel. In one experiment, he added earcons to the buttons in a PalmPilot calculator; when touched, each button made a distinct sound. This auditory feedback helped users enter data more effectively and they preferred the approach over the calculator that had mute buttons (Brewster, 2002).

The most expressive sounds that we humans make are, of course, those that convey language. So there's been a lot of interest in investigating effective ways to enable users to talk to their devices, using speech recognition techniques, and to listen to spoken output via speech synthesizers. While both recognition and synthesis systems can now produce reasonably high-quality results and can operate fairly robustly at the desktop, it is worth noting that the places people want to use their mobile devices and the sorts of input they want to make often present difficult challenges to the technology (see Box 1.5).

BOX 1.5 **THE TROUBLE WITH SPEECH**

Speech recognition and synthesis look natural choices for mobile interaction, but there are problems:

- **Noise.** Background noises of say a train or a busy street can still lead to severe degradations in accuracy and cause generated utterances to be misheard or missed altogether.
- **Spontaneity.** At the desktop, people might well want to express full sentences carefully, in dictation-style mode, but when on the move they are likely to utter ➤

spontaneous commands, requests and clarifications which could be full of difficult-to-handle content. This speech-in-action will contain lots of false starts and stumbles – ''umm ... when's my next ... no ... tomorrow's appointment'', for example – which people can handle easily but can cause recognizers to falter quickly.

- **Out-of-vocabulary words.** Recognizers rely on dictionaries, but words that people want to use in the street, including names of people and places – ''meet Jaydon at Te Papa'', for instance – might well not be in the lexicon. Similarly, accurate synthesis of such phrases is also difficult.
- **Cognitive burden.** Attending to speech consumes much of a user's cognitive processing abilities. Think carefully, then, about the situations where speech output is essential and limit the amount of information delivered. ■

One system that has tried to leverage the benefits of speech for mobiles and to address some of the problems is MIT Media Lab's Nomadic Radio (Sawhney and Schmandt, 2000). The system is really a sort of mobile messaging appliance, providing access to email, personal notes, calendar entries, news broadcasts and the like. Users don't have to grapple with interaction devices like screens or a keyboard; instead all of these services are accessed mainly through audio input and output. Voicemail and other audio-based information, like news summaries, are simply played to the user, but text-based information, like email, is first converted to speech using a synthesizer. There are also auditory cues to indicate events like message arrival and system breakdowns. A technique called spatialized audio gives the user the impression that different sound sources are coming from distinct locations around their head – news to the left, voicemail to the right, and so on. Meanwhile, speaking to the system – ''Go to my messages'', ''I am confused, what can I say?'' – is the way the user accesses information and controls the system's operation.

Haptic Interfaces

As you flick through this book's pages, your fingers will sense the movement of the pages, even the slight air movements the action generates. Using these inputs, you'll be able to approximate how near you are to the section you really want to read. Carry a stack of books from a library and your sense of touch will be supplemented by your abilities to perceive movements, such as beginnings of a topple, as the top books begin to slide out of your hands. Haptics, then, involve feedback from touch and movement sensors in the skin, muscles, the inner ear and some other organs. Mobile researchers have become increasingly interested in putting such capabilities to use.

Mobile phones have long had very simple haptic interfaces; instead of ringing and disturbing an important meeting, they can be set to 'vibrate mode' to provide discreet notification. This approach, though, can only communicate one 'bit' of information: the vibrations are either on or off, indicating that there is a call/message or not. In contrast, the TouchEngine vastly expands on this limited vibra-vocabulary (Poupyrev *et al.*, 2002). Sony researchers who developed the system were motivated by physiological experiments showing how sensitive and discriminating our sense of touch can be. We can notice two stimuli just 5 ms apart – or twice as fast as a blink – and can sense displacements on our palm as low as 0.2 microns in length, much smaller than a single pixel on a mobile phone display.

The TouchEngine uses a haptic actuator, set inside the handheld, to convert electrical signals into motion. With its added abilities, the mobile can give the user touch-based feedback by moving part of the PDA screen, or the entire screen. But what useful extra information can this device communicate?

Its inventors experimented with a range of possibilities, from notification of incoming calls to attempts to convey more complex information. Instead of simply telling the user there's an incoming call, the user can be given information about who the caller is, or the urgency of the call, by varying the rhythm, intensity and gradient of the vibration.

Another application that was tried was a tactile progress bar. While a visual progress bar – such as the one you see when waiting for information to download from the Internet – is useful when there is spare screen space and the user can give their attention to monitoring it, as on the desktop, its merits in the mobile case are less clear. As an alternative, then, the TouchEngine can present a tactile-based progress bar. The handheld emits short pulses, decreasing the period between each such 'click' the nearer the task is to completion.

A further prototype implemented a touch-based version of the paper-shuffling auditory icon mentioned earlier. The user tilts the handheld to view a map. As the map slides, instead of playing a sound conveying paper movement, the device generates a scratching tactile pattern that becomes a simple pulse when the edge of the map is reached.

Vibrations and force feedback will quickly become common, but there are examples of interfaces that go beyond providing feedback via touch and involve the user in touching, grasping and otherwise manipulating the device (Harrison *et al.*, 1998). The Gummi interface illustrates how very 'hands-on' interaction with computing devices could become in the longer-term (Schwesig *et al.*, 2003). The proposal is for devices that you can actually twist and bend to express your needs. Imagine a display you can grasp with both hands, one on either side of the screen, flexing it upwards and downwards to control the amount of zoom on a map or other document. To try the concept, the researchers combined a non-flexible TFT screen – the sort of display found on handhelds today – with touchpads on either side. The user squeezes the pads, simulating the sorts of bending movements that researchers envisage with future display technologies (see Figure 1.5).

Gestural interfaces

You can powerfully and quickly communicate by moving your hands, nodding your head, pointing a finger. Research into gestures, from simple movements of a device to complex head nods, promises to provide useful ways to enter information and control future commercial mobiles.

EXERCISE 1.3 GESTURES AND LARGE SCREEN INTERACTION

Imagine a large screen display that the presenter can interact with by using gestures. Instead of having to click a button or move a mouse, they control the information being shown using body movements; but what should those movements be? Design prototype gestures for the following types of control:

- Next slide
- Previous slide ➤

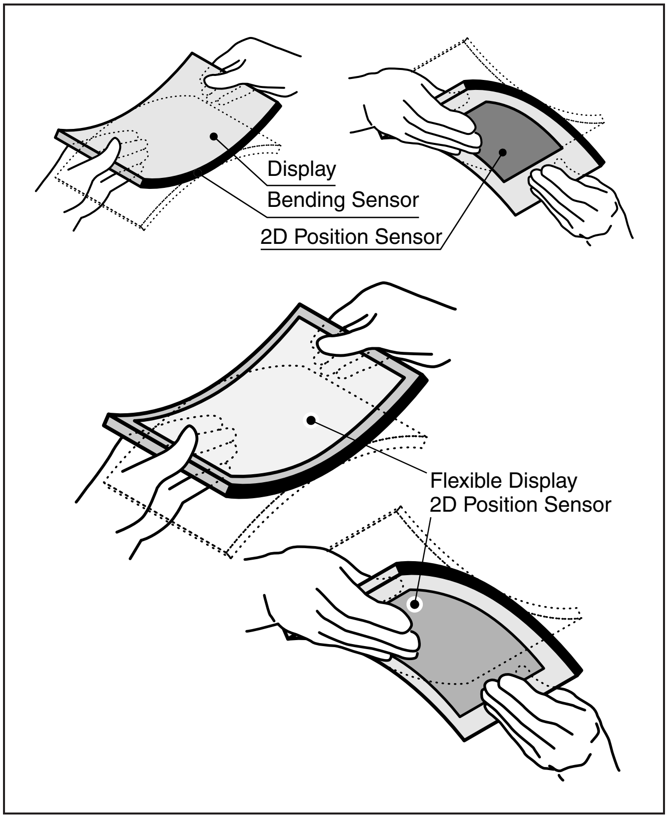

FIGURE 1.5

The Gummi interface – bend the display to interact

- Zoom in to magnify the display
- Zoom out to reduce the view
- Remove some information
- Remove the complete document from the display.

Think about the mapping between the gestures and the actions – do they seem natural? How does the system know when the presenter is giving it an instruction as opposed to simply gesturing to the audience?

Perhaps the most successful and best known gesture-like interfaces are those for text input and editing on handheld computers. The unistroke method (Goldberg and Richardson, 1993) and the

Graffiti handwriting technique used in the early PalmPilots are examples of approaches that use simple, distinct gestures, expressed using a pen stylus, for both alphanumeric characters and editing commands, such as deleting text or changing from lower case to upper case.

Stylus or finger-based movements can also control an application as well as being used to enter text. Examples of such approaches are seen in the SmartPad (Rekimoto *et al.*, 2003) and TouchPlayer (Pirhonen *et al.*, 2002).

SmartPad is for mobiles, with the basic push-button keypad being supplemented with a sensing grid that can detect the user's light touch, a bit like the touchpad mice used on some laptop computers. Pick up a mobile and sweep your finger across the keypad, to the left or right, or try a circular movement. These are easy to do, even one-handed, and if your phone is equipped with a SmartPad, those movements could be interpreted as a wish to view an alternative page of content – forward or back – or as a virtual jog-wheel control for scrolling through information.

The TouchPlayer, prototyped on a PocketPC-type device, gives the user eyes-free control of a music application by combining simple gestures and auditory feedback through the earcons mentioned earlier. If you want to skip forward to the next track, you move your finger to the right; to increase the player's volume you make a circular sweeping movement, like turning a knob.

In both prototypes, the use of gestures allows the designer to achieve two important things:

- Overcome the lack of physical space for input. The gestures avoid the need to add additional physical buttons or other controls to the device or clutter the limited screen space with buttons and other widgets.
- Accommodate the use-conditions likely with the devices. Mobile users are unlikely to want or be able to give their full attention to interacting with their devices. For example, many music players are used while people are jogging vigorously on a treadmill in the gym; their exercise experience will be affected if they have to try to concentrate on a small screen, locate a button or menu, and activate a function.

Moving up from these micro-gestures, the next type of gesture being researched involves the device itself. Here, tilt-based systems are important and have been used for both text, cursor and application control:

- **Text and cursor control**. In one tilt-to-write system, found to be almost 25% faster than multi-tap, different characters are selected depending on the positioning of the device (Wigdor and Balakrishnan, 2003). In another prototype, cursor movement is controlled by tilting. Incidentally, this system also embodies two increasingly important elements of mobile interaction design – fun and pleasure. The user experience is similar to moving a knob of butter around a frying pan: the steeper the tilt, the faster the cursor runs down the screen (Weberg *et al.*, 2001).
- **Application control**. Two of the systems we've already mentioned – the Peephole and the TouchEngine – allow users to interact by moving the handheld up and down and left-to-right for information viewing, such as scrolling through a list. In another experimental effort, Ken Hinckley and a team from Microsoft Research looked at an alternative application of movement. They were interested in finding a way to switch on a handheld's memo-recording function (Hinckley *et al.*, 2000). Many PDAs have a button, often on the device's side, that if pushed activates the recorder. Hinckley and his team thought about a way of saving the user the trouble of explicitly pressing 'record'. To do this they built a prototype that can recognize when the user intends to store a voice message. Using a number of sensors, such as one to measure the

handheld's proximity to other objects and others that indicate how the device is being held, the prototype is able to detect when the user brings the handheld up to their head, holding it like a mobile phone, and then starts recording. It's easy to imagine extensions to this sort of idea: move your music player to the center of your body, near your heart, and access your favorite playlist; or touch it on your leg and listen to the music you like to jog to.

All of the gestures discussed so far are small-scale ones – you would hardly notice someone performing them. If some research prototypes make it out of the lab and into the street, though, you might come across people who seem to be behaving rather strangely. These systems involve users in more extravagant, obvious movements to express their needs. Take, for example, one mobile system that uses nod-recognition to control selections from a menu presented through audio (Brewster *et al*., 2003). Like Nomadic Radio, via spatialized audio, the user perceives different sound sources coming from different positions relative to their head. To select a source, the user nods in its direction.

An evaluation of this system's usefulness showed that people were able to walk around and control the system effectively by nodding. The effort they put into interacting with the system, though, did slow them down – their pace slowed by nearly a third. This is a good reminder that interacting on the move will disrupt something else the user wants to do – you need to minimize the effort required to use your system.

While such schemes sound odd, with the potential to make users feel self-conscious as they walk down the street, you have to remember that little more than a decade ago, even talking into a phone in public would have marked you out as an eccentric. Now with hands-free headsets, self-talkers and gesturers are a common sight in all major cities.

BOX 1.6 AROMATIC OUTPUT?

An interview with Jenny Tillotson

Input and output based on vision, audio and even touch will be common and conventional in mobile devices. Our ability to perceive and respond to smell, though, has been relatively underexploited.

This paucity of investigation is being addressed by groups of researchers interested in aromatic output. Aromas have advantages, it's argued, of being highly evocative while also being unobtrusive – a form of interaction that fits well with the goals of ambient and ubiquitous computing. Aromatic output could enhance websites or games or, more banally, be added to calendar applications:

. . .pick up the children at 3.30 *. . . the aroma of baby powder wafts across the room at 3.00 p.m. as a gentle reminder of the upcoming appointment.* (Kaye, 2004)

Jenny Tillotson, a researcher at Central St Martin's College of Art, London, has been investigating the use of aromas in a mobile context since 1997. A fashion designer, ➤

she explores the integration of scent-output technologies with fabrics, leading to radical, wearable computers.

MJ: What motivated you to consider the use of smell?

JT: My main focus is wellness: how can technologies enhance physical and emotional well-being? Aromas are known to have calming and healing properties and I want to see if and how aromatic output can be triggered and generated using the clothes people wear.

MJ: Many researchers with a technology background are building 'wearable computers'. How does your approach differ?

JT: First off, I'm an artist so the places I seek my inspiration for concepts are probably quite different from those of the technologist. For example, I often look to nature and biology to see how animal and plant life interact or are structured. When I was working on a honey-type aroma output, I modeled the output device – the fabric – closely to honeycomb structures. Secondly, my wearables are less utilitarian than many other visions: so, I envisage the fabric generating a localized 'scent bubble', providing aroma molecules for the right moment for the right effect, triggering new emotions and enhancing the intimate contact with other living things. I hope we will develop a new hypersensitivity, learn new and stimulating pleasures and recreate lost memories all through the aromas delivered by the technology.

MJ: Picking up on the utility of this approach, are you exploring the use of this for more mundane applications?

JT: Well, there's the 'scent clock', an aroma-based way of telling the time. In aromatherapy there are a range of distinct smells, or 'notes'. We're looking at associating these with specific minutes and hours. But the aim is to go beyond the simple function of informing the wearer of the time and to provide aromas which will be useful in terms of evoking and shaping emotions. You could imagine too a mobile phone that not only has a ring tone but a scent tone; as you bring the phone to your head you are given a slight aroma based on who the call is from, or perhaps the purpose of the call.

MJ: There's also a lot of interest in conventional mobile design in community aspects of the technology to allow people to relate, share experiences and collaborate. You talk about 'enhancing the intimate contact with other living things' – can you give an example?

JT: Perfume obviously impacts on more than just the wearer and is used to signal subtly from one person to another. The aromatic clock output, then, would affect not just the wearer but those standing close by too. Inter-person interaction has been a ➤

very important motivation for my work, but again, my take on it is quite different from the 'hard' technological approaches you commonly see. So, there have been quite a few mobile dating-type research prototypes – when your device notifies you that someone you might be interested in is in the vicinity. In our concept, sensors in your garments could be programmed to detect someone whose pheromone profile is of interest to you and to send them a sample of your own pheromones. Love is literally in the air. ■

Multi-modality

Think back to the café scene – when you see someone pointing to the menu, they are probably speaking too, saying perhaps ''What's that dish like?''. If the person is only speaking or pointing, we could describe them as operating in a unimodal way; they are using just one method to communicate. By combining two or more ways to express themselves, they are being multimodal in their interactions. In our café example, employing two modalities can help in two ways. First, it reduces the amount of communication effort between customer and waiter; the customer doesn't have to refer verbosely to the dish, saying perhaps ''What's the *Spaghetti al forna Italiano* like?''. Instead, they can abbreviate the full description to just 'that dish'. Second, imagine the noise from an excited party at a nearby table drowning out part of the customer's request; in this case, the waiter can use the other input, the pointing, to help understand what's being asked.

As we have seen, as technology develops we're likely to see mobiles that can support several modalities – sound cues, speech input and output, touch and gestures, for example. These communication forms can be combined, just as they are in human-to-human interactions, to make for less cumbersome dialogs and to help resolve ambiguous input. The advantages of a multimodal approach could be particularly welcome in the mobile case. Hurried users will appreciate the shortcuts multimodality provides, saving them from having to spell out their needs laboriously as they might have to if just one input technique were available. Users are also likely to make more input errors with their mobiles: a mis-selected option when using a stylus while walking; a strangely pronounced spoken command uttered while stressed. The redundancy provided by using more than one input will help the device to be more accommodating.

The QuickSet multimodal system, described by Sharon Oviatt, demonstrates some of the potential advantages of using multiple inputs for mobiles (Oviatt, 1999). QuickSet is a tablet-sized computer, equipped with speech input and pen-driven gesture interaction. In one trial, users were asked to operate the system in a fire and flood control simulation – they had to imagine they were in charge of coordinating rescue services in a disaster, an increasingly important use of handhelds. They could talk to the system and gesture at the same time, issuing commands like ''Show me the hospital'' while pointing to a location on the map, or circling a part of the display and saying ''Zoom in'' to see an enlarged view. Multimodality improves the accuracy of the system in recognizing what the user wants to do. Speech recognition systems often cope badly where there is a lot of background noise, but with QuickSet, using extra gestural inputs, error rates are reduced by up to 35%.

Designing for some, Benefits all

In the 1980s, few in mainstream HCI research were interested in users who had special needs – visual, hearing or cognitive impairments, for instance – although there were some notable exceptions (see Edwards and Long (1995) for a review). Fortunately, this lack of activity has been vigorously redressed and now there's the flourishing research area of universal accessibility. As well as benefiting minority user groups, these efforts have improved the lives of many users.

A good example from mobiles of how design for special needs leads to a much wider win is the predictive text system, T9, known to most users through its use in mobile phone text messaging. Originally, its developers were looking at ways to help impaired users enter text on a conventional PC. Their target users could control only their eye movements, so the question was how such limited interaction could be used for input into the computer. The answer involved designing a pair of glasses capable of spotting where the wearer was gazing. As the eye can focus accurately on only eight regions, the developers grouped letters together and placed them on distinct parts of the screen. Then, as the user looked at different letter clusters, a dictionary process gave the users potential word matches as input progressed.

Just as the eye-gaze users were limited with their eight input regions for text entry, so are standard mobile phone users, with only a small set of buttons on the keypad. Tegic, the company that licenses T9, saw that the specialized input technology, designed for challenging users, could be effective in accommodating device limitations as well. As the company's website puts it:

Soon, [the developers] realized that this technology could benefit a much broader audience who was struggling with the same small form factor issues. (Tegic)

So, as a mobile developer, it's worth your while to keep track of the work going on in the universal usability field (see *Resources* at the end of the book). There will be other innovations, like T9, driven by users who themselves have 'limited bandwidth' for interaction, and these may well transfer to mobile devices that have restricted input–output capabilities.

Just as design for limited ability users has led to benefits for all, mobile design will help enhance conventional, fully featured computers. Non-mobile developers, then, should certainly pay attention to all the novel input and output schemes being explored for mobile devices. The mobile space has some key advantages as a breeding ground for effective interaction design. There's the obvious need to innovate to overcome the form-factor problems and impacts of the context these devices are used in. But there's also less clutter, less distractions as a clean, simple design is sought. On a conventional PC, in contrast, with its huge screen space there's a real temptation to add more and more to the interactive possibilities; just look at the over-featured software we're all familiar with.

Novel Technology Problems

Technological developments, then, allowing interactions ranging from tilting to touching, from speaking to nodding, will add to the designer's repertoire. You need to be aware, however, of some side-effect design problems these new techniques will pose. Key presses and mouse movements, though inappropriate in some mobile situations, do have the advantage of being unambiguous and discrete. Getting robust recognition of inputs like speech and gesturing in real-world contexts remains an unsolved problem.

Even when the techniques are highly reliable, you will still have to make difficult design choices as to which to use. Just as conventional software developers tend to add new features to their applications continually, there will be real pressures to give devices all the latest, most dazzling interaction technologies. Although you might find it hard to persuade your colleagues, particularly those in marketing, to resist bloating the devices in this way, you should certainly put up a good fight, insisting on selecting those that will give the user simple, direct, unnoticeable ways of communicating their needs.

1.4 IMPOVERISHING INTERACTIONS?

The mobile's small screen, limited keypad or other interaction limitations should not be used as an excuse for bad interaction design. If a customer complains how hard it is to access a mobile's functions, a defensive response might be "What do you expect on such a small screen?". While device characteristics – things you might have no control over – could lead to some user problems, your interaction design choices will have the bigger impact on the quality of interaction.

Every day we encounter many examples of poorly thought-out interactions, and not just in computer systems. How many times have you tried to pull on a door handle, only to find, silly you, that you should have pushed? Or struggled to work out how to operate the shower-come-bath unit in your hotel room? Yearning for a refreshingly warm post-journey soak, you find yourself doused by a blast of cold water from the shower. Did the designers consider how much frustration, wasted time and disappointment they were sowing when they made their choices?

If there are problems with simple things like doors and showers, is there any hope for the far greater complexity in interactive computer systems? Any PC user will be familiar with the meaningless error messages, inappropriate interruptions and teeth-clenching frustrating events like sending email after email without the attachments being attached.

Sadly, as new technologies come along, old mistakes are repeated, and mobiles are certainly not immune. Over the years, mobile users have found themselves lost as they attempt to navigate the increasingly complex set of functions their devices provide (we'll explore this further in Chapter 8). They've been perplexed by the techno-vocabulary littering the interfaces – from 'data bearers' to 'gateways' – failing to cope with the degree of technical expertise required to set up 'fun' applications like multimedia messaging. And many have been angered when half-way through composing a special text message when the phone rings, the mobile switches into 'call' mode and their efforts are lost.

1.4.1 REASONS FOR POOR DESIGN

Why do developers repeatedly inflict poor experiences on their users? Three key reasons are:

- perceived financial cost of better design;
- an overwhelming emphasis on technology over purpose; and
- a lack of user-based 'debugging'.

Financial Short-Termism

A product's price is a highly visible factor used by customers to help them choose between one option and another. Very much less visible, at first glance, is the quality of the interaction design. In store, a device that will provide many happy years of pleasant, effective use could look much like another which will frustrate, confuse and annoy. As quality interaction increases production costs, a manufacturer might feel less motivated to invest in careful design: what's the point if you can sell lots of devices anyway, through slick marketing and competitive pricing? As we will see later, this is a rather short-sighted view.

Techno-Fixation

Technological wizardry is exciting to developers and users. As we have seen already, there will be lots of novel, interesting – and some even effective – ways for users to interact with their mobile devices. For the developer, it is easy to be tempted to always try to add the most impressive features.

The user, in turn, may feel like a second-class citizen if their device does not offer the latest, fastest, fully featured innovations.

Walk into any consumer electronics store and you'll find 'demonstration' modes on many gadgets – one press turns the passive device into a sophisticated seducer, lights flickering, displays animated as you're given a tour of the seemingly unlimited potential the device has to change your world. It's very hard not to get caught up in the drama of these shows, but when you get home, after the purchase, the user experience might be a lot less palatable (Thimbleby, 1996a).

Some developers might also argue they have enough to cope with, just to get the complex technology to work. Sure, trying to get a device to switch robustly between the local WiFi connection in a coffee bar to a cellular network channel, all without the user noticing, *is* technically very challenging and the achievement laudable. But these issues should not mean that users' complex, diverse needs are overlooked. What's the point of technical mastery if the user's experience is dull and desperate? It's like a master chef baking the finest Belgian chocolate cake, full of clever layers of flavor, only to expect diners to consume it through a straw.

Overlooking the real bugs

Designers can also easily gain a false sense of satisfaction with the products they develop. If you spend many months working on a system, spotting its technical failings – bugs that cause the device to malfunction or stop working altogether – is relatively easy, but gaining a sense for the interaction glitches is much harder to do.

Part of the problem is to do with the designer psyche. When you use something you've designed yourself, you will approach the interaction with a very different perspective from your target user. You are the device's creator with a detailed insider's knowledge of the system's design. What seems almost mystically bizarre to the user will be straightforward and systematic to you. Furthermore, having exerted a great deal of intellectual effort and time in developing a design, you will also find it hard to criticize the outcomes. In fact, spotting flaws at a late stage will cause unpleasant emotional tension, something psychologists term 'cognitive dissonance'; to overcome this feeling, you're likely to rationalize away the problems, saying things like "it's not that big a problem" or "it's the user's fault, they need to read the manual".

User-bug blindness also comes from external sources. Marketer-borne feedback might also encourage design over self-confidence. Marketing needs to sell a company's products and the first group to buy into a new technology, the so-called early adopters, might well share your positive views on the product's design or be more tolerant or more able to cope with its failings (Norman, 1999, pp. 34–46).

The answer, then, is to expose ordinary users to early designs to which you're less committed, and see what they really think. Failing to do this will mean that fatal interaction flaws will be found too late; then the shock in glimpsing the difference between your perception and that of others can be quite profound, like listening to a tape-recording of your speech and wondering, "Do I really sound like this?".

1.4.2 IMPACTS OF POOR DESIGN

But why should you care whether or not your designs are well received? What should motivate you to invest additional resources into producing better interactions? Three things to consider are the emotional, economic and ethical impacts of your work.

Emotional Impact

Coming to the realization that your designs are poor when it is too late is an emotion worth avoiding. The thought of your design causing millions of despairing sighs is a great motivator to improve the approach and outcomes of your work. Most designers design in order to produce something of value that others – not just other designers – will enjoy and gain satisfaction from. The dream of hundreds of thousands or even millions of people having a better day because of your designs is a highly appealing one.

As a designer, it is really important to understand that the choices you make will have a significant impact on your users' emotions, stress levels and mental energy. Sadly, most people's experience is that technology affects them negatively more than it does positively. The media have made great play of 'computer rage', with a well-known piece of TV news footage showing an employee aggressively destroying his workstation, symbolic of the bad emotions technology is seen as fostering. To bring a degree of scientific objectivity to the apparently widespread poor experiences, a group of researchers set out to assess the frustration levels computer technology brings into people's lives (Ceaparu *et al.*, 2004). The results are disturbing, particularly for mobile developers.

People rated themselves as often being very frustrated with their computers. Situations causing most frustration were error messages, non-robust data connections, system freezes, excessively long downloads, and missing or hard-to-find system features. With mobiles, all of these factors can be exacerbated and we might expect even higher levels of frustration. For example, small displays could lead a designer to produce shorter, even more cryptic error messages, and feature lists that are difficult to navigate, and connection reliability and data transfer speeds can also be lower.

The research also found that you are more likely to have a higher immediate level of frustration if some technology problem occurs during an important task. Interruptions when you are involved in something less critical cause lower levels of emotion. Mobile users will often be relying on their devices to help them just-in-time, under pressure – "I need those sales figures, right now". So again, raised negative emotional responses seem probable.

While the study asked users to subjectively assess their feelings, frustration does have very real physiological impacts: poor design strains the body. Richard Hazlett of the Psychiatric Department at Johns Hopkins medical school, illustrates this, demonstrating the link between facial muscle activity and frustration levels (Hazlett, 2003). He showed that badly designed interfaces – such as websites that are difficult to use – generated distinct patterns of electrical activity, reflecting the degree of muscle tension.

Some researchers are interested in measuring such physiological responses in order to produce systems that can relate to people on an emotional basis – indeed, there's a whole research area known as 'affective computing' (Picard, 1997). Imagine, then, a handheld that can monitor your stress levels from the sweatiness of your hand as you grip it, and adapt the way it interacts with you. While such efforts are interesting, for most of us involved in design the aim should be to reduce the level of frustration and stress our users suffer in the first place.

Economic Impact

People waste one-third to one-half of the time they spend in front of the computer (Ceaparu *et al.*, 2004). Some of this unproductive time is spent trying to fix problems; the rest is time taken up in repeating work that was lost because of the problem, such as restoring a mistakenly deleted file. Coping with fixing the problems wastes most effort: users spend between a quarter and a third of their computer time just trying to get back to a productive state after interruption.

For many years now, usability evangelists have used economic arguments to urge companies to take interaction design issues seriously, some even suggesting that global productivity is being affected through difficult-to-use systems (Landauer, 1996). Jacob Nielsen, one of the most successful and vocal of the ease-of-use gurus, puts it this way: "...usable design saves money and saves jobs" (Nielsen, 2003).

Lots of the marketing associated with mobiles speaks loudly of the economic gains in having the ability to communicate and access information whenever and wherever needed. Given such claims, and the lack of spare time mobile users tend to have, they will be especially displeased if they suffer the degree of wasted time common in other computer systems.

There is an additional economic incentive for mobile developers to produce devices and services that users take up and use extensively. Globally, and particularly in Europe, network operators have spent many billions of dollars on acquiring licenses to operate advanced services. In addition to these vast sums, a great deal of expenditure has gone into rolling out the infrastructure needed to provide coverage for all the hoped-for sophisticated mobile interactions. Shareholders will want these investments to pay off as soon as possible, but every device and service that is difficult to configure, hard to operate or frustrating to use will further lengthen the already long period before their patience is rewarded.

Ethical Impacts

Stressed users, lower productivity and reduced revenues are one thing; lost lives, a damaged environment and unhealthy consumer attitudes are rather more serious.

Mobiles in safety-critical situations

'Killer App' is an IT industry cliché, but the drive to find an essential application all users need is strong one, more so for mobiles. Although it may be hard to discover that 'killer' to supplement the surprise success of text messaging, unwittingly many current devices and services are potential killers themselves.

In the UK there are over 40 million mobile phone users. If each of these wastes 60 seconds a day trying to operate their device, every day a lifetime of human effort dies, wasted. While such a statistic might be a fun way to motivate your colleagues to take interaction design seriously, there are application areas where real deaths might be caused through impoverished interactions. For certain interaction design products, reducing user fatalities would seem, therefore, to be the 'killer app' – a key justification for the methods we discuss in this book. Simply put, basic design improvements might save lives.

First, take transport. There have been several cases of aircraft crashes or near-catastrophes arising from difficult-to-use systems, poor error messages and the like. Even pilots, who are highly trained individuals and experts at coping with complexity, have at times struggled with the technology. Mass-produced mobile technology is promising to bring complexity down to earth, with feature-laden devices available to every car driver:

> ... *one of the processors embedded in your car could signal your PDA that it's time for an oil change. The request for an appointment is simultaneously received by your cell phone, which interacts transparently with the PDA to schedule both the appointment and the oil change.* (Di Pietro and Mancini, 2003)

A car radio analysis showed how a range of interaction design problems might lead to a driver being seriously distracted (Marsden *et al.*, 1999). Examples include:

- Routine tasks when operating the radio taking a long time, requiring the driver's full attention
- Drivers having to move their head closer to the device, reducing their road vision, to read a display

- 'Time-outs' that undo a sequence of user settings if the driver fails to complete the process in time, encouraging them to persist in interacting with the radio when they should return their full attention to the driving conditions.

Radios are relatively simple compared to the navigation and route guidance systems, traffic congestion monitors and other services becoming available to drivers. Poor interaction designs will distract drivers from what they should be doing – driving – and serious accidents will happen.

Medicine is another domain where safety is key and poorly designed systems have the potential to cause tragic outcomes. Hospitals are full of high technology, employed to help practitioners to diagnose, treat and monitor patients' conditions. As these systems are introduced, there's a growing awareness of errors that might be caused by poor interaction design. Chris Johnson, who has studied many air traffic incidents, sees similar problems for medicine. Just as 'fly-by-wire' aircraft require pilots to become computer operators, clinicians' dependence on complex medical systems is increasing. One case he relates clearly illustrates how failings in interface design could seriously affect patients. A drug infusion device, used to deliver medication in a controlled way, displayed drug unit information in an inconsistent way, switching from micrograms (MCG) to milligrams (MG):

When using the dose calculator function for a nitroglycerin drip, the program changes from MCG on one screen to MG on the next screen. A provider trying to start an IV infusion quickly may not notice the change and continue on programming the infusion. At the end the decimal point is not easy to read and the dosing error may not be noticed. The error described allows for only 10% of the desired dose to be delivered. (Johnson, 2003)

Handhelds and other mobiles are joining the ensemble of devices found in clinics. Doctors and nurses refer to their PalmPilots to look up drug information or to jot down some observations for later use. There are also plans to extend the use of wireless devices within many hospitals.

Patients themselves are also getting their hands on healthcare mobiles. Some of these monitor vital signs. Patients might wear a number of sensors – to track the heart rate, pulse and breathing rate – with the readings sent to a walkman-sized mobile device worn on the belt (McGarry *et al.*, 2000); Exercise 1.4 illustrates an interface design for this sort of application.

Going on the previous evidence of errors caused through badly designed interfaces, more and more medical mobiles, used by both trained professionals and ordinary people, can only mean there is plenty of room for future serious interaction failings.

EXERCISE 1.4 INTERFACE DESIGN FOR A MOBILE VITAL SIGNS MONITOR

Figure 1.6 shows one of the proposed interface designs for a wireless vital signs monitor. The top indicators show the battery level and whether one or more of the patient's vital signs are approaching a problematic level. The lower section gives readouts of the patient's heart rate, with the panel displaying 'HEART' also capable of displaying scrolling pager-like messages. The middle portion of the interface gives the current ➤

time. Function display options allow the user to view other vital signs information such as breathing rate.

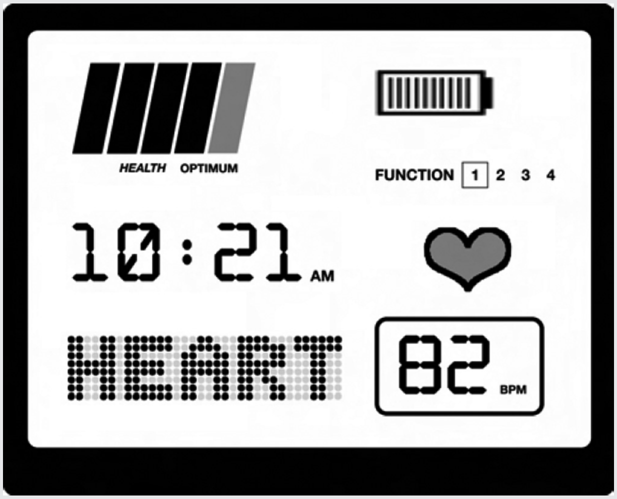

FIGURE 1.6

Vital signs wearable monitor prototype (adapted from McGarry *et al*., 2000)

Think about possible problems that might arise through this interaction design. Sketch out alternatives. Improvements could include:

- Replacing function numbers with icons (heart, lung shape, etc.)
- Replacing scroll buttons with direct access – one button for each function
- Making bar chart easier to interpret by, e.g., renaming '*HEALTH* OPTIMUM' legend and redesigning layout
- Placing battery indicator in alternative location – closeness to health bar chart could lead to confusion. ■

Mobiles and environmental problems

In the words of Jonathan Ive, vice-president of industrial design at Apple and designer of iMac and iPod:

Maybe it's too pragmatic, too modest but I guess we can design products that people will actually want to keep, even when they are technologically obsolete. (Ive, 2004)

In the United Kingdom, millions of tonnes of electronic equipment are thrown away every year (Thimbleby and Jones, 2002). The mobile mass market heightens this serious threat to the environment. The disposable phones, mentioned earlier, are obvious potential landfill contributors, but even expensive devices, ones you might expect purchasers to hold on to for some time, are being discarded and dumped at a relatively high rate. Why does this happen and how can interaction designers make a difference?

Developing unhealthy attitudes

Studies of how technologies mature, from innovative novelty through to commodity, provide some answers. When a new technology comes along, it might not be advanced or robust enough to satisfy user needs. During this development phase, you might expect people to buy a device – say an early handheld without wireless connectivity – and to upgrade when another emerges that is better able to meet their needs, such as connecting to remote information sources. However, at some point, the technology should mature so that users' technological needs for performance, reliability and so on are satisfied. At this point, Don Norman argues, interaction designers become particularly valuable (Norman, 1999). When anyone can supply the required technology, one way to differentiate products in order to compete is by providing excellent user experiences.

Now, while undeniably there are some unmet technological needs with mobiles, fueling current upgrade behaviors, the technology is becoming mature enough to support many user goals. The mobile industry needs strong-willed interaction designers able to spot and articulate these cases, as well as companies that are courageous enough to invest in products that provide effective, fulfilling user experiences – products that users have no reason to discard too quickly.

Even if the technology exists to satisfy a user's needs, they can be made to feel dissatisfied, perceiving there to be a better solution they should buy into, and persuading them to dispose of their current device. One way this happens is through what's called 'feature creep' – the adding of extra, not necessarily widely used, facilities in successive product upgrades.

Here's the scenario. An interaction designer studies users, identifies a clear need, and sees that the technology exists to supply this amply. The designer then produces a design for a system that simply supports the user as they carry out their goals. Time passes, and the company decides to release another version of this device with 10 extra features. Despite the fact that none of these might be used, or even useful, to most of its customers, users will be tempted to upgrade – after all, who wants to feel left behind? Even if they don't want to purchase the new version, they may be forced to so that their device remains compatible with those of colleagues and friends who have upgraded: if all your friends are sending multimedia messages but your phone cannot receive them, what will you do? This upgrade cycle – and the associated refuse – can continue indefinitely. Another battle you may have to face as an interaction designer, then, is persuading engineering and marketing colleagues to resist the apparently easy money to be made through feature expansion.

Persuading companies to change their strategy might sound like an impossibly ambitious task for any one interaction designer. Individual designers can, though, easily begin to make a difference in smaller ways. A poor interface to a technology that is adequate in all other senses – fast enough, robust enough, etc. – will breed dissatisfaction in the user who might feel they have to buy an alternative device that appears easier to use. Designers who write meaningless error messages, fail to give feedback to let a user know the results of their actions, or make it difficult to find important features, might be motivated to better practices if they remembered that each poor design choice could lead to another green field being turned into a rubbish site.

BOX 1.7 FLOWERS FROM DEAD MOBILES

Working with Motorola, researchers at Warwick University in the UK have developed mobile phone covers which, when planted, naturally degrade and grow into a flower. Work was motivated by the environmental impact of increasing mountains of disposed mobile phones. See Figure 1.7 and Color Plate 3.

FIGURE 1.7
Graceful degradation

1.5 OUTLINE OF THE REST OF THIS BOOK

We've already seen what mobiles *could* be; the rest of the book is about what they *should* be and how to go about attaining these ideals.

In the next two chapters of this introductory part, we'll consider what design qualities people will value in mobiles they buy, and the approaches you could use to ensure these are crafted into your products.

After this scene setting, we go into the detail of how to design mobile interactions. Part II – *Developing effective mobile applications* – explores the techniques you can use to gain insights into user needs as well as examining the process of turning these into reality, and seeing how the prototypes fare, through evaluation.

Throughout the book, we'll be presenting useful pointers, provocations and guidelines to help you design. These are drawn from the work of many others as well as ourselves. The third part – *Design gallery* – is dedicated to raising the issues and presenting advice on important elements in many mobile interactive systems: things like navigation, information presentation, sophisticated visualizations and collaboration.

SUMMARY

It's easy to have a limited vision of the mobile future – mobiles as just supercharged phones, carried in the pocket. But mobiles have the potential to be key building blocks in the new, digitally augmented world. If designers and developers simply view them as consumer gadgets, sophisticated trinkets, a great opportunity will have been lost. The technology is personal and pervasive, and poor interaction design will have serious impacts – for users and the industry. Careful, inspired innovations can change the world, bringing pleasure, helping businesses and even saving lives.

WORKSHOP QUESTIONS

- The MediaCup shown in Color Plate 1 has a processor and memory embedded in its base. It can communicate with other devices (including other cups) placed nearby. What uses might such a device have?
- Human–computer interaction educators tend to stress the importance of maintaining 'implementation-free' thinking and prototyping for as long as possible in the design process. To what extent do you think this is possible or desirable in the mobile context?
- Predictive text systems use dictionaries to find the best single word matches for a string of text. How could you potentially improve the quality of the word suggestions a system makes and what data structures would you need to furnish your design?

DESIGNER TIPS

- *Develop an 'appliance attitude' to the applications and devices you are working with. Identify a small, coherent set of functions users really want and deliver them in a simple, direct way. If you want to – or have to – provide many other features, hide them away.*

- *Start to think now how you might employ the more advanced input–output technologies being developed – how your current designs might change if your users could squeeze or tilt, for example. But also begin to develop resistance to using every innovation in all your applications.*
- *Keep track of the work being done on universal usability – research into how disabled users might be better served by technology. These people have 'impoverished' interfaces and the work might inform your challenged devices.*
- *If you've been working in HCI for some years on non-mobile projects, relax as you move to this new area. Mobiles require more than utility/task-focused thinking; try to consider enjoyment, pleasure and fun in your designs.*