This article was downloaded by: [DUT Library]
On: 08 October 2014, At: 12:50
Publisher: Taylor & Francis
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK

Behaviour & Information Technology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tbit20

A survey of what customers want in a cell phone design

Chen Ling [a] , Wonil Hwang [b] & Gavriel Salvendy [c d]
[a] School of Industrial Engineering, University of Oklahoma , Norman, OK, USA
[b] School of Industrial and Information System Engineering, Soongsil University , 511 Sangdo-Dong, Dongjak-Gu, Seoul, 156-743, South Korea
[c] Purdue University, School of Industrial Engineering , West Lafayette, IN, USA
[d] Department of Industrial Engineering, Tsinghua University , Beijing, P.R., China
Published online: 14 May 2007.

To cite this article: Chen Ling , Wonil Hwang & Gavriel Salvendy (2007) A survey of what customers want in a cell phone design, Behaviour & Information Technology, 26:2, 149-163, DOI: 10.1080/01449290500128214

To link to this article: http://dx.doi.org/10.1080/01449290500128214

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the “Content”) contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at http://www.tandfonline.com/page/terms-and-conditions

Behaviour & Information Technology, Vol. 26, No. 2, March–April 2007, 149–163

Taylor & Francis
Taylor & Francis Group

A survey of what customers want in a cell phone design

CHEN LING†**, WONIL HWANG‡* and GAVRIEL SALVENDY¶§***

†School of Industrial Engineering, University of Oklahoma, Norman, OK, USA
‡School of Industrial and Information System Engineering, Soongsil University, 511 Sangdo-Dong, Dongjak-Gu, Seoul, 156-743, South Korea
¶Purdue University, School of Industrial Engineering, West Lafayette, IN, USA
§Department of Industrial Engineering, Tsinghua University, Beijing, P.R. China

The cell phone is an information appliance that has been widely used. It provides instant access to information and makes people more 'connected'. The objective of our study is to investigate the relationship among the design features of the cell phone and identify the most important design features and design factors. In our survey study, we asked 1,006 college students using a 7-point Likert scale structured questionnaire to evaluate their preference of the design features and overall satisfaction of their current cell phone. Nine design factors were derived. Ten cell phone design features and five design factors that significantly impact a user's satisfaction were identified. The most important design features are: the physical appearance, size and menu organisation, which together account for 42% of the total variance of a user's overall satisfaction.

Keywords: Cell phone; Design; Customers; User preferences

Downloaded by [DUT Library] at 12:50 08 October 2014

1. Introduction

The cell phone is an effective communication device, which had 152 million users in the US in 2004 and 1 billion users worldwide. It is expected that in the year 2007, global users will increase to 2 billion (Charney 2003, Frenzel 2004). People use cell phones to have fast access to information for lookup and entry on-the-go, and quick communication through instant messaging and voice calling (Weiss 2002). Moreover, people use the imbedded cell phone features such as games, cameras, organisers and mobile internet for various purposes of entertainment, organising, or even shopping. The cell phone is becoming an integral part of people's everyday life, and making people more 'connected'.

Cell phones are getting smaller and lighter, but they support more features at the same time. This situation is what Norman (1988) warned against as 'creeping featurism', which is 'a tendency to add to the number of features that a device can do, often extending the number beyond all reasons'. Although these features can provide more utilities, they can also complicate the design and make the cell phone more difficult to use. 'Though the presentation possibilities are expanding day by day, our capacity to understand, use and integrate new information and technology has not grown at the same rate' (Watzman 2003). With the unchanged human's cognitive limit, a cell phone packed with too many features may overwhelm the users due to its complexity. A study shows that it was difficult to find and use uncommon functions in cell phones (Klochar *et al.* 2003). In fact, the cell phone was voted as the invention that Americans hate most, but cannot live without, according to the eighth annual Lemelson-MIT Invention Index study (2004).

Competition among cell phone manufacturers is fierce. Figure 1 shows the market share of the cell phone market in the second quarter of 2004. Nokia currently holds the largest market share, but is losing ground to the new rising manufacturers. To maintain and increase their market

*Corresponding author. Email: wonil@ssu.ac.kr
**chenling@ou.edu
***salvendy@ecn.purdue.edu

Behaviour & Information Technology
ISSN 0144-929X print/ISSN 1362-3001 online © 2007 Taylor & Francis
http://www.tandf.co.uk/journals
DOI: 10.1080/01449290500128214

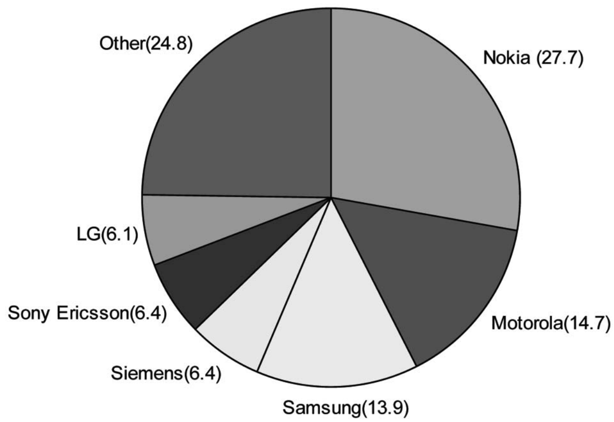

Figure 1. Cell phone market share in second quarter of 2004 (Data based on Arnfield 2004).

shares, the cell phone manufacturers need to carry out careful user interface design with special attention to the user's capability, limitation and preference. One way is to learn from the past. They can find out what features are liked or disliked most by users, and what features have the most impact on the user's overall satisfaction of the cell phone. With this knowledge, the cell phone manufacturers can put more effort into improving the more important features, and can give less priority to those less important features. To streamline the cell phone usage, functions provided by the more important features should be easier to access than the less important ones.

Usability comprises ease of use and usefulness, and these drive user satisfaction. User satisfaction, in turn, results in usage (Isrealski and Lund 2003). This study investigates the relationship among the design features of the cell phone and identifies the most important design features and factors based on an extensive survey study of the heavy users of cell phones – college students. The result can help cell phone manufacturers to prioritise their design efforts and improve user satisfaction.

2. Background literature

With the growth of cell phone usage, much research effort has been put into studies related to cell phones. Some research deals with the safety issues associated with cell phone usage during driving (Alm and Nilsson, 1995, Parks and Ward 2001, Strayer and Johnston 2001), and health issues such as relationship between cell phone use and brain tumours (Hardell *et al.* 1999, Inskip *et al.* 2001). Some others deal with accessibility issues of designing cell phones for people with disability such as poor vision or disabled upper extremities (Smith-Jackson *et al.* 2003). And many deal with the cell phone design issues to improve usability (e.g. Chae and Kim 2004, Han *et al.* 2004).

Table 1 shows a summary of the research related to cell phone design based on the studied features and the applied usability evaluation method. A brief description of the five cell phone design features is: the text-entry method, the menu design, the display screen, the multimedia messaging and the mobile internet; and three types of usability evaluation methods are presented in the paragraphs below.

The most commonly used text-entry method is the key-based method, which includes the multi-press method, the two-key input method and T9 predictive input method. Research shows that the T9 method is the fastest method among the three methods used (Silfverberg *et al.* 2000, James and Reischel 2001). It was also found that input with the index finger is faster than the thumb (Silfverberg *et al.* 2000). The hierarchical menu in cell phones enables users to access different embedded functions and cell phone settings. Bocker and Suwita (1999) viewed the menu design as a central design element for cell phones. They did a usability experiment with 80 subjects to compare the use of icons and texts in the menu display and found that the text display resulted in better task performance, but the icon display received higher purchasing intention because it is more fun to use. The display screen of cell phones is the window for information presentation to users, and is typically small in size. It was found that the display screen size and the horizontal depth in menu hierarchy strongly affect the navigation activities and perception of mobile internet users for complex search tasks (Chae and Kim 2004). Multimedia messaging enables users to exchange still images, sound and video content. Berg *et al.* (2003) studied the teenager's behaviour of gift-giving using the multimedia messaging function. Mobile internet on cell phones makes pervasive computing possible. Compared with the stationary internet, the mobile internet has three characteristics: personal, instant connection to the internet, and with less resource in terms of smaller screen; less convenient input/output facilities; and lower processing capacity (Chae and Kim 2003). Users prefer using the mobile internet when they try to purchase low-risk products such as books, CDs, movie tickets, etc. The mobile internet users prefer low-intensity content such as a joke or ringtone to high-intensity content such as education services and online games (Chae and Kim 2003).

Many different usability evaluation methods have been applied to help evaluate cell phone design features. According to Hilbert and Redmiles (2000), the usability evaluation methods can be divided into three categories: predictive, observational and participative. The predictive evaluation methods make predictions about usability attributes based on psychological modelling techniques, or based on design reviews performed by experts. Examples of this category of methods include Fitt's law, GOMS model, ACT-R model and keystroke level model (KLM), etc. Fitt's law was applied to predict the expert text-entry rates on a 12-key cell phone keypad (Silfverberg *et al.* 2000). A KLM model was applied

Downloaded by [DUT Library] at 12:50 08 October 2014

Table 1. Summary of research related to cell phone design.

Usability evaluation methods		Predictive				Observational		Participative
Cell phone features		GOMS	Fitt's Law	ACT-R	KLM	User testing	Ethnography study	User interview/ questionnaire
Individual features	Text entry		Silfverberg *et al.* 2000		Dunlop and Crossan 2000	Dunlop and Crossan 2000, Silfverberg *et al.* 2000, James and Reischel 2001, Hirotaka 2003		
	Menu design	Amant *et al.* 2004	Amant *et al.* 2004	Amant *et al.* 2004		Bocker and Suwita 1999, Amant *et al.* 2004, Chae and Kim 2004		
	Display screen							
	Multimedia messaging (MMS)						Berg *et al.* 2003	Berg *et al.* 2003
	Mobile internet					Buchanan *et al.* 2001		Buchanan *et al.* 2001, Chae and Kim 2003
Multiple features						Han *et al.* 2004, Klockar *et al.* 2003		Our study

to compare the performance of the predictive text entry method and the traditional multi-press text input method (Dunlop and Crossan 2000). Amant *et al.* (2004) compared the prediction from three models: Fitt's Law, the GOMS model and the ACT-R model to real user's performance data for five menu traversal tasks, and found that the GOMS model and the ACT-R model gave more accurate predictions. The observational evaluation methods, on the other hand, measure usability attributes based on observations of users interacting with prototypes or fully functioning systems. User testing and ethnography study both belong to this category. For example, Han *et al.* (2004) carried out a user study on 65 features of 50 different cell phones. They used multiple regressions to find the relationship between user satisfaction and the design features, and derived critical design features such as the brightness of body colour, vertical length of body, number of default bells, etc. The third category – participative evaluation – collects information regarding usability attributes directly from users based on their subjective reports, such as user interviews and questionnaires. The benefit of participative evaluation is its ability to capture aspects of a user's needs, desires, thought processes and experience, which are difficult to obtain otherwise. Our study belongs to this category.

Compared with other research in the cell phone design area, our study contributes to empirical cell phone studies in two unique ways. First, we study the relationship among multiple design features and the relationship between these features and the user's overall satisfaction. Studying these relationships is important because even when users are satisfied with the individual features that a cell phone supports, it is not guaranteed that they will like the phone as a whole. The whole product ought to weave the individual parts harmoniously together to provide a satisfactory user experience. Our study captured the user's perception of the whole cell phone as well as the individual features, and subsequently delved in to explore their relationships. Second, we used the participative evaluation method including interview and questionnaire as the major tool to collect data. Compared to a similar study by Han *et al.* (2004), which also studied the relationship between multiple features and user's satisfaction with user testing method, our study collected a user's preference data with higher ecological validity. Han *et al.* (2004) had 76 subjects carry out three tasks with each of the 50 cell phones within about four hours. Then they asked the subjects to evaluate different design features for these 50 cell phones. It is obvious that the extent of exposure that each subject gets from each cell phone is limited in such a short time. It is not likely that an accurate or omnifaceted sense on the usage of the cell phone can be obtained. In contrast, subjects in our study are exposed to the usage of their cell phone for much longer duration, and have used the product in real-life settings. Our data captures the user's real feelings towards their own cell phone after they have used their phones in their everyday lives.

3. Survey method

We first interviewed 150 university students (who were cell phone users) with an in-depth, open-ended questionnaire. Their opinions about the most important cell phone features were elicited. Based on their answers, the 30 most frequently mentioned cell phone features were derived and a structured questionnaire measuring users' overall satisfaction with the phone and their preference level on the 30 features was

Downloaded by [DUT Library] at 12:50 08 October 2014

developed according to suggestions given in Salvendy and Carayon (2001). The 7-point Likert scale anchored with opposing adjective phrases was used. Not all features were available on all phones. If any feature is not available on the subject's current cell phone or they perceive that they don't have that feature, they will mark not applicable (N/A) for the question on that feature. Demographic information including user's age, gender, ethnic group, experience with cell phone, major of study, the manufacturer and model of his/her current cell phone was collected. The number of college students participating in the survey study was 2,571. Since this study is more concerned with improving the design features of a cell phone, differences among the service providers were not studied.

Out of the 30 cell phone features, we restricted our analysis to 20 common features after we eliminated 10 newly developed features, including voice-activated dialing, digital camera, web browser and security feature (fingerprint detector or password) etc., which were not available to the cell phones owned by most respondents. Table 2 lists the 20 features with a brief description of each. Prior to the analysis, we excluded the observations that contained 'N/A' in any of the 20 common features, because the cases having 'N/A' can be regarded as missing cases. Case deletion (i.e. listwise deletion and complete-case analysis) is the most popular and generally valid method to deal with missing cases that occur completely at random (Schafer and Graham 2002). The bias from deleting the cases of 'N/A' might not be serious, because 'N/A' in our data occurred with no special pattern. Afterwards, to keep consistent respondents who respond to the survey seriously, we removed outliers that showed inconsistent or random responses to the same constructs. When the subject's attitude is not serious, they tend to mark random answers to the question. After these data-preprocessing procedures, a total of 1,006 observations remained with 20 common features for the analyses. Table 3 describes the general demographic characteristics of the 1,006 subjects, such as the gender, age, cell phone usage experience, ethnic group and academic major. Data from over eight different cell phone manufacturers was collected.

4. Results and discussion

4.1 *Overview*

The 7-point Likert scale structured questionnaire has an acceptable level of internal consistency (Cronbach's alpha value of 0.83). The mean and standard deviation of the preference score for each of the 20 cell phone features arranged from the largest preference score to the lowest are listed in table 4. All 20 features have an above neutral (> 4) preference level with their means ranging from 4.7 to 6.2. The average preference level for all features is 5.5. The preference level for the overall satisfaction is 5.7.

Table 2. Mobile phone features studied.

Features	Description
Body colour	The colour(s) of the cell phone body.
Ringtone range	The number of ringtones that can be selected, including the preset selections that come with the phone, and the capacity provided for downloading other ringtones.
Keypad design	The design of the keypad of the cell phone, including its size, shape, colour and button arrangement, etc.
Physical appearance	The visual appearance of the cell phone.
Game	The games provided with the cell phone and the capacity provided for downloading other games.
One touch dialling	The function to call frequently used numbers from phone book entries with the push of a single key.
Phone book	The collection of telephone numbers the user stores on the cell phone.
Call log memory	The memory capacity for call log, which allows the user to see a certain number of last incoming, outgoing and missed call numbers.
Caller ID	The feature that lets the user know who is calling by displaying the number and/or name of the calling party on your phone.
Organizer feature	The feature that allows the user to arrange schedules, and write down to-do-list.
Alarm reminder	The feature that rings or vibrates to notify the user about a data book event that the user scheduled.
Vibrating alert for message and call	The feature that tells the user of incoming message or call by means of vibration mechanism.
Voice mail	A computerised answering service of the cell phone that automatically answers the call, plays a greeting and records a message. After the message is retrieved, it can be deleted, saved, or forwarded.
Personalisation	The ability to customise the cell phone to the user's needs
Menu organisation	The organisation scheme of the cell phone menu to access different functions or settings.
Size of cell phone	The physical dimension of the cell phone including its length, width and thickness.
Weight of cell phone	The weight of the cell phone.
Durability	The degree to which the cell phone retains its physical properties while subjected to stress, such as heavy use, or adverse environmental conditions.
Button size	The size of buttons on the cell phone, including the keypad button, on-off button, volume button, etc.
Battery duration	The length of time the user can talk on a cell phone without recharging the battery. It is usually expressed in terms of number of hours of talk time or standby time.

Downloaded by [DUT Library] at 12:50 08 October 2014

Table 3. Demographic profiles of participants and their cell phones.

Variables	Description	Frequency	Percent
Gender	Male	629	62.5
	Female	377	37.5
Ethnicity	Caucasian American	410	48.6
	Asian American	310	36.8
	Hispanic American	55	6.5
	African American	40	4.7
	Others	28	3.3
Major	Engineering	380	51.9
	Management	157	21.4
	Liberal art	43	5.9
	Science	38	5.2
	Technology	21	2.9
	Agriculture	19	2.6
	Consumer and family sciences	17	2.3
	Pharmacy	16	2.2
	Education	14	1.9
	Nursing	7	1.0
	Health sciences	5	0.7
	Veterinary medicine	2	0.3
	Medical education	2	0.3
	Undergraduate studies programme	1	0.1
	Others	10	1.4
Cell phone manufacturer	Nokia	278	27.7
	Samsung	225	22.4
	Motorola	161	16.0
	Sony Ericsson	144	14.3
	Sanyo	83	8.3
	LG	71	7.1
	Siemens	18	1.8
	Kyocera	7	0.7
	Others	17	1.7
Variables	Mean	SD	n
Age (years)	21.8	2.80	885
Cell phone Experience (years)	2.7	2.09	930

Downloaded by [DUT Library] at 12:50 08 October 2014

As seen in table 4, the caller ID feature has the highest mean preference level of 6.2, and the lowest standard deviation value of 0.89. It means most users unanimously like this feature, which can imply this is a mature feature with well-established technology that most users liked, and is well designed by all manufacturers. In contrast, the game feature has the lowest preference level of 4.7, and the second highest standard deviation of 1.30. Since its preference rating is just above neutral, it shows that the game feature does not particularly impress users, but neither are they upset about the feature. It may imply that the game design in cell phone is not mature enough, and people may not like the idea of playing games on a cell phone very much. The big standard deviation shows that users have different opinions on the game feature in a cell phone. The ringtone range feature received the highest standard deviation of 1.31 and an average preference level of 5.1, which is below the features' overall average of 5.5. This may be due to the fact that the ringtone choices provided by the cell phone varies greatly among manufacturers and among older and newer phone models. The users' preference on this feature is not very high. There is plenty of room for improvement for the ringtone range.

4.2 *Intercorrelation matrix*

The relationships among the design features are analysed with the Pearson Correlation method (see table 5). All of the correlations were statistically significant. We consider the correlation coefficients that are greater than 0.4 to indicate moderate correlation, because the shared correlation between the two variables is at least 16% (Cramer 1997). Twenty-five pairs of moderately correlated features such as size and weight, organiser feature and alarm reminder, keypad design and button size, etc. are identified and marked in bold in table 4. They are all positively correlated with each other.

Due to the large number of moderately correlated feature pairs, it is possible that some latent factors that can incorporate these correlated features exist. Therefore, a further factor analysis is needed. We can also

Downloaded by [DUT Library] at 12:50 08 October 2014

Table 4. Basic statistics of preferences of cell phone features (n = 1006).

Cell phone features	Mean	SD
Caller ID	6.2	0.89
Phone book	5.9	0.91
Vibrating alert for message and call	5.9	1.12
Call log memory	5.7	1.00
Voice mail	5.7	0.91
Physical appearance	5.6	0.94
Menu organisation	5.6	0.98
Size of cell phone	5.6	1.19
Weight of cell phone	5.6	1.16
Body colour	5.5	1.04
Keypad design	5.5	0.92
Button size	5.5	0.94
Battery duration	5.5	1.23
One touch dialling	5.4	1.05
Alarm reminder	5.4	1.22
Durability	5.4	1.16
Personalisation	5.2	1.06
Ringtones range	5.1	1.31
Organiser feature	5.1	1.11
Game	4.7	1.30
User's overall satisfaction	5.7	1.03

see that the overall satisfaction is correlated with many features, including body colour, physical appearance, phonebook, personalisation, menu design, size, weight and durability of the phone. A further multiple regression study is necessary to find out the causal relationship between the overall satisfaction and these features.

4.3 *Factor analysis*

To explore the latent structure of the 20 features and form clusters of related features, a principle component factor analysis with varimax rotation was performed. Nine factors were identified through the factor analysis. The total percentage variance explained by these nine factors of the overall variance of the data was 73.3%. The factor loadings for each feature with each factor are shown in table 6. When a factor loading is greater than 0.5 for a phone feature, it is considered to be significant, and the feature can be classified into that corresponding factor.

As seen in table 6, the result of the factor analysis clearly clustered the related features together. Factor 1 is a dominating factor which explained 13.5% of the total variance of the data. It contains five items: phonebook, call log memory, caller ID, voice mail and menu organization, where the first four features provides the needed information for phone calls, and the last one enables access to this information. All the five items are directly related to making and receiving phone calls; therefore we named this factor 'calling-related features'.

Factor 2 comprises features of ringtone range, personalisation and game. These features are related to the cell phone's capacity to allow users to choose or download their own preferred settings to make their phones unique, such as changeable faceplates, ringtones, menu ordering, display contrast, etc. Therefore, this factor is labelled 'personal preference'.

Factor 3 contains the size and weight of the cell phone. As a mobile device, cell phones needs to be easy to carry around. Small and lightweight make a phone more portable. Thus, this factor is named 'portability'. Factor 4 includes the organiser feature and alarm reminders. The organiser feature helps to consolidate pieces of information such as time, location, etc. about schedule and calendars. The user may also set the alarm to remind them of the time for a meeting. Since both features help the cell phone user to be more organised in time arrangement, Factor 4 is labelled 'organising features'.

Factor 5 includes keypad design and button size. The keypad area comprises many buttons such as the number keys, the directional keys, the menu key and the soft keys, etc. Thus, the keypad design includes aspects of the button design (including button size, shape, feel, rise, back glow, etc.) and button arrangement, among which, button size is a very important issue ergonomically. Since cell phones are always used while the user grasps the handset with single hand, and inputs the information on the keypad with the thumb (Hirotaka 2003), too small buttons make dialling difficult and error-prone for people with big thumbs. That was why the button size feature is mentioned frequently by our interviewee, and is thus separately studied. Overall, we named Factor 5 the 'keypad area design'.

Factor 6 has loading items of durability and battery duration. Durability is defined as how long the device can last under normal use, or whether the device can resist impact from abnormal use. Cell phones might be scratched, dropped to the ground, or hit by a hard surface. It requires the cell phone to have a tough case and material. The battery duration is the length of time users can talk on their cell phone without recharging the battery. Since both the durability and battery duration are related to how long the phone usage can last, Factor 6 was named the 'durable aspect' of the cell phone.

The loading items of Factor 7 include the body colour and the physical appearance of the cell phone. Physical appearance tells how the cell phone looks. Its scope is broad, which includes the style, shape, colour, brightness and size of the cell phone components, and the harmony of the whole cell phone. Among them, the body colour of the phone is the most eye-catching feature, and makes the direct first impression. That is why it is studied separately. The preference of the physical appearance and body colour is subjective and depends on the user's aesthetic

Downloaded by [DUT Library] at 12:50 08 October 2014

Table 5. Correlation matrix of cell phone features and user's satisfaction.

Cell phone feature	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Body colour	1.00																				
2. Ringtones range	0.28	1.00																			
3. Keypad design	0.29	0.20	1.00																		
4. Physical appearance	**0.53**	0.30	0.33	1.00																	
5. Game	0.23	**0.43**	0.15	0.18	1.00																
6. One touch dialling	0.22	0.22	0.22	0.24	0.24	1.00															
7. Phone book	0.32	0.25	0.32	0.31	0.21	0.21	1.00														
8. Call log memory	0.27	0.26	0.24	0.29	0.18	0.23	0.50	1.00													
9. Caller ID	0.30	0.20	0.28	0.30	0.13	0.19	**0.47**	0.39	1.00												
10. Organiser feature	0.29	0.29	0.21	0.25	0.33	0.28	0.34	0.27	0.19	1.00											
11. Alarm reminder	0.24	0.23	0.21	0.23	0.25	0.20	0.32	0.28	0.26	**0.55**	1.00										
12. Vibrating alert	0.29	0.29	0.24	0.29	0.18	0.21	0.37	0.31	0.36	0.30	0.33	1.00									
13. Voice mail	0.29	0.19	0.28	0.26	0.22	0.26	**0.45**	0.38	**0.41**	0.26	0.24	0.31	1.00								
14. Personalisation	0.38	**0.41**	0.23	0.32	**0.41**	0.21	0.34	0.28	0.27	0.37	0.26	0.27	0.28	1.00							
15. Menu organisation	0.33	0.25	0.35	0.32	0.27	0.23	**0.48**	**0.41**	0.36	**0.40**	0.33	0.31	**0.42**	0.39	1.00						
16. Size of cell phone	0.34	0.22	0.30	**0.46**	0.15	0.12	0.29	0.21	0.32	0.21	0.18	0.26	0.24	0.26	0.26	1.00					
17. Weight of cell phone	0.36	0.20	0.28	**0.44**	0.12	0.15	0.24	0.19	0.29	0.21	0.17	0.28	0.22	0.19	0.26	**0.65**	1.00				
18. Durability	0.25	0.23	0.35	0.25	0.22	0.21	0.27	0.27	0.26	0.24	0.22	0.26	0.27	0.27	0.29	0.18	0.17	1.00			
19. Button size	0.32	0.17	**0.54**	0.31	0.13	0.25	**0.40**	0.30	0.32	0.24	0.25	0.27	0.27	0.22	**0.40**	0.27	0.22	0.30	1.00		
20. Battery duration	0.26	0.21	0.33	0.24	0.19	0.20	0.25	0.27	0.24	0.24	0.24	0.24	0.24	0.23	0.29	0.26	0.26	**0.54**	0.30	1.00	
21. User's satisfaction	**0.45**	0.35	0.35	**0.51**	0.24	0.24	**0.44**	0.36	0.36	0.30	0.25	0.36	0.35	**0.41**	**0.44**	**0.50**	**0.40**	0.39	0.32	0.37	1.00

Notes: 1) All correlation coefficients are significant ($p < 0.001$).
2) Correlation coefficients in bold type indicate moderate correlations ($r \geqslant 0.4$).

Downloaded by [DUT Library] at 12:50 08 October 2014

Table 6. Factor analysis of cell phone features.

Cell phone features	Factor 1	Factor 2	Factor 3	Factor 4	Factor5	Factor 6	Factor 7	Factor 8	Factor 9	Communality estimates
Body colour	0.19208	0.14505	0.15092	0.12356	0.12199	0.10965	**0.80662**	0.05844	0.04234	0.77872
Ringtones range	0.07442	**0.73348**	0.08550	0.02190	0.07430	0.08049	0.14907	0.06306	0.37811	0.73248
Keypad design	0.13939	0.10155	0.18344	0.04031	**0.79830**	0.21190	0.08987	0.07534	0.05050	0.76351
Physical appearance	0.15682	0.10276	0.33970	0.07399	0.15764	0.08511	**0.71858**	0.10678	0.11676	0.72951
Game	0.09762	**0.79648**	0.07021	0.18565	0.02674	0.09427	−0.03672	0.15748	−0.06290	0.72301
One touch dialling	0.14494	0.13359	0.02441	0.12205	0.12607	0.08585	0.11627	**0.91818**	0.06402	0.93828
Phone book	**0.70800**	0.12258	0.07804	0.19574	0.24220	0.03768	0.12337	−0.04209	0.13043	0.65478
Call log memory	**0.66486**	0.09458	−0.02758	0.10950	0.05913	0.15837	0.17222	0.05423	0.17590	0.55585
Caller ID	**0.65780**	0.02130	0.22639	−0.00532	0.11616	0.09979	0.08188	0.00671	0.29691	0.60279
Organiser feature	0.16015	0.23856	0.08536	**0.79666**	0.06484	0.09738	0.12665	0.13308	−0.00089	0.77194
Alarm reminder	0.16575	0.07218	0.05687	**0.82343**	0.09097	0.09814	0.06418	0.02132	0.20901	0.78012
Vibrating alert for message and call	0.28433	0.11136	0.13630	0.21812	0.10538	0.10732	0.10618	0.06559	**0.76253**	0.77905
Voice mail	**0.71980**	0.10814	0.14374	0.06622	0.04086	0.12300	0.04081	0.24574	−0.06670	0.63814
Personalisation	0.27844	**0.62696**	0.04059	0.17259	0.07271	0.10687	0.33883	−0.07581	−0.05152	0.64195
Menu organisation	**0.56341**	0.22383	0.11181	0.31895	0.30488	0.09364	0.13847	−0.01960	−0.16300	0.62961
Size of cell phone	0.16616	0.11377	**0.83809**	0.05876	0.13916	0.07074	0.17837	−0.02875	0.04922	0.80583
Weight of cell phone	0.11565	0.03915	**0.85435**	0.08253	0.08469	0.09291	0.18379	0.06006	0.08639	0.81229
Durability	0.17280	0.14102	−0.00348	0.06486	0.17536	**0.81382**	0.11223	0.05573	0.09262	0.77129
Button size	0.24449	0.01353	0.05797	0.11953	**0.80685**	0.10920	0.15620	0.07576	0.07955	0.77701
Battery duration	0.14538	0.07443	0.17606	0.12801	0.12815	**0.82774**	0.06661	0.04626	0.02509	0.78285
Variance explained by each factor	2.69178	1.82603	1.77335	1.66387	1.62301	1.56233	1.53784	1.00148	0.98933	14.66903
% Variance explained by each factor	13.5	9.1	8.9	8.3	8.1	7.8	7.7	5.0	4.9	73.3

perspective. Thus, Factor 7 is named the 'aesthetic aspect' of the phone. Factors 8 and 9 have only one loading item: one touch dialling and vibrating alert, respectively. So, they are named after their respective loading features.

For those factors that included more than one feature, their Cronbach's alpha values were calculated. All were above or very close to 0.70, which indicate acceptable internal consistency. The nine factors with their corresponding design features and internal consistency values are listed in table 7. All nine factors can be used as different aspects for the designer to consider.

4.4 *Multiple regressions*

Two multiple linear regression analyses were carried out to investigate how the 20 design features and the nine design factors identified earlier predict the users' overall satisfaction.

4.4.1 Multiple regressions between user satisfaction and the 20 design features. To investigate how preferences of the 20 design features can predict the users' overall satisfaction, a multiple regression model was used. We checked the assumptions of normality, constant variance and linearity first, and didn't find any violation against them. Using the overall satisfaction as the dependent variable, and the cell phone design features as the independent variables, we performed a stepwise multiple regression analysis to select the significant independent variables. As a result, 10 design features were selected, which together accounted for 49.95% of the user's overall satisfaction. The 10 selected features include: physical appearance, size of cell phone, menu organisation, durability, phone book, personalisation, body colour, ringtone range, battery duration and vibrating alert for messages and calls. Among them, the three most significant features that predict the variation of overall satisfaction are physical appearance (with partial R-square of 0.26), the size of cell phone (with partial R-square of 0.09) and the menu organisation (with partial R-square of 0.06), which together accounts for 42% of the total variance of user's overall satisfaction. The result of the stepwise multiple regression analysis is shown in table 8.

4.4.2 Multiple regressions between user satisfaction and the nine design factors. Similarly, when we use the user's overall satisfaction as the dependent variable, and the nine cell phone design factors extracted by the factor analysis as the independent variables, we carried out another stepwise multiple regression analysis to investigate which design factors best predict the overall satisfaction (see table 9). The result produced five important design factors including aesthetic aspect, calling-related function, portability, durable aspect and personal preference. All five factors together accounted for 47.22% of the user's overall satisfaction. Since design factors are different design aspects for the designer to consider, the designers should consider the selected five factors first while assigning design resources.

Among the five significant design factors, the two most significant are aesthetic aspect (with partial R-square of 0.30) and calling-related function (with partial R-square of 0.10), which together accounted for 38% of the user's

Table 7. Factor s and internal consistencies.

Factors	Cell phone features	Cronbach's alpha
Factor 1 (Calling-related feature)	Phone book	0.79
	Call log memory	
	Caller ID	
	Voice mail	
	Menu organisation	
Factor 2 (Personal preference)	Ringtones range	0.68
	Game	
	Personalisation	
Factor 3 (Portability)	Size of cell phone	0.78
	Weight of cell phone	
Factor 4 (Organising feature)	Organiser feature	0.71
	Alarm reminder	
Factor 5 (Keypad area design)	Keypad design	0.70
	Button size	
Factor 6 (Durable aspect)	Durability	0.70
	Battery duration	
Factor 7 (Aesthetic aspect)	Body colour	0.69
	Physical appearance	
Factor 8 (One touch dialling)	One touch dialling	Not applicable[1]
Factor 9 (Vibrating alert)	Vibrating alert for message and call	Not applicable[1]

Note: 1) Has only one variable.

Downloaded by [DUT Library] at 12:50 08 October 2014

Downloaded by [DUT Library] at 12:50 08 October 2014

overall satisfaction. When results from the two multiple regression analyses are looked at together, we can see more clearly that these two significant factors are indeed important design aspects to consider because most of their contributing features were also selected as significant. Both contributing features for aesthetic aspect of the cell phone such as the physical appearance and the body colour were selected among the significant features. Since people not only use cell phones as a means of communication, but also look upon it as a means to enhance their personal image, it is very important for designers to design good-looking cell phones in order to satisfy their users. For the calling-related features of the cell phone, two contributing features such as menu organisation and phone book were selected as significant features. The initial and essential role of cell phones is to make and receive phone calls. To streamline the features related to placing and receiving a phone call, the menu needs to be designed with good traversal and navigation ability, and phone books need to have larger capacity and better usability.

4.5 *Comparisons*

For 20 cell phone features, various comparisons are conducted to find whether there is any significant difference in the user's preference level between genders, manufacturers and models within a manufacturer.

4.5.1 Comparison between genders. The preference scores of the male and female subjects were compared for each feature (see table 10). The result indicated that male and female college students have significant different preferences on three phone features: games, alarm reminders and button size.

Although the statistical differences between genders for the three features are significant, the practical differences are not big enough to be meaningful. The result might indicate some behavioural differences between genders. For the game feature, the preference score of the male subjects is 4.6% higher than that of the female subjects. This might indicate that male students are more likely to play games on

Table 8. Prediction of user satisfaction: stepwise selection of cell phone features.

Step	Cell phone feature	Partial R-square	Model R-square	F-value	*p*-value
1	Physical appearance	0.2598	0.2598	352.40	<.0001
2	Size of cell phone	0.0920	0.3518	142.33	<.0001
3	Menu organisation	0.0635	0.4153	108.75	<.0001
4	Durability	0.0384	0.4537	70.37	<.0001
5	Phone book	0.0193	0.4729	36.57	<.0001
6	Personalisation	0.0105	0.4835	20.35	<.0001
7	Body colour	0.0059	0.4893	11.52	0.0007
8	Ringtones range	0.0053	0.4947	10.48	0.0012
9	Battery duration	0.0026	0.4973	5.20	0.0227
10	Vibrating alert for message and call	0.0022	0.4995	4.35	0.0372

Table 9. Prediction of user satisfaction: stepwise selection of cell phone factor s.

Step	Factor	Partial R-square	Model R-square	F-value	*p*-value
1	Aesthetic aspect (Factor 7)	0.2963	0.2963	422.84	<.0001
2	Calling-related feature (Factor 1)	0.0979	0.3942	162.08	<.0001
3	Portability (Factor 3)	0.0415	0.4357	73.64	<.0001
4	Durable aspect (Factor 6)	0.0261	0.4618	48.60	<.0001
5	Personal preference (Factor 2)	0.0104	0.4722	19.70	<.0001

Table 10. Gender difference in preference of cell phone feature.

	Mean					
Cell phone feature	Male	Female	% mean difference[1]	DF	t-value	*p*-value
Game	4.80	4.58	4.6	1004	2.56	0.0107
Alarm reminder	5.38	5.55	−3.2	1004	−2.13	0.0337
Button size	5.43	5.55	−2.2	886[2]	−2.14	0.0324

Notes: 1) % mean difference = {(male mean – female mean) / male mean} × 100
2) Degree of freedom is calculated with Satterthwaite method (1946) due to unequal variance of the two gender's data.

Downloaded by [DUT Library] at 12:50 08 October 2014

cell phones and get more enjoyment from it. For the alarm reminder feature, female students have a 3.2% higher preference score than male students. This may indicate that female students used the alarm reminders more often and find them more useful than male students. For the button size feature, the preference score for the female students is 2.2% higher than male students. The reason for this might be that the cell phone buttons are getting smaller as the phone size decreases. Since males tend to have bigger fingers than females, the male students might find the buttons too small to use whereas the female students are not bothered.

4.5.2 Comparison among manufacturers. Comparisons were made among the four most popular manufacturers: Nokia, Motorola, Samsung and Sony Ericsson, to find out whether they are significantly different from each other regarding each design feature. Twelve design features were found to be significantly different among the four manufacturers. For each of the 12 features, Duncan's multiple range tests were run to compare all the manufacturers. The preferred group and not-preferred group with different manufacturers were identified. The models in the preferred group are significantly different from the ones in the not-preferred group in terms of a user's preference level. The analysis result is shown in table 11. The manufacturers should continue to maintain their high standards in the features in which they performed best, and emulate the good design to improve on those features in which they performed not so well.

4.5.3 Comparison among different models of Nokia. Nokia is currently the world's largest cell phone manufacturer with the largest market share. In our collected data, it also has the largest number of users and is the most preferred manufacturer for many design features. Therefore, we decided to scrutinise this manufacturer, and find out which models made by Nokia are preferred most regarding the 20 design features. The seven most used Nokia models in our survey data are presented in figure 2 and were compared using ANOVA.

These seven models include a range of different designs. Nokia 3650 has a rotary keypad. Nokia 3595 puts two numbers on one button. The others use the traditional 12-key keypad. The release time of these seven models ranges from the first quarter of 2001 to the fourth quarter of 2003. Duncan's multiple range tests were run to compare all the models. The result is shown in table 12. Four features including phone book, size of cell phone, weight and physical appearance, have significantly different preference scores among the seven models. For each feature, the

Table 11. Significant difference in preference of cell phone feature among four manufacturers (Nokia, Samsung, Motorola and Sony Ericsson).

			Duncan Grouping	
Cell phone feature	F-value[1]	p-value	Preferred group (mean)	Not-preferred group (mean)
Phone book	4.15	0.0063	Nokia (5.93), Motorola (5.93)	Sony Ericsson (5.71), Samsung (5.70)
Menu organisation	3.36	0.0183	Nokia (5.73), Motorola (5.60), Sony Ericsson (5.56)	Motorola (5.60), Sony Ericsson (5.56), Samsung (5.46)
Ringtones range	5.19	0.0015	Nokia (5.34), Sony Ericsson (5.19), Motorola (5.11)	Motorola (5.11), Samsung (4.89)
Game[3]	5.29	0.0013	Nokia (4.96), Sony Ericsson (4.92)	Motorola (4.68), Samsung (4.56)
Size of cell phone	2.82	0.0378	Samsung (5.81), Motorola (5.63), Sony Ericsson (5.57)	Motorola (5.63), Sony Ericsson (5.57), Nokia (5.52)
Weight of cell phone	4.14	0.0063	Samsung (5.78)	Sony Ericsson (5.49), Motorola (5.47), Nokia (5.44)
Organiser feature	3.33	0.0192	Sony Ericsson (5.30), Samsung (5.19), Nokia (5.18)	Motorola (4.93)
Alarm reminder	17.11	$<.0001$	Sony Ericsson (5.67), Nokia (5.65), Samsung (5.60)	Motorola (4.91)
Button size	2.90	0.0344	Samsung (5.54), Motorola (5.52), Nokia (5.45)	Nokia (5.45), Sony Ericsson (5.27)
Durability	4.78	0.0026	Nokia (5.61)	Samsung (5.34), Motorola (5.29), Sony Ericsson (5.24)
Battery duration	3.26	0.0211	Nokia (5.65), Motorola (5.43)	Motorola (5.43), Samsung (5.37), Sony Ericsson (5.35)
One touch dialling	2.74	0.0423	Samsung (5.40), Nokia (5.39), Sony Ericsson (5.33)	Sony Ericsson (5.33), Motorola (5.13)

Notes: 1) Degree of freedom is (3,804).
2) Sample sizes are Nokia = 278, Samsung = 225, Motorola = 161 and Sony Ericsson = 144.
3) Sony Ericsson and Motorola are also grouped together by the Duncan test.

Figure 2. Seven Nokia phone models studied (images reproduced here with permission from Nokia).

Downloaded by [DUT Library] at 12:50 08 October 2014

preferred group and not-preferred group with different models are identified. The models in the preferred group are significantly different from the ones in the not-preferred group, in terms of the user's preference. The comparison result is interesting because Nokia 8265, an older phone model released in the second quarter of 2002, is always in the preferred group, whereas the newer models such as Nokia 3650 and Nokia 6600 end up in the not-preferred group. This tells us that the newer models are not necessarily better in terms of a user's preference.

When we look at the design specifications for the four features of the models in table 12, we can see some trends in customer's preferences. The phone book design comprises different aspects such as storage capacity, phone number display options (i.e. name with large font, name list, or name and number) and the possibility of using a phone number from memory (fetch service). For the phone book design, the most preferred model – Nokia 8265 – has a capacity of 250 entries. The Nokia 3595, which is also in the preferred group, has a capacity of 500 entries. In the not-preferred group, the Nokia 3360 only has a capacity of 200 entries. Therefore, we may conclude that users prefer cell phones with phonebooks of higher storage capacity.

For the size of the cell phone, the most preferred model – Nokia 8265 – has a physical dimension of 107mm long × 48mm wide × 22mm thick. It is the size that can fit comfortably in any purse or blouse pocket, and can be comfortably held in one hand. In contrast, the least preferred model – Nokia 3650 – has a physical dimension of 130mm long × 57mm wide × 26mm thick. It is more cumbersome to carry around. Therefore, our data indicates higher user preference for smaller cell phones.

For the weight of the cell phone, the most preferred model – Nokia 6610 – only weighs 84 grams, whereas the least preferred model – Nokia 6600 – weighs 125 grams. Those in the not-preferred group are heavier than those in the preferred group. Thus, the data suggests that the users prefer cell phones that are lighter in weight.

For the physical appearance, the most preferred model is the Nokia 8265, and the least preferred one is the Nokia 3595. The Nokia 8265 model was designed for the style-conscious and socially active consumer. Tremendous design efforts have been put into the aesthetic aspect of the phone. Its keypads and display lenses can produce a colourful glow when the phone's backlight is activated, which accent the new covers and add appeal to the stylish target market

Table 12. Significant difference in preference of cell phone feature among seven models of Nokia (3360, 3390, 3595, 3650, 6600, 6610 and 8265).

			Duncan Grouping	
Cell phone feature	F-value[1]	p-value	Preferred group (mean)	Not-preferred group (mean)
Phone book	2.35	0.0346	8265 (6.59), 3595 (6.02)	3595 (6.02), 6610 (5.93), 6600 (5.77), 3390 (5.73), 3650 (5.68), 3360 (5.35)
Size of cell phone	4.76	0.0002	8265 (5.88), 3360 (5.80), 6610 (5.78), 3390 (5.66), 3595 (5.11)	3595 (5.11), 6600 (4.65), 3650 (4.54)
Weight of cell phone[3]	3.53	0.0029	6610 (5.76), 8265 (5.68), 3390 (5.44), 3360 (5.18), 3595 (5.15)	3390 (5.44), 3360 (5.18), 3595 (5.15), 3650 (4.80), 6600 (4.53)
Physical appearance	2.61	0.0203	8265 (5.96) 6610 (5.66) 3650 (5.62)	6610 (5.66), 3650 (5.62), 6600 (5.22), 3360 (5.11), 3390 (5.04), 3595 (5.02)

Notes: 1) Degree of freedom is (6,126).
2) Sample sizes are 3360 = 11, 3390 = 9, 3595 = 19, 3650 = 20, 6600 = 18, 6610 = 45 and 8265 = 11.
3) Nokia Models 8265, 3390, 3360, 3595, 3650 are also grouped together by the Duncan test.

Downloaded by [DUT Library] at 12:50 08 October 2014

(Nokia 2002). In contrast, the Nokia 3595 is a more technology-driven model with many features, but uses an unconventional keypad design with two numbers on the upper and lower side of a button. Not only does it put extra mental load on the user – because users have to mind which side of the key they are pressing – it also looks odd. This might be the reason that it received lower user preference. Since the physical appearance deals with aesthetic aspect of the design and is quite subjective, it is hard to say what kind of design will be preferred more. Special efforts from the manufacturers should be employed to enhance style and the appeal of the physical appearance.

5. Conclusion

The dataset we collected includes those of the four major cell phone manufacturers: Nokia, Motorola, Samsung and Sony Ericsson. Our data captured young college students' perspective of their current cell phones. We derived nine design factors for cell phones from factor analysis. With multiple regression analysis, we derived the 10 most important design features for user's overall satisfaction, which explained 49.95% of the variance that accounts for user's overall satisfaction. The analysis shows that the most important design features are: the physical appearance, size and menu organisation, which together accounts for 42% of the total variance contributing to customer satisfaction. For the 12 design features that have significant difference among manufacturers, the best and worst manufacturer regarding each feature was established from the survey. We also confirmed some common thoughts in user preference with our data, for example users prefer smaller and lighter handsets, and they prefer larger phone book capacity. Since we used participative evaluation methods including interview and questionnaire, our data captures the user's preference with high ecological validity. All of our study is based on our collected data, and there is no implication on other products of the manufacturers studied.

The purpose of this study is to prioritise the design features and design aspects of cell phones based on user's feedback to optimise the customer's satisfaction. Current technology has enabled more fancy and appealing features to be added to cell phones. However, instead of having a technology-driven design with a laundry list of features but difficult-to-use functions, we should take the user-goal-driven strategy (Cooper 1999). When the development resources are limited, the most important design factors and features should receive the most attention. Although new features are emerging, features related to the aesthetic look of the phone, the calling-related factors and portability heavily affect the user's overall satisfaction. Based

Table 13. Classification of cell phone features.

Classification	Features Impacting overall satisfaction[1]	Features which do not impact overall satisfaction
Above average score of preference[2]	Size	Keypad design
	Body colour	Call log memory
	Menu organisation	Caller ID
	Physical appearance	Voice mail
	Battery duration	Weight
	Phone book design	Button size
	Vibrating alert	
Below average score of preference	Durability	Game
	Personalisation	One touch dialling
	Ring tone range	Organiser
		Alarm alert

Notes: 1) Significant cell phone features to overall satisfaction of cell phone based on multiple regression.
2) Cell phone features whose preference scores are above overall average (5.5).

Downloaded by [DUT Library] at 12:50 08 October 2014

on our analysis of user's preference and satisfaction data, our major suggestion is never to underestimate the impact of the basic design features and factors of the cell phone. While developing new features, cell phone manufacturers should keep on applying their resources to enhance these important features. This result agrees with opinions held by Consumer Reports (2004).

Based on descriptive statistics and multiple regression analysis, the 20 design features can be classified as illustrated in table 13. The multiple regressions analysis can classify the features into those impacting overall satisfaction and those that do not. The basic statistics can classify them into above average and below average, based on the average preference scores that they received. In our basic statistics analysis, the average score for all of the features is 5.5; therefore, features receiving a preference score above or equal to 5.5 are considered to be above average, and below 5.5 are considered as below average. These are subjective descriptions and do not consider the fact that some numbers may be below or above the average, but they may not be statistically different from the average. Then, design efforts can be prioritised. For significant features with above-average scores, continuous effort should be put to maintain their excellent standard. For significant features with below-average scores, it is urgent for manufacturers to spend effort and resources improving these features. For insignificant features with above-average scores, manufacturers should not spend a lot of resource on them now. For insignificant features with below-average scores, manufacturers should improve them when resources permit.

Due to the characteristics of the survey study, we have no control over which manufacturers or models will be included in our data. In fact, the data we collected is so diverse that it includes more than 10 cell phone manufacturers. Within each manufacturer, there are usually more than 10 models including old and new ones. On the one hand, this kind of data can represent the diversity in the current cell phone market and give the variance we needed in our analysis. On the other hand, it makes it difficult to perform statistical analysis on individual models within manufacturers, due to the small sample size for each cell phone model. That is why we only performed ANOVA on the seven Nokia models, which has the more concentrated data points. In order to perform model-to-model comparison, further investigation with usability experiment could be carried out to derive more specific design guidelines to improve individual features.

Survey study is a very useful input for knowledge base. Since our survey is based on currently available cell phone models and features, it just tells us which is best among the current designs. It is possible that empirical experiments can end up with better designs and guidelines for the cell phone features. The survey study serves to help reduce the investigation scope and provide a helpful base to design further empirical experiments.

Acknowledgement

We want to give sincere thanks to the students in the Job Design classes in the spring semester of 2004 at Purdue University for their effort of data collecting in this study. This work was supported by the Soongsil University Research Fund.

References

Alm, H. and Nilsson, L., 1995, The effects of a mobile telephone task on driver behavior in a car following situation. *Accident Analysis and Prevention*, **27,** pp. 707–715.

Amant, R., Horton, T.E. and Ritter, F.E., 2004, Model-based evaluation of cell phone menu interaction. In *Proceedings of the ACM Conference in Human Factors in Computing Systems (CHI)*, E. Dykstra-Erickson and M. Tscheligi (Eds), 24–29 April, Vienna, Austria (New York: ACM), pp. 343–350.

Arnfield, R., 2004, Nokia losing ground. *Wireless Newsfactor*. Available online at www.newsfactor.com/story.xhtml?story_title=Study__Nokia_LosingGround&story_id=26131 (accessed 2 August 2004).

BERG, S., TAYLOR, A.S. and HARPER, R., 2003, Mobile Phones for the next generation: Device designs for teenagers. In *Proceedings of the Conference on Human Factors and Computing systems CHI 2003*, 5 – 10 April, Fort Lauderdale, Florida, pp. 433 – 440.

BOCKER, M. and SUWITA, A., 1999, The evaluation of the Siemens C10 mobile phone: usability testing beyond 'quick and easy'. In *Proceedings of the Human Factors and Ergonomics Society, 43rd Annual Meeting* (Santa Monica: HFES), pp. 379 – 383.

BUCHANAN, G., MARSDEN, G. and PAZZANI, M., 2001, Improving mobile internet usability. In *Proceedings of the 10th International Conference on World Wide Web*, May 2001 (Hong Kong, China), pp. 673 – 680.

CHAE, M. and KIM, J., 2003, What's so different about the mobile internet? *Communications of the ACM*, **46,** pp. 240 – 247.

CHAE, M. and KIM, J., 2004, Do size and structure matter to mobile users? An empirical study of the effects of screen size, information structure, and task complexity on user activities with standard web phones. *Behaviour and Information Technology*, **23,** pp. 165 – 181.

CHARNEY, B., 2003, Cell Phone user to double. *CNET News*. Available online at http://news.com.com/2100-1039-5060745.html (accessed 4 August 2004).

CONSUMER REPORTS, 2004, Best Phones: Basic features matter most, 21 – 24 February.

COOPER, A., 1999, *The Inmates are Running the Asylum* (Indianapolis: Macmillan Computer Publishing), pp. 179 – 201.

COX, A. and WALTON, A., 2004, Evaluating the viability of speech recognition for mobile text entry. *HCI 2004: Design for life*, 6 – 10 September (Leeds Metropolitan University, UK), pp. 25 – 28.

CRAMER, D., 1997, *Basic Statistics for Social Research* (NewYork: Routledge), pp. 277 – 280.

DUNLOP, M.D. and CROSSAN, A., 2000, Predictive text entry methods for cell phones. *Personal Technologies*, **4,** pp. 134 – 143 (London: Springer-Verlag).

FRENZEL, L.E., 2004, March of the cell phones. *Electronic Design*. Available online at www.elecdesign.com/Articles/Index.cfm?ArticleID = 7056 (accessed 12 January 2004).

HAN, S.H., KIM, K.J., YUN, M.H., HONG, S.W. and KIM, J., 2004, Identifying mobile phone designing features critical to user satisfaction. *Human Factors and Ergonomics in Manufacturing*, **14,** pp. 15 – 29.

HARDELL, L., NASMAN, A., PAHLSON, A., HALLQUIST, A. and MILD, K.H., 1999, Use of cellular telephone and the risk for brain tumors: a case-control study. *International Journal of Oncology*, **15,** pp. 113 – 116.

HILBERT, D.M. and REDMILES, D.F., 2000, Extracting usability information from user interface events. *ACM Computing Survey*, **32,** pp. 384 – 421.

HIROTAKA, N., 2003, Reassessing current cell phone designs: using thumb input effectively. *Proceedings of CHI '03* (Ft. Lauderdale, Florida: ACM), pp. 938 – 939.

INSKIP, P.D., TARONE, R.E., HATCH, E.E., WILCOSKY, T.C., SHAPIRO, W.R., SELKER, R.G., FINE, H.A., BLACK, P.M., LOEFFLER, J.S. and LINET, M.S., 2001, Cellular-telephone use and brain tumors. *New England Journal of Medicine*, **344,** pp. 79 – 86.

ISREALSKI, E. and LUND, A.M., 2003, The evolution of human – computer interaction during the telecommunications revolution. In *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications*, J.A. Jacko and A. Sears (Eds), pp. 772 – 789 (Mahwah: Lawrence Erlbaum Associates).

JAMES, C.L. and REISCHEL, K.M., 2001, Text input for mobile devices: comparing model prediction to actual performance. In *Proceedings of the CHI 2001*, New York, pp. 365 – 371.

KLOCKAR, T., CARR, D., HEDMAN, A., JOHANSSON, T. and BENGTSSON, F., 2003, Usability of mobile phones. In *Proceedings of the 19th International Symposium on Human Factors in Telecommunications*, 1 – 4 December, Berlin, Germany, pp. 197 – 204.

LEMELSON-MIT PROGRAM, 2004, Cell phone edges alarm clock as most hated invention, yet one we cannot live without. Available online at http://web.mit.edu/invent/n-pressreleases/n-press-04index.html (accessed 15 July 2004).

MACKENZIE, I.S. and SOUKOREFF, R.W., 2002, Text entry for mobile computing: Models and methods, theory and practice. *Human-Computer Interaction*, **17,** pp. 147 – 198.

NOKIA, 2002, Nokia introduces freshly-styled, wireless internet-enabled phone for the stylish set. Available online at http://press.nokia.com/PR/200201/846005_5.html (accessed 10 August 2004).

NORMAN, D., 1988, *The Design of Everyday Things* (New York: Basic Books), pp. 172 – 177.

PARKS, A.M. and WARD, N., 2001, Case study: a safety and usability evaluation of two different car-phone designs. *International Journal of vehicle design*, **26,** pp. 165 – 169.

SALVENDY, G. and CARAYON, P., 2001, Data collection and evaluation of outcome measures. In *Handbook of Industrial Engineering: Technology and Operations Management*, Third Edition, G. Salvendy (Ed.), pp. 1451 – 1468 (New York: John Wiley & Sons).

SATTERTHWAITE, F.E., 1946, An approximate distribution of estimates of variance components. *Biometrics Bulletin*, **2,** pp. 110 – 114.

SCHAFER, J.L. and GRAHAM, J.W., 2002, Missing data: our view of the state of the art. *Psychological Methods*, **7,** pp. 147 – 177.

SILFVERBERG, M., MACKENZIE, S. and KORHONEN, P., 2000, Predicting text entry speed on mobile phones. In *Proceedings of the ACM CHI 2000 Conference on Human Factors in Computing Systems* (New York: ACM), pp. 9 – 16.

SMITH-JACKSON, T., NUSSBAUM, M.A. and MOONEY, A.M., 2003, Accessible cell phone design: development and application of a need-analysis framework. *Disability and Rehabilitation*, **25,** pp. 549 – 560.

ST AMANT, R., HORTON, T.E. and RITTER, F.E., 2004, Model-based evaluation of cell phone menu interaction. In *Proceedings of the ACM Conference on Human Factors in Computing Systems CHI 2004*, 24 – 29 April, Vienna, Austria, pp. 343 – 350.

STRAYER, D.L. and JOHNSTON, W.A. 2001, Driven to distraction: Dual task studies of simulated driving and conversing on a cellular phone. *Psychological Science*, **12,** pp. 462 – 466.

WATZMAN, S., 2003, Visual design principles for usable interfaces. In *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications*, J.A. Jacko and A. Sears (Eds), pp. 263 – 285 (Mahwah: Lawrence Erlbaum Associates).

WEISS, S., 2002, *Handheld Usability* (West Sussex, England: John Wiley & Sons), pp. 4 – 6.

Downloaded by [DUT Library] at 12:50 08 October 2014