SMS Usage Satisfaction
Influences of Hand Anthropometry and Gender

Vimala Balakrishnan & Paul H.P. Yeow, Multimedia University, Melaka, Malaysia

Hand anthropometry and gender influences on Short Message Service (SMS) usage satisfaction were investigated using structured questionnaire interviews with 110 participants. The collected data were then filtered, resulting in a total of 73 participants. Hand-size, thumb length, circumference and mobile phone dimensions were recorded. Focus was on keypad design factors, which include: key size, shape, layout, texture, simplicity and space between keys. Females were found to be more satisfied with the key size and layout than males. Significant differences were noted among subjects with different hand-size with respect to key size and space between keys. One of the recommended improvements is to have larger keys with more space between them for those with large hand-size. The results obtained can be used by mobile phone designers to design customized mobile phones; for example, mobile phones that suit users with larger hands and thumbs, especially males.

Keywords: hand anthropometry, gender, keypad design factors

Short Message Service (SMS) is a service that allows users to communicate non-vocally, expressing themselves via combinations of alphanumerical characters with a maximum of 160 characters per single SMS message. The first text message is thought to have been sent to a mobile phone in 1992 (GSM 2000). Since then, mobile phone messaging has exploded. The Mobile Data Association (MDA) has reported

Balakrishnan, Vimala & Paul H.P. Yeow. "SMS Usage Satisfaction: Influences of Hand Anthropometry and Gender." *HUMAN IT* 9.2(2007): 52–75.

that 133 million text messages were sent in the United Kingdom between midnight December 31st 2004 and midnight January 1st 2005, making it the highest ever recorded daily quantity of SMS messages sent (text.it 2005). Ericsson reported that SMS has been the biggest mobile data service thus far in Malaysia (Wong & Pang 2005). SMS growth is being driven by inexpensive, convenient, interpersonal communication, as well as by applications in business and games. Moreover, it is a fast medium of communication as a message can be delivered to the recipient within a matter of seconds.

A study conducted by Barkhuus (2005) revealed that SMS plays an important role in young adults' lives as it helps them to overcome shyness and to manage their social lives by building and maintaining their relationships. SMS was also found to be hugely popular among young adults in Norway (Ling 2001). The technique was found to help users develop new and deeper relationships with "text mates" and altered the way they express themselves (Reid & Reid 2004). Grinter and Eldridge (2001) analyzed texting patterns among British boys and girls aged between 15 and 16 years old. They found that females send and receive more messages than males, and that messages are commonly used to adjust meeting times from conversations that already took place between two people. A questionnaire study conducted by Faulkner and Culwin (2005) examined texting activities among mobile phone users and found that these activities decline with age and that females engage in text messaging more than males. Oksman and Rautiainen (2003) observed similarities in the ways teenagers in Finland and other Nordic countries use mobile phones to develop and maintain social networks, resulting in their own communications culture. Though numerous studies have been conducted related to SMS, very few were related to SMS users' subjective satisfaction (Yun *et al*. 2003; Han *et al.* 2004).

The image or impression a user has while interacting with a product design determines the user's satisfaction level. According to Wong and Pang (2005), the success of mobile services depends ultimately on the successful development and the satisfaction of an end user market rather than on technical development. This notion is also supported by Melcher *et al*. (2003), who claim that the success of technological improvements in mobile communication will be determined by the level of user

centeredness of applications and devices. The concept of user satisfaction has been used since the early 1980s and it can be seen as the sum of a user's feelings and attitudes with regard to several factors that affect the usage situation (Bailey & Pearson 1983). The success or failure of any product is heavily dependent on the end users' satisfaction. A key element affecting user satisfaction with a mobile phone is device ergonomics. The industrial and mechanical designers face a challenging task in fitting the display, keys and other components into an appealing, ergonomic and durable package that is of the right size and usable with only one hand. SMS is interesting from a usability point of view, as the cumbersome interaction design of the mobile phone goes against fundamental usability guidelines, since it is fitted on resource-poor devices, with small screens and poor keypads.

Mobile Phone Keypads

Mobile phones still have a keyboard designed for dialing numbers, which makes text messaging difficult. The standard ISO mobile phone has only 12 keys ('0'-'9', '#' and '*') to input the entire alphabets, punctuations and numerical characters (Figure 1). Each physical key is therefore overloaded with three or four alphabetical characters; for example, the digit '9' is used for 'W', 'X', 'Y' and 'Z'. Consequently, this requires the users to make multiple key presses in order to make their intended selection.

Studies related to keypad designs are numerous; however, most attempt to tackle keypad design problems by focusing on the text input mechanism (Mackenzie 2002; Wigdor & Balakrishnan 2004; Ward *et al.* 2000; Silfverberg *et al.* 2000). The Fastap keypad was designed by placing 52 independent keys onto an area the same size as the standard ISO keypad. Though it offers an increased performance over an ISO keypad, it remains to be seen how mobile phone users will assess the trade-off between the increased performance of advanced input technologies and their additional cost (Cockburn & Siresena 2003). The tiny sizes of keys were also identified as one of the problems related to mobile phone use in several studies (Maragoudakis *et al.* 2002; Kurniawan *et al.* 2006; Soriano *et al.* 2005). A study conducted with a group of elderly people revealed that keys that are placed too close to one

another cause problems while handling a mobile phone (Ornella & Stephanie 2006).

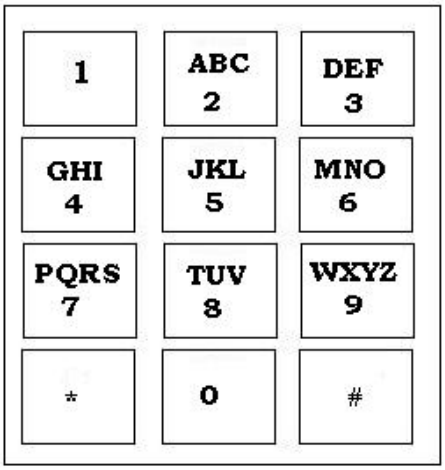

Figure 1. Standard ISO 12-key keypad design.

Anthropometry

Anthropometric data (physical measurements) can be used in ergonomics to specify the physical dimensions of workspaces, workstations and equipment, as well as be applied in related product design (Bridger 1995). Many studies have used anthropometric data in various product designs; however, none of these involved mobile phones. For example, Chou and Hsiao (2005) conducted a case study on how to apply anthropometric measurements when designing an electric scooter. Kothiyal and Tettey (2001) collected anthropometric measurements to design any equipment, working and living facilities for elderly people in Australia. In the mobile phone world, users generally hold the mobile phone in one hand while attempting to create text messages with their thumb. Mobile phones that are small can be unfriendly as it might be tedious for users with large hands to hold and text at the same time. This is also true for users with small hands, who operate large mobile phones. Messaging activities can be particularly cumbersome for users with large thumbs who have to struggle making key presses on tiny keys that are placed

close to each other. In this study, hand anthropometry will be applied to investigate its influence (if any) on mobile phone users' SMS satisfaction.

Gender

Apart from hand anthropometry, gender could be another factor influencing mobile phone user satisfaction. Cross-gender differences have been analyzed by some researchers to study the motives for use of mobile devices and services. Some examples include motives for using mobile Internet (Lee *et al.* 2002), mobile phones (Kwon & Chidambaram 2000), mobile text messaging, mobile gaming services and mobile contact services (Nysveen *et al.* 2005). Other studies that have used gender as one of the demographic factors are Ling (2005), who analyzed SMS usage among teenagers in Norway, Faulkner and Culwin (2005), who investigated the mobile phone and texting phenomenon in the U.K. and Reid and Reid (2004), who analyzed the psychological reasons for messaging in the U.K.

Aim

This study aims to investigate and evaluate the influence of hand anthropometry and gender of mobile phone users on their SMS usage satisfaction, focusing only on the keypad design factors.

Research Framework

User satisfaction in using SMS based on the standard ISO mobile phone keypad design was identified as the dependent variable, whereas keypad design factors were the independent variables (Table 1). These factors were obtained from a study conducted to identify mobile phone design features that are critical to user satisfaction. Regression analysis was used to develop empirical models to link design features to satisfaction levels. Design properties that are "desirable" and "undesirable" were extracted by comparing the values of the critical design features (Han *et al.* 2004). The hand anthropometry and gender of the subjects were the moderating variables. Figure 2 shows the overall research framework used in this study.

Keypad design factors	Explanation
Size	Size of the keys/buttons used to SMS
Simplicity	Simplicity of the keypad design with respect to messaging (ease of use)
Space between keys	Existing space between the keys/buttons
Shape	Shape of the keys/buttons (square, rectangle, oval, etc.)
Layout	The way the keys/buttons are arranged on the frontal display (4 x 3 arrangement, etc.)
Texture	Tactual satisfaction related to key texture/material (soft, hard, coarse, etc.)

Table 1. Mobile phone keypad design factors.

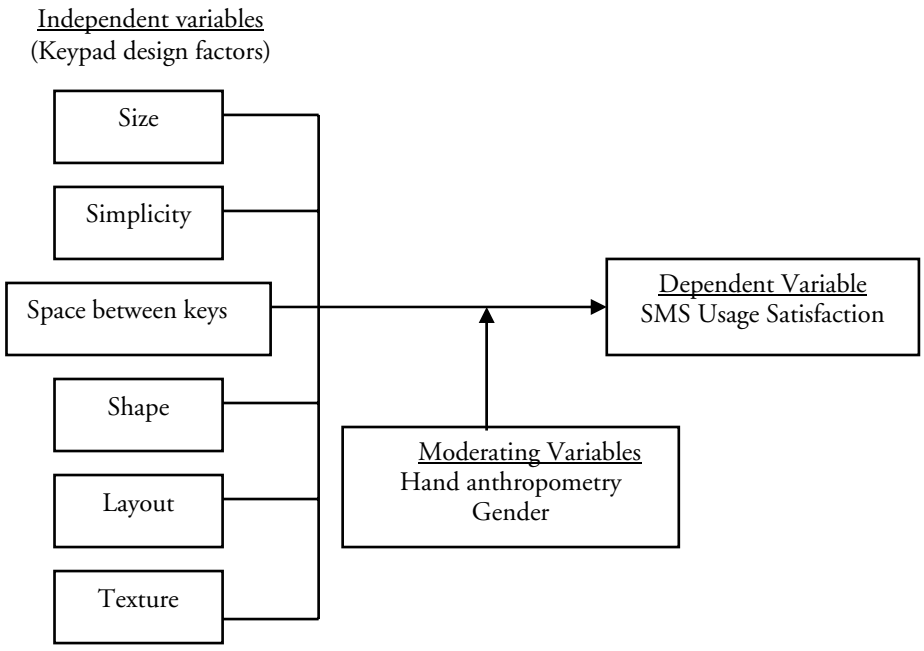

Figure 2. Research framework.

Materials and Methods

Subjects

The subjects in this study were selected based on a purposive sampling technique, that is, a technique employed by researches with a purpose in mind. A specific, predefined group was sought (Patton 1990). The method is appropriate for the study, as it involves a choice of subjects who are in the best position to provide the information needed (Sekaran 2000). SMS is hugely popular among young people (Ling 2001; Reid & Reid 2004). Therefore, a total of 110 young participants were recruited. All the subjects were Malaysians, comprising all the three major ethnicities of the country (Malays, Chinese and Indians). These subjects represent some of the major states in Malaysia, such as Selangor, Federal Territory (Kuala Lumpur), Melaka, Perak and Johor. The majority of the subjects (84/110) were students from a local university and the rest were approached in various public places (malls, local library, etc.). The subjects were filtered based on mobile phone ownership (brands and models), whereby brands and models used by fewer than five subjects were excluded. This resulted in a total of 73 subjects, including 36 males and 37 females (students, programmers and salespersons). Their ages ranged from 18 to 23 years (mean = 21.4 years old, *SD* = 1.7).

All subjects had prior experience in using SMS (mean = 3.7 years, *SD* = 1.26). All of them were right-handed and they used their thumbs to compose a message. Almost 78.1% (57/73) of the subjects used the *multitap* technique for text entry, 9.6% (7/73) used predictive text entry and 12.3% (9/73) used both these techniques interchangeably. In the *multitap* system, one or multiple key presses need to be made to make a certain selection. For example, the key '2' is pressed once for 'a', twice for 'b' and thrice for 'c'. As an example, *"life"* is entered as 555-444-333-33. Predictive text entry uses automated linguistic knowledge and allows the user to choose from possible combinations of characters, shown from the most frequent words to the least frequent words (James & Reischel 2001). The mobile phones used in this study were by two popular producers: Nokia and Motorola. The models were selected to reflect the smallest difference (less than 10%) in terms of length, width and

thickness. The length ranges from 102-113 mm, the width from 44-48 mm and the thickness from 13.5-19 mm. Table 2 shows a summary of the mobile phone dimensions and ownership. The models selected were Nokia (3310, 6610, 3315, 6100 and 3200) and Motorola C300.

Mobile phone model	**Dimension (mm)** (**Length x Width x Thickness**)	**Ownership** (**Number of subjects**)
Nokia 6100	102 x 44 x 13.5	27
Nokia 3315	113 x 48 x 16	13
Nokia 6610	106 x 44 x 18	11
Nokia 3310	113 x 48 x 15	9
Nokia 3200	105 x 44 x 19	8
Motorola C300	106 x 44 x 16	5

Table 2. Summary of mobile phone models and dimensions.

Anthropometric measurements

Figure 3(a) shows the manner in which a user normally holds a mobile phone, that is, by gripping the phone with their fingers (in most cases with all five fingers) while it sits on the palm. Users with large hands might find it difficult to hold a small mobile phone, whereas small hand-sized users might find it difficult to hold a large mobile phone. In both cases, users will be dissatisfied, as they will not be able to hold the mobile phone comfortably while messaging. In the present study, hand-size was measured by taking two measurements, namely hand breadth and hand length. Hand breadth was measured at the distal ends of the metacarpal bones (from the index finger to the little finger) whereas the length of the hand was measured from the crease of the wrist to the tip of the middle finger, with the hand held straight and flat (Figure 3(b)).

Figure 3(a).

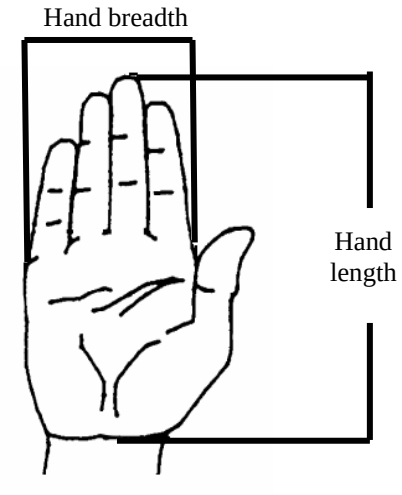

Figure 3(b).

Users compose messages by pressing on the keys, normally using their thumbs (Figure 4(a)). Thus, it is important for all keys to be within the reach of the thumbs. Moreover, users who have large thumbs might find making key presses on the tiny keys to be cumbersome. In this study, the length of the thumb was measured from the second joint of the thumb to the tip of the thumb whereas the circumference was measured at the widest point of the thumb (Figure 4(b)). All four measurements (Figures 3(b) and 4(b)) were taken based on the definitions used by Vasu and Mital (2000). Table 3 shows the summary statistics for these anatomical measurements based on gender. None of the measurements were signify-cantly different between the dominant and the opposite hands, thus only the dominant hand measurements are displayed in the table.

Figure 4(a).

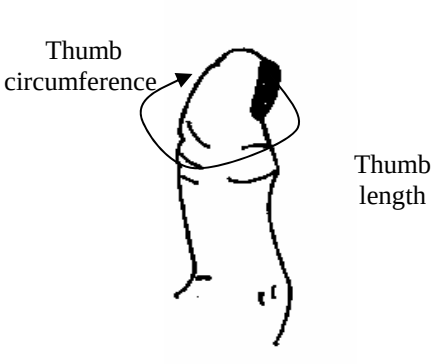

Figure 4(b).

Measurements	Male (N=36)	Female (N=37)
	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)
Hand length (cm)	18.3 ± 1.2 (16.5 – 18.5)	16.5 ± 1.2 (13.5 – 16.5)
Hand breadth (cm)	9.0 ± 0.5 (8.0 – 9.4)	6.9 ± 0.4 (6.0 – 8.2)
Thumb length (cm)	6.2 ± 0.8 (4.8 – 7.0)	5.2 ± 0.65 (4.2 – 6.5)
Thumb circumference (cm)	5.8 ± 0.75 (4.5 – 7.8)	5.4 ± 0.58 (4.5 – 7.2)

Values represented are measurements from the dominant hands. No significant difference was found between the dominant and the opposite hands.

Table 3. Hand anthropometric statistics based on gender.

Three hand-size groups (small, medium and large) were defined for each gender, based on the hand breadth categories used by You *et al.* (2005): for males, <8.8 cm was small, 8.8-9.2 cm was medium and >9.2 cm was large; for females, <7.3 cm was small, 7.3-7.7 cm was medium and >7.7 cm was large. The number of subjects was as follows: for males, 9 small, 14 medium and 13 large; for females, 11 small, 15 medium and 11 large.

Interview questionnaire

An interview questionnaire was designed based on Sinclair's (1995) guidelines. It was tested on five subjects and revised before it was finalized. The questionnaire was developed in English and had two major sections. Section A was intended to obtain the demographic profile of the subjects and their mobile phone characteristics. It consisted of questions addressing issues such as dominant hand, finger(s) used when composing messages and experience in using SMS. In section B, the subjects rated their satisfaction/dissatisfaction with SMS usage based on the keypad design factors by using Likert's five-point scale, whereby 1 means "Strongly dissatisfied"; 2 means "Dissatisfied"; 3 means "Neutral"; 4 means "Satisfied"; and 5 means "Strongly Satisfied".

Interviews

Face-to-face interviews were conducted using the above questionnaire on a one-to-one basis, beginning with the subjects filling in their background information, which included their age, gender, years of experience in sending SMS, the finger(s) used in composing SMS and so forth. The interviewer then measured the subject's hand anthropometry (hand and thumb size). Mobile phone characteristics, such as brand, dimension, and support of predictive text entry, were also recorded. The interviewers then walked through the rest of the questionnaire with the subjects, encouraging them to give comments, opinions and suggestions for each item. All verbal comments were recorded by the interviewers. Each interview session lasted for about 30 minutes. Three interviewers were involved in the activities, which took approximately six to seven weeks in total. All three interviewers were knowledgeable of mobile phone features and SMS application, so that they could easily interact with the subjects during the interview sessions.

Statistical Analysis

The data collected were analyzed using the Statistical Package for the Social Sciences (SPSS) software. Analysis of variance (ANOVA) and Tukey Post-Hoc analysis were used to analyze the significant differences (if any) between the genders and among hand-size groups with respect to

the effect of keypad design factors on SMS usage satisfaction. All results are considered significant at $p < 0.05$ level.

Results

Analysis of variance

The statistically significant difference(s) of the variables gender and hand-size group as well as the interaction between them was tested against each of the mobile phone keypad design factors. Table 4 shows that the effect of gender is significant for key size and layout. Females were found to be more satisfied with the key size (mean = 3.73) and layout (mean = 4.01) than males (mean = 3.15 and 3.33 respectively). The effect of hand-size is significant for key size and space between keys. Tukey post-hoc analysis revealed that small hand-sized subjects are more satisfied with the key size than subjects with medium hand-size (p = 0.003) and large hand-size ($p < 0.001$). Small hand-sized subjects are also more satisfied with the space between keys than medium hand-sized (p = 0.006) and large hand-sized subjects ($p < 0.001$). Finally, the effect of interactions between gender and hand-size is significant only for space between keys. As shown in Figure 5, there is a clear gender difference for subjects with medium and large hand-sizes, with females being more satisfied than males. This difference is not prominent between genders for subjects with small hand-sizes. No significant effects were found for key simplicity, shape or texture. The mean values are: for simplicity (females=3.42, males=3.56); shape (females=3.79, males=3.87); and texture (females=3.71, males=3.67). Nor did Tukey post-hoc analysis reveal any significant differences between subjects with different hand-sizes.

Keypad design factors	**Gender F ratio (p-value)**	**Hand-size F ratio (p-value)**	**Gender x Hand-size F ratio (p-value)**
Size	4.52	11.71	0.75
	(0.037*)	(0.000*)	(0.479)
Simplicity	1.32	0.19	0.10
	(0.255)	(0.897)	(0.910)

Space between keys	2.77	12.95	4.78
	(0.100)	(0.000*)	(0.012*)
Shape	0.24	1.35	0.57
	(0.626)	(0.266)	(0.570)
Layout	3.16	1.21	0.28
	(0.042*)	(0.310)	(0.755)
Texture	0.12	0.37	0.257
	(0.737)	(0.690)	(0.774)

F ratio- F-statistic value; $\alpha = 0.05$; *p*-value from ANOVA;*-significant at $p<0.05$

Table 4. ANOVA model for keypad design factors, tested for gender, hand-size and gender x hand-size.

Table 5 indicates that the effect of hand-size is significant for overall user satisfaction for keypad designs, with respect to SMS usage. Tukey post-hoc analysis revealed that subjects with a small hand-size are more satisfied with the overall keypad designs ($p = 0.003$) than subjects with a large hand-size. The effect of interaction between gender and hand-size is also found to be significant. As shown in Figure 6, differences can be seen between genders in all the hand-size groups, with females being more satisfied than males. However, the difference seems to be more prominent between females with a large hand-size and males in the same group. The effect of gender itself is not found to be significant ($p > 0.05$).

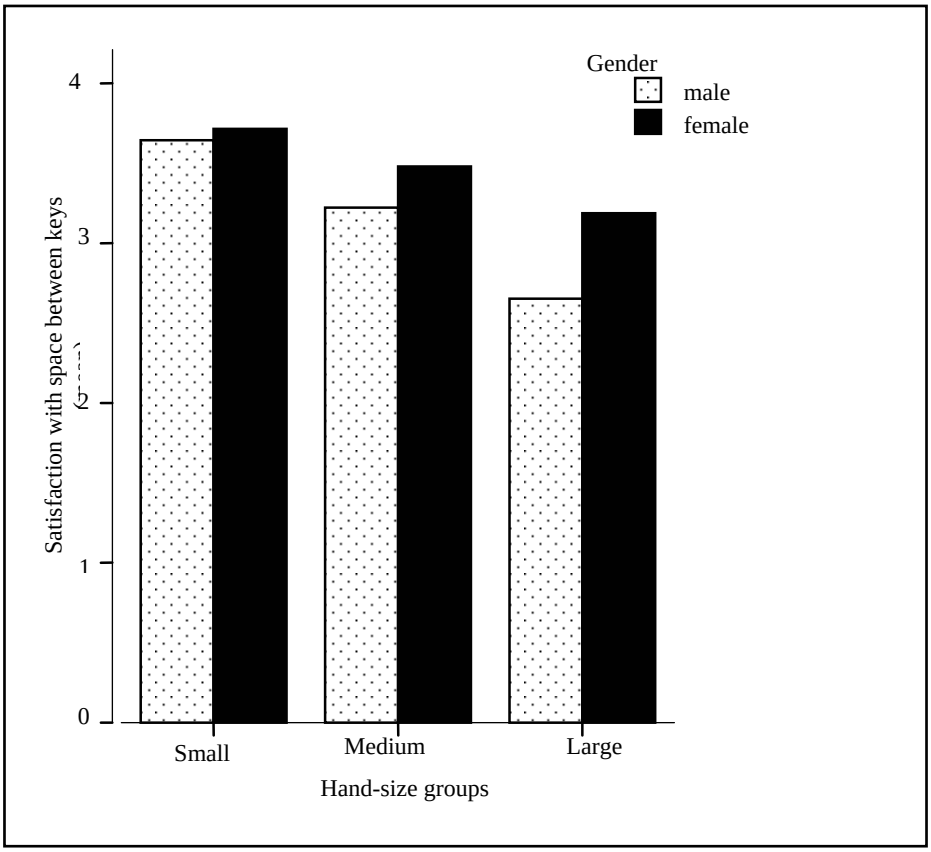

Figure 5. Interaction effects on satisfaction with space between keys (gender x hand-size).

Variables	**F ratio**	***p*-value**
Gender	0.128	0.721
Hand-size	3.17	0.048*
Gender x Hand-size	6.12	0.006*

F ratio- F-statistic value; $\alpha = 0.05$; *p*-value from ANOVA;*-significant at $p<0.05$

Table 5. ANOVA test for overall keypad design satisfaction with respect to SMS usage.

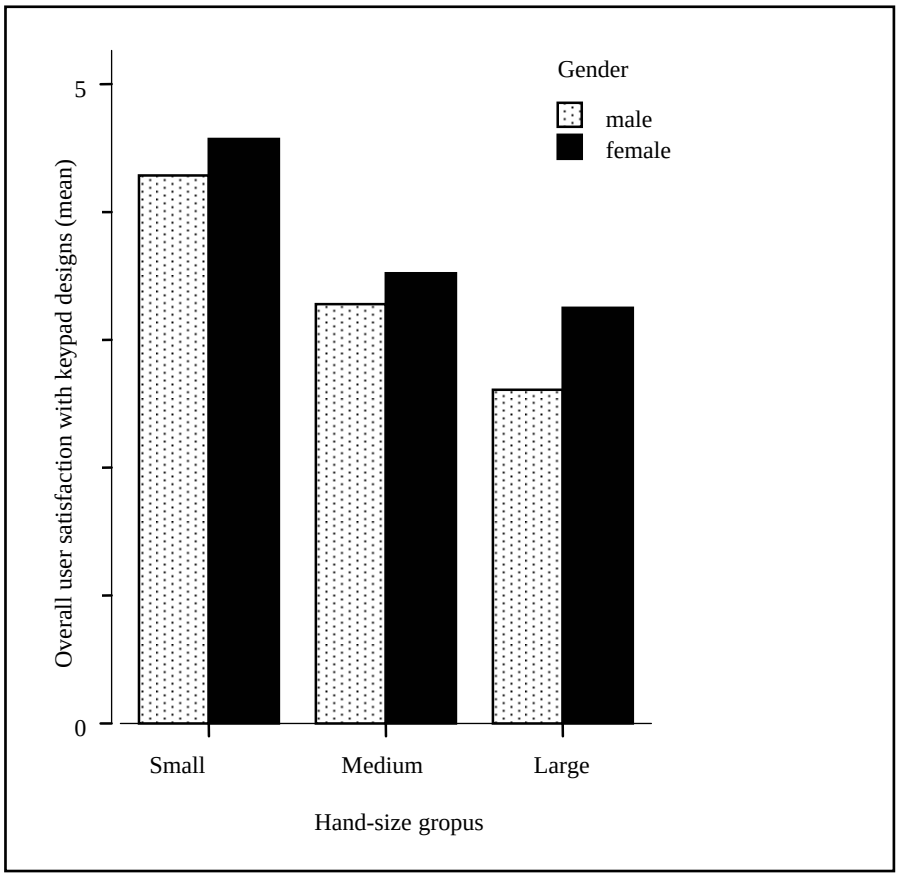

Figure 6. Interaction effects on the overall user satisfaction for keypad designs (gender x hand-size).

Discussion

Key size and layout

According to the *p*-values in Table 4, gender and hand-size have varying effect on the subjects' satisfaction with respect to mobile phone keypad

design factors. Both these variables were found to significantly affect users' satisfaction with key size. Females are more satisfied with key size than males. This could be contributed to the fact that females generally have smaller hand and thumb sizes than males, as shown in Table 3. Small hand-sized subjects are more satisfied with key size than subjects with medium and large hand-sizes. Miniaturization seems to be a trend in the design of mobile phones these days. When mobile phones get smaller in size, key size is also forced to shrink. Small keys become one of the major problems for mobile phone users with large hands and thumbs as making multiple key presses without errors becomes an almost impossible task. A similar finding was made by Soriano *et al.* (2005), who reported that four out of five male participants in their study claimed that the size of the keys became an issue when messaging, especially for those with large fingers. However, this result is only based on comments given by their subjects. Small key sizes were also reported as one of the mobile phone usability problems in many other studies, but none of them took anthropometric details into consideration (Axup *et al.* 2005; Ornella & Stephanie 2006). A common criticism is that mobile phones have become too small, which means that aim and accuracy suffer when adult hands finger child-sized buttons. The miniaturization of mobile phones was also cited as the main cause for users accidentally hitting the wrong keys, as mobile phone sizes are better suited to a young child than to a fully grown adult (Croasmun 2004).

Gender was found to be significantly affecting user satisfaction with keypad layout. The majority of the mobile phones come with a standard 12-key layout as shown in Figure 1. This is due to the small size of the mobile phones. Although the subjects were familiar with the current layout, it was highlighted that having more keys would increase their satisfaction in messaging, as this would reduce key overloading. Key overloading has previously been cited as the main obstacle in mobile phone text entry (James & Reischel 2001; Cockburn & Siresena 2003; Maragoudakis *et al.* 2002; Mackenzie 2002). Having additional keys on mobile phones will no doubt reduce the number of presses on the same key that one has to make in order to compose a message. However, the subjects were also quick to point out that an increase in number of keys should not considerably increase the size of the mobile phones. Keypad

layout was identified as one of the usability issues in using SMS by Axup *et al.* (2005). Soriano *et al.* (2005) also reported that mobile phone users looked for a layout that is easy to understand, access and press. Han *et al.* (2004) identified harmoniousness as one of the critical design features that affect user satisfaction. Harmoniousness was defined as feeling that the components of a product are well matched or in harmony. They reported that the arrangement of a display and its relevant buttons may affect perceived harmoniousness of any product, including mobile phones. This implies that the layout or the arrangement of the input and output mechanisms of any product affect user satisfaction. If the keys are well arranged, users might find it easier to reach the keys to enter messages. Moreover, the possibility of hitting the wrong keys can be reduced, resulting in the users making fewer errors while messaging, particularly males who have larger hands and thumbs than females (Table 3).

Space between keys

Table 4 also shows that hand-size has a significant effect on subjects' satisfaction with respect to space between the mobile phone keys. Subjects with small hands were found to be more satisfied with the space between keys than those with larger hands. The interaction effect of *gender x hand-size* was also found to be significant for space between keys, with medium and large hand-sized females having a higher level of satisfaction than males in the same category (Figure 5). Therefore, females' satisfaction could be contributed to the fact that they are physically smaller in size than males (Table 3). The trend towards smaller mobile phones causes the keys to be cluttered closely to one another, hence limiting the space between the keys. The majority of the males (63.8%; 23/36) reported that messaging becomes cumbersome as they tend to make more errors while composing messages because they frequently press the wrong key, especially when messaging is done within a rapidly changing physical environment, such as when moving. Frequently having to correct their errors hinders these users with large hand and thumb sizes from adopting SMS. A similar result was obtained by Balakrishnan *et al.* (2005), based on their interviews with 30 young people, but the researchers did not focus on the varying anthropometric details or on gender. Ornella and Stephanie (2006) also found that

limited space between the keys constituted a problem for elderly mobile phone users (60–80 years old). Soriano *et al.* (2005) found that spacing between the keys became an issue especially for participants with large fingers, based on their survey among middle-aged users. Moreover, subjects with larger hands and thumbs tend to be more careful when making key presses to avoid making unwanted errors and this increases the time spent on composing a message. Due to this, the subjects tend to make phone calls, because that is a faster process than making slow key presses to create a text message.

Key simplicity, shape and texture

The results in Table 4 indicate that no significant effects were found for key simplicity, texture and shape. The mean values show that their responses are neutral for all three factors. The subjects generally find the keypad design to be simple enough to be used for messaging activities and they are also quite happy with the key texture. Though the difference is not significant, the females scored lower in the mean values for key shape than the males. One male subject in this study commented: "the look, shape or color of the keys is not important as long as I get to message…". This comment may indicate that females place more emphasis on aesthetic values than do males. A similar finding was reported by Yun *et al.* (2003), where females considered the body color, button shape and brightness of color of mobile phones to be more important than males did. The males felt that clearness of menu items and softness of bell sound were some of the important features that affected their satisfaction.

Overall keypad design satisfaction

Subjects with small hand-sizes are more satisfied with the overall keypad design, regardless of their gender. However, females were found to be more satisfied with the overall keypad design than males in all the hand-size categories, with the largest difference occurring among large hand-size subjects (Table 5, Figure 6). This is probably due to the fact that males are physically larger; hence they have larger hand-sizes and thumb-sizes than females. Subjects who have larger hand-sizes find it relatively difficult to compose a message by continuously pressing on the tiny keys

that are arranged with limited space in between them. This causes frustration at times and leads users to make phone calls instead of spending more time on messaging. This finding is consistent with the result shown in Table 4, proving that subjects' dissatisfaction with the key size and space between the keys affect their overall SMS usage satisfaction.

Recommendation

A comprehensive investigation based on hand anthropometry and gender was conducted to analyze the effects on users' SMS usage satisfaction. The findings indicate that hand anthropometry and gender have varying effects on user satisfaction, specifically on key size, space between keys and layout. These factors can be used as a benchmark for mobile phone designs, or for customized mobile phone designs that cater to specific groups of users, for example, users with larger hands and thumbs. This will encourage more users to use SMS, as user satisfaction results in usage (Isrealski & Lund 2003). As for researchers, the insights provided from this study will add to the literature on the relationship(s) between the various keypad design factors and mobile phone users' SMS satisfaction, when moderated by hand anthropometry and gender. Apart from providing a platform, these findings also add to a better understanding of mobile phone design problems related to SMS as well as to determining the important keypad design factors that affect user satisfaction. It can be followed by further research, such as laboratory or usability experiments.

Conclusion

Structured questionnaire interviews with 73 subjects focusing on six mobile phone keypad design factors were used to investigate the effect of hand anthropometry and gender on their SMS usage satisfaction. Measurements of hand breadth and length as well as thumb length and circumference were collected for this purpose. The results show that gender and hand-size significantly affect user satisfaction with respect to key size, with females and small hand-sized subjects being more satisfied than males and subjects with medium and large hand-sizes respectively. Subjects with small hands are also more satisfied with the space between the keys than those with large hands. Significant interactions between *gender x hand-size* were observed for space between keys. It was found

that for medium and large hand-sized subjects, the males are more dissatisfied with the space between keys than are the females. The effect of gender was significant for keypad layout. Finally, it was found that small hand-sized subjects are more satisfied with the overall keypad design than large hand-sized subjects, regardless of their gender. Moreover, interactions between *gender x hand-size* revealed that females are more satisfied with the overall keypad design than males in all the hand-size groups. However, the clearest difference is noticeable for subjects with large hand-sizes. Neither hand anthropometry nor gender was found to significantly affect satisfaction with key simplicity, texture and shape. Findings from this study will prove to be beneficial to mobile phone designers, researchers and, most importantly, to the mobile phone users themselves.

Vimala Balakrishnan, is pursuing her PhD in the field of mobile phones and ergonomics at Multimedia University, Malaysia.
E-mail: vimala.balakrishnan@mmu.edu.my

Paul H.P. Yeow, PhD, is a Senior Lecturer at Multimedia University, Malaysia. He is the Deputy Chairman of the Ergonomics Centre. His research interests include human factors, ergonomics and information systems.

References

AXUP, J., S. VILLER & N. BIDWELL (2005). "Usability of a Mobile, Group Communication Prototype while Rendezvousing." *CTS'05 International Symposium on Collaborative Technologies and Systems-Special Session on Mobile Collaborative Work, St. Louis, USA*.

BAILEY, J. & S. PEARSON (1983). "Development of a Tool for Measuring and Analyzing Computer User Satisfaction." *Management Science* 29.5: 530-545.

BALAKRISHNAN, V., P.H.P. YEOW & D.C.L. NGO (2005). "An Investigation on the Ergonomic Problems of Using Mobile Phones to Send SMS." *Contemporary Ergonomics 2005: Proceedings of the International Conference on Contemporary Ergonomics (CE2005), 5-7 April 2005, Hatfield, UK*. Eds. P.D. Bust & P.T. McCabe. London: Taylor & Francis. 195-199.

BARKHUUS, L. (2005). "Why Everyone Loves to Text Message: Social Management with SMS." *Proceedings of the 2005 International ACM SIGGROUP Conference on Supporting Group Work, Florida, USA*.

BRIDGER, R.S. (1995). *Introduction to Ergonomics*. New York: McGraw-Hill.

CHOU, J.R. & S.W. HSIAO (2005). "An Anthropometric Measurement for Developing an Electric Scooter." *International Journal of Industrial Ergonomics* 35: 1047-1063.

COCKBURN, A. & A. SIRESENA (2003). "Evaluating Mobile Text Entry with the Fastap Keypad." *People and Computers XVII, Vol. 2: British Computer Society Conference on Human Computer Interaction, Bath, England*. University of Canterbury, Computer Science and Software Engineering. 77-80.

CROASMUN, J. (2004). "Are Ergonomists Really Consulted in Mobile Phone Design?" <http://www.ergoweb.com/news/detail.cfm?id=961> [2007-02-02]

FAULKNER, X. & F. CULWIN (2005). "When Fingers Do The Talking: A Study of Text Messaging." *Interacting with Computers* 17: 167-185.

GRINTER, R.E. & M.A. ELDRIDGE (2001). "y do tngrs luv 2 txt msg?" *Seventh European Conference on Computer-Supported Cooperative Work*. Eds. W. Prinz, M. Jarke, Y. Rogers, K. Schmidt & V. Wulf. Bonn: Kluwer Academic Publishers. 219-238.

GSM ASSOCIATION PRESS RELEASE (2000). "G-Mail Growth: Global Surge Continues." GSM Association, Ireland. <http://www.gsmworld.com> [2003-04-21]

HAN, S.H, K.J. KIM, M.H. YUN, S.W. HONG & J. KIM (2004). "Identifying Mobile Phone Design Features Critical to User Satisfaction." *Human Factors and Ergonomics in Manufacturing* 14.1: 15-29.

ISREALSKI, E. & A.M. LUND (2003). "The Evolution of Human: Computer Interaction during the Telecommunications Revolution." *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications*. Eds. J.A. Jacko & A. Sears. Mahwah: Lawrence Erlbaum Associates. 772 – 789.

JAMES, C.L. & K.M. REISCHEL (2001). "Text Input for Mobile Devices: Comparing Model Prediction to Actual Performance." *CHI 2001* 3.1: 365-371.

KOTHIYAL, K. & S. TETTEY (2001). "Anthropometry for Design for the Elderly." *International Journal for the Occupational Safety and Ergonomics* 7.1: 15-34.

KURNIAWAN, S., M. MAHMUD & Y. NUGROHO (2006). "A Study of the Use of Mobile Phones by Older Persons." *CHI 2006* (Work in Progress), Quebec, Canada.

KWON, H.S. & L. CHIDAMBARAM (2000). "A Test of the Technology Acceptance Model: The Case of Cellular Telephone Adoption." *Proceedings of the HICSS-34, Hawaii*.

LEE, W.J., T.U. KIM & J.Y. CHUNG (2002). "User Acceptance of the Mobile Internet." Working Paper, IT Management Research Center, Seoul.

LING, R. (2001). "'We Release Them Little by Little': Maturation and Gender Identity as Seen in the Use of Mobile Telephony." *Personal and Ubiquitous Computing* 5: 123-136.

LING, R. (2005). "The Socio-Linguistics of SMS: An Analysis of SMS Use by a Random Sample of Norwegians." *Front Stage – Back Stage: Mobile Communication and the Renegotiation of the Social Sphere, Conference Proceedings*. Eds. R. Ling & P. Pedersen. London: Springer. 335-349.

MACKENZIE, S.I. (2002). "Mobile Text Entry Using Three Keys." *Proceedings of the Second Nordic Conference on Human-Computer Interaction, NordiCHI 2002*. New York: ACM. 27-34.

MARAGOUDAKIS, M., N.K. TSELIOS, N. FAKOTAKIS & N.M. AVOURIS (2002). "Improving SMS Usability Using Bayesian Networks." *Methods and Applications of Artificial Intelligence*. Eds. I.P. Vlahavas & C.D. Spyropoulos. Berlin: Springer-Verlag. 179-190.

MELCHER, R., R. SEFELIN, V. GILLER & M. TSCHELIGI (2003). "Improving the User Experience on Mobile Devices and Services." *Proceedings of the Telecommunication and Mobile Computing Conference, 11-12 March 2003, Graz, Austria*.

NYSVEEN, H., P.E. PEDERSEN & H. THORBJORNSEN (2005). "Intention to use Mobile Services: Antecedents and Cross Service Comparisons." *Journal of the Academy Marketing Science* 33.3: 330-347.

OKSMAN, V. & P. RAUTIAINEN (2003). "Perhaps It Is a Body Part: How the Mobile Phone Became an Organic Part of the Everyday Lives of Finnish Children and Teenagers." *Machines that Become Us: The Social Context of Communication Technology*. Ed. J. Katz. New Brunswick, NJ: Transaction Publishers. 293-308.

ORNELLA, P. & B. STEPHANIE (2006). "Universal Designs for Mobile Phones: A Case Study." *CHI 2006* (Work in Progress). Quebec, Canada.

PATTON, M.Q. (1990). *Qualitative Evaluation and Research Methods*. Newbury Park, CA: Sage Publications.

REID, F.J.M. & D.J. REID (2004). "Text Appeal: The Psychology of SMS Texting and Its Implications for the Design of Mobile Phone Interfaces." *Campus-Wide Information Systems* 21.5: 196-200.

SEKARAN, U. (2000). *Research Methods for Business: A Skill Building Approach*. New York: John Wiley and Sons.

SILFVERBERG, M., I.S. MACKENZIE & P. KORHONEN (2000). "Predicting Text Entry Speed on Mobile Phones." *CHI 2000* 2.1: 9-16.

SINCLAIR, A.M. (1995). "Subjective Assessment." *Evaluation of Human Work: A Practical Ergonomics Methodology*. Eds. J.R. Wilson & E.N. Corlett. London: Taylor & Francis. 69-100.

SORIANO, C., G.K. RAIKUNDALIA & J. SZAJMAN (2005). "A Usability Study of Short Message Service on Middle-Aged Users." *Proceedings of OZCHI 2005, Canberra, Australia*.

TEXT.IT (2005). "Top Texting Days."
<http://www.text.it/mediacentre/default.asp?intPageID=478> [2006-08-18]

VASU, M. & A. MITAL (2000). "Evaluation of the Validity of Anthropometric Design Assumptions." *International Journal of Industrial Ergonomics* 26: 19-37.

WARD, D., A. BLACKWELL & D. MACKAY (2000). "Dasher: A Data Entry Interface Using Comtinous Gestures and Language Models." *Proc. ACM UIST, San Diego, California*.

WIGDOR, D. & R. BALAKRISHNAN (2004). "A Comparison of Consecutive and Concurrent Input Text Entry Techniques for Mobile Phones." *CHI 2004* 6.1: 81-88.

WONG, C.C. & L.H. PANG (2005). "Correlations between Factors Affecting the Diffusion of Mobile Entertainment in Malaysia." *ICEC 2005, Xi'an, China*.

YOU, H., A. KUMAR, R. YOUNG, P. VELUSWAMY & D.E. MALZAHN (2005). "An Ergonomic Evaluation of Manual Cleco Plier Designs: Effect of Rubber Grip, Spring Recoil and Worksurface Angle." *Applied Ergonomics* 36: 575-583.

YUN, M.H., S.H. HAN, S.W. HONG & J. KIM (2003). "Incorporating User Satisfaction Into the Look-And-Feel of Mobile Phone Design." *Ergonomics* 46.13/14: 1423-144.