Determining the Predictors and a Cross-gender Analysis for Messaging Satisfaction

Vimala Balakrishnan & Paul H.P. Yeow

A total of 110 youths were interviewed to determine the important predictors for mobile phone messaging satisfaction based on the mobile phone design and health effect factors. A cross-gender analysis was also performed to analyze the gender differences towards messaging satisfaction. Factor analysis resulted in seven independent variables viz. Mobile Phone Design, Keypad Design, Screen Design, Text Entry Speed, Text Entry Usability, Health-Lower Extremity and Health-Upper Extremity whilst Users' SMS Satisfaction was the dependent variable. Stepwise multiple regression determined Text Entry Speed and Text Entry Usability as the most important predictors for Users' SMS Satisfaction. Gender analysis revealed females to be more satisfied with Mobile Phone Design, Keypad Design and Text Entry Speed than males; however, there were no significant differences for their Users' SMS Satisfaction. Results obtained can be used by mobile phone designers to design customized mobile phones, for example, mobile phones which are specially catered for males.

Keywords: health effect, mobile phone design, keypad design, screen design, text entry

Short Message Service, better known as SMS, is a service that allows mobile phone users to send and receive short messages as a means of non-verbal communication. SMS recorded tremendous success in many countries, including Asian countries like Singapore, Philippines, and

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Malaysia. According to the communication and multimedia facts and figures released by Malaysian Communication and Multimedia Commission (MCMC), there were approximately 9.9 billion SMS users in 2006 and this number shot to 14.7 billion in 2007 (MCMC 2007). SMS is popular, especially among youths, as it is inexpensive, informal, instantaneous and convenient (Ling 2005).

There are many studies involving mobile phone designs. However, not many have focused on users' satisfaction, especially with regard to SMS applications. For example, Han *et al.* (2004) determined the important factors affecting users' satisfaction by focusing on the overall mobile phone design regardless of any particular application. We feel that it is important to focus on an application as the effects of a particular design may differ among the applications. For example, the screen design may not be an issue when audio calls are made, whereas features such as its size, resolution etc. may be important to read text messages.

A portion of the results from the present study was published in Balakrishnan (2009) and Balakrishnan and Yeow (2007). The former study focused on the overall usage pattern of SMS among Malaysian youths, without taking any of the mobile phone design factors into consideration. In Balakrishnan and Yeow (2007), the focus was solely on a single factor, viz. keypad design, which was assessed based on users' hand measurements. In this paper, we aim to investigate the factors affecting users' SMS satisfaction by focusing on the mobile phone design and health effect factors. In addition, we also aim to assess gender differences (if any) when it comes to mobile phone design features and users' satisfaction.

Overview of Mobile Phone Design and Health Effect Factors

We define mobile phone design factors as factors related to hardware, i.e. Mobile Phone Design, Keypad Design and Screen Design, while Text Entry factor is related to software.

Mobile phone design

Mobile phones come in various shapes and sizes. It is however yet to be studied if the mobile phone design itself imposes a problem to its users, especially in terms of messaging. One of the common problems related to mobile phone design is miniaturization. Mobile phones available in the current market are small and slim, making it difficult for users to hold the phone comfortably, especially those with larger hands (Balakrishnan & Yeow 2007). A focus group study with seven women revealed that older users have difficulty holding small mobile phones (Kurniawan *et al.* 2006). In addition, the participants in Kurniawan *et al.* (2006) also stated that they prefer a mobile phone that can be grabbed and held comfortably, indicating that the tactual feeling while holding a mobile phone is equally important. Other studies, e.g. Han *et al.* (2004) and Yun *et al.* (2003), reported features such as size, shape and body material to be important determinants among mobile phone users. These were however based on the overall mobile phone design, including color, sound and animation, and regardless of the applications used. Determining predictors based on a particular application is important, as different factors may have varying effects on the users. For example, users can use hands-free gadgets for audio calls. Messaging while holding a small mobile phone is a more tedious task, however. Therefore, the present study focuses on mobile phone design (physical) features that are directly related to SMS activity.

Keypad design

Common criticisms related to the keypad design are the tiny keys and the limited space between the keys (Axup *et al.* 2005; Kurniawan *et al.* 2006). In Soriano *et al.* (2005), the middle-aged participants stated as their preferences for a keypad layout that is easy to understand. Some researchers re-designed the keypads to reduce the number of keystrokes needed to enter a word (Lesher *et al.* 1998; Levine & Goodenough-Trepagnier 1990), while others like Chang and O'Sullivan (2005) showed that the tactile feedback provided when keys are pressed offers a good satisfaction experience among mobile phone users.

Screen design

Mobile phones tend to have small screens with, low resolution, allowing only a few lines of text to be displayed at a time (Brewster 2002; Buchanan *et al.* 2001). Elderly users were found to prefer large, clear and bright screens in Kurniawan *et al.* (2006) and Massimi *et al.* (2007). The size of the text is also an important factor affecting text legibility. It has been shown that larger text sizes are more readable than smaller sizes for paper based materials (Rudnicky & Kolers 1984) and computer screens (Bernard *et al.* 2003). Moreover, low screen resolution also makes it difficult for users to read text on small screens (Mizobuchi *et al.* 2005).

Text entry

Multitap, which requires the users to make multiple key presses on the keypad, is the most widely used text entry method on mobile phones. It is however often criticized for being slow (Mackenzie 2002). Alternatively, the predictive method that attempts to predict words as they are entered can be frustrating and slow, when the phone does not recognize the words (Starner 2004). Most of the studies related to text entry focused on text entry speed (Friedman *et al.* 2001), while others highlighted problems related to the complex menus (Ziefle & Bay 2004, 2006). Friedman *et al.* (2001) found that users required the same amount of training and elicited the similar frustration levels for both the text entry methods. Audio feedback when key presses are made has also been shown to improve task performance. For example, Brewster (2002) investigated the benefits of adding sound to buttons for mobile interactions via Personal Digital Assistants (PDA), and found that sounds increased the amount of data people could enter while walking.

Health effect

A prolonged activity of text messaging may have adverse effects on the user. Andrew Chadwick, the director of the British Repetitive Strain Injury (RSI) Association, claimed that children are especially prone to painful swelling and inflammation of the fingers and thumbs from sending too many text messages on their phones (Batista 2001). A similar report cites this dexterous task as the reason for increased incidences of RSI in both adults and children (British Broadcasting Corporation 2006). It may also be necessary to investigate if heavy messaging results in pain in the neck, shoulder or upper arms. Studies have reported users having experienced such pains due to prolonged use of other handheld devices, but none were related to mobile phones. For example, interview results by Atkinson *et al.* (2004) among 45 users using non-keyboard input devices (e.g. mouse and touch-screen) found 85 per cent of interviewees having experienced muscular aches and pains, mainly at lower and upper backs, necks, shoulders and right wrist and hand.

Users' SMS satisfaction

Not many studies directly relating users' satisfaction and SMS exist, and those related to mobile phones are very few. Yeow *et al.* (2008) conducted a survey among 300 students and working adults in Malaysia and found factors such as peer chatting and family coordination to be important factors affecting users' satisfaction in using mobile phones. None of the mobile phone design factors were however taken into consideration. Ling *et al.* (2007) investigated 20 mobile phone features such as phone book, game, physical appearance etc., and found aesthetic aspects, portability, calling-related feature, durability etc. to be the important factors affecting users' overall satisfaction. The researchers focused on the overall mobile phone physical design without taking any particular application into consideration.

Statement of hypotheses

Prior studies revealed that SMS is particularly popular among the younger users, since it is cheap, fast and convenient (Eldridge & Grinter 2001; Ling 2005). Other factors that determine or affect mobile phone users' overall satisfaction include peer chatting, family coordination, and social interruptions (Yeow *et al.* 2008) as well as battery durability and support of voice mail (Ling *et al.* 2007). As none of these studies emphasized the design factors, the present study aims to identify the Mobile Phone Design and Health Effect factors that may affect Users' SMS Satisfaction. Therefore, Hypothesis 1 was formulated as:

H1 – There is no association between Mobile Phone Design and Health Effect factors and Users' SMS Satisfaction.

A lower adjusted R^2 value is expected in the current study, as it has been shown that many other factors contribute to the users' satisfaction in using the mobile phones with a high adjusted R^2 , for example, an adjusted R^2 value of 0.51 in Yeow *et al.* (2008) and 0.47 in Ling *et al.* (2007).

Previous studies have also investigated gender differences for mobile phone and SMS adoption, and most reported that females generally engage in messaging activities more than males do (Eldridge & Grinter 2001; Ling 2005). None of the studies, however, investigated the differences between the genders for Users' SMS Satisfaction based on the Mobile Phone Design and Health Effect factors. Therefore, Hypothesis 2 and Hypothesis 3 were formulated as:

H2 – There is no difference between males and females for satisfaction towards Mobile Phone Design and Health Effect factors.

H3 – There is no difference between males and females for Users' SMS Satisfaction.

Research Design

Figure 1 shows the research framework of the present study. Five independent variables were identified, otherwise collectively known as the Mobile Phone Design and Health Effect factors. The Mobile Phone Design factor comprised Mobile Phone Design, Screen Design, Keypad Design and Text Entry. Users' SMS Satisfaction was identified as the dependent variable. Gender is used to examine if there is any significant differences between males and females with respect to their satisfaction towards Mobile Phone Design and Health Effect factors, and also on their SMS satisfaction.

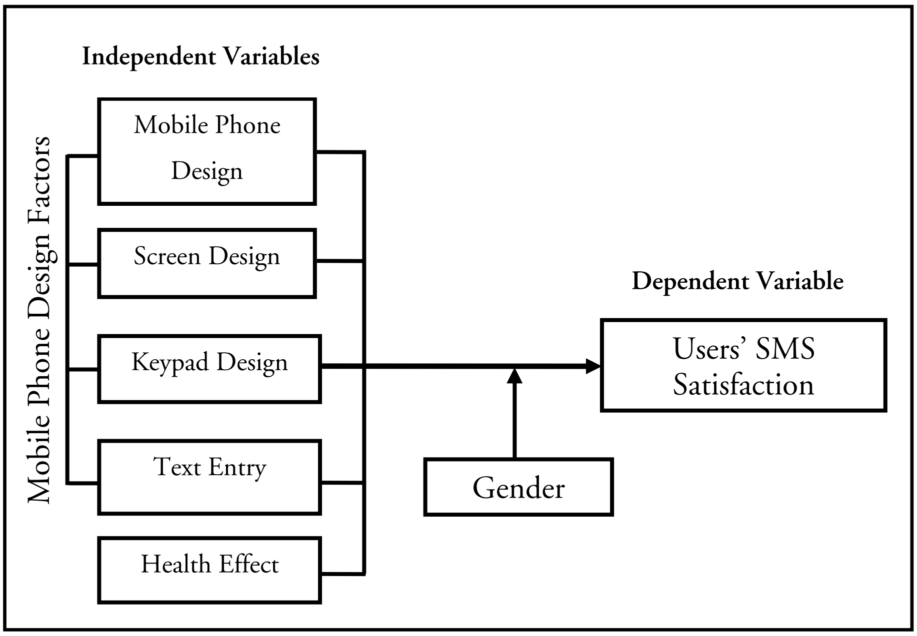

Figure 1: Research framework.

All factors used in this study were defined based on the reviews of the Mobile Phone Design and Health Effect factors in the preceding section. The operational definitions for each of the factors are provided in Table 1.

Variables	References
Mobile Phone Design The aspects related to the size, shape, weight and "feel" (the tactual feeling when one holds the mobile phone).	Han *et al.* 2004; Kurniawan *et al.* 2006; Yun *et al.* 2003
Keypad Design All the aspects related to key size, shape, space between keys, tactile feedback (based on texture of the keys, e.g., coarse, hard, soft etc.), simplicity of the keypad design (the ease of using the overall keypad design to message) and keypad layout (the manner in which the keys are arranged, that is, 4x3,	Axup *et al.* 2005; Han *et al.* 2004; Yun *et al.* 2003

QWERTY etc.).	
Screen Design All the aspects that are related to screen design features such as screen size, resolution, brightness, colour, font or text size, shape and position.	Buchanan *et al.* 2001; Kurniawan *et al.* 2006
Text Entry All aspects related to text entry features such as the speed or efficiency of the text entry method, learnability, ease of use, menu traversals, special character selections (e.g. symbols to support emoticons, space etc.), case conversions, support for incoming and outgoing messages and audio feedback when key presses are made.	Ziefle & Bay 2004, 2006
Health Effect Any pain or discomfort felt after prolonged usage of SMS.	Batista 2001; Balakrishnan *et al.* 2005
Users' SMS Satisfaction The subjective impression/emotion/feeling/attitude felt while using SMS with a mobile phone design.	Han *et al.* 2004; Yun *et al.* 2003

Table 1: Operational definitions.

Interviews

Data collection was performed via structured questionnaire interviews. The interview questionnaire consisted of close-ended questions, addressing issues such as gender, frequency of messaging, and years of SMS experience. In addition, thirty-six questions were designed to measure users' SMS satisfaction/dissatisfaction, based on the independent and dependent variables. This paper particularly focuses on determining the general predictors of users' messaging satisfaction and on analyzing any gender differences when it comes to messaging satisfaction. It is therefore to note that not all the results from the interview questionnaire are presented here.

The interviews took place in two states in Malaysia, namely, Melaka and Perak in the year of 2005. These two states were selected, as they have a high mobile phone penetration rate. For example, there were approximately 88 mobile phone users out of every 100 inhabitants in

Melaka and 57 mobile phone users out of every 100 inhabitants in Perak (MCMC 2006). The interviews were conducted face-to-face on a one-to-one basis, in order to eliminate biased responses. All the information provided by the respondents had been guaranteed of confidentiality beforehand. Comments, opinions, and suggestions provided by the respondents were noted by the interviewer.

Respondents

Proportional quota sampling was used, based on the respondent's gender. This resulted in an equal number of males and females (55 each) for a total of 110 respondents. These were recruited using convenience sampling by sending out flyers, bulletin board announcements, etc. The respondents were Malaysians (i.e. Malays, Chinese, and Indians), aged between 17 and 25 (mean = 21.5 years). In Malaysia, the youths generally leave high-school and pursue their studies in higher education institutions such as colleges and universities at the age of 17. The probability of them owning a mobile phone is higher than of those in the younger age groups such as 13 or 14. Therefore, youths ranging from 17 to 25 were sought in this study, a majority of them being students (76.3 per cent, 84/110). Most (80.9 per cent) of the respondents used multitap, 11.8 per cent used predictive text entry and 7.3 per cent used both methods interchangeably. The mean years of experience in using SMS was 3.8 years.

Mobile phones

The respondents answered all the interview questions based on their own mobile phones. All the respondents owned single-hand operable mobile phones. The majority (88.2 per cent, 97/110) owned bar phones, the rest owned flip phones. Moreover, all the mobile phones had a similar 4 x 3 keypad layout and supported predictive text entry. Table 2 shows the summary of the mobile phone characteristics used by the respondents in the present study.

Brand	N	%	Dimension, mm (min–max)	Weight, g (min–max)
Nokia	73	66.4	102 x 42.6 x 19.4 – 113 x 48 x 16	76 – 114
Samsung	14	12.7	80 x 40 x 22 – 111 x 45 x 17	72 – 85
Motorola	10	9.1	106 x 44 x 16 – 110 x 48 x 15	82 – 108
Sony Ericsson	9	8.2	102 x 43 x 17 – 101 x 48 x 19.5	84 – 93
Siemens	2	1.8	105 x 45 x 16	86
Alcatel	2	1.8	98 x 42 x 20 – 98 x 45 x 20	77 – 80

Table 2: Mobile phone characteristics.

From Table 2 it can be noted that Nokia had the highest number of owners, whereas Alcatel and Siemens had the lowest. The difference of the horizontal perimeters between the largest (136mm) and smallest (116mm) mobile phone was only 20mm (that is approximately 14.7 per cent), which was very small. The horizontal perimeters were calculated based on the width and thickness of the mobile phones (i.e. [width + thickness] x 2). These two dimensions were selected based on the way the mobile phones are held in the palm when messaging. In addition, the majority of the mobile phones were also very light, with the heaviest phone weighing merely 114g. These dimensions and weights were comparatively smaller than some other mobile phones available in the market (e.g. Nokia 3650 has a dimension of 130mm x 57mm x 26mm, weighs 130g, and has a horizontal perimeter of 166mm). Therefore, the mobile phones in this study can be considered to be small and light.

Outcome of the Statistical Analyses

Statistical Package for the Social Sciences (SPSS) version 13.0 was used to analyze all the data collected. Two factor analyses were performed on the independent and dependent variables, separately. The results are as follows.

Mobile Phone Design and Health Effect factors

The first factor analysis was conducted on the 31 items measuring users' agreement/disagreement and satisfaction/dissatisfaction towards the Mobile Phone Design and Health Effect factors. Text Entry and Health Effect were split into two factors by the factor analysis, resulting in a total of seven factors (see Table 3).

Factors		Factor Loading
Factor 1: Screen Design (Cronbach α=.896)		
1.	Screen size effect	.702
2.	Screen brightness effect	.672
3.	Screen resolution effect	.809
4.	Screen colour effect	.780
5.	Screen position effect	.748
6.	Screen shape	.803
7.	Font size displayed on the screen	.632
	Eigenvalue	7.76
	Variance (%)	26.76
Factor 2: Keypad Design (Cronbach α=.891)		
8.	Size of the keys used for messaging	.802
9.	Ease of use of the keypads and menu items	.739
10.	Amount of space available between the keys	.833
11.	The shape of the keys	.793
12.	The logical layout of the keys on the mobile phone	.761
13.	The tactile feedback when key presses are made (based on texture)	.603
	Eigenvalue	5.23
	Variance (%)	44.80
Factor 3: Text Entry Usability (Cronbach α=.860)		
14.	Ease of converting upper case to lower case letters and vice versa.	.737
15.	Ease of messaging based on the text entry method used.	.855
16.	Ease of looking for SMS functions via the menu hierarchies.	.804
17.	Ease of using special characters like symbols, punctuation marks etc.	.701
18.	Ease of learning the text entry method by someone who is inexperienced.	.502
	Eigenvalue	2.64
	Variance (%)	53.90
Factor 4: Mobile Phone Design (Cronbach α=.890)		
19.	Mobile phone weight	.785

20.	Mobile phone shape	.854
21.	Mobile phone dimension	.783
22.	Mobile phone feel	.823
	Eigenvalue	1.95
	Variance (%)	60.64
Factor 5: Health – Upper Extremity (Cronbach α=.859)		
23.	Pain felt in the eyes	.572
24.	Pain felt in the neck	.808
25.	Pain felt in the upper arm	.894
26.	Pain felt in the shoulder	.907
	Eigenvalue	1.57
	Variance (%)	66.05
Factor 6: Health – Lower Extremity (Cronbach α=.622)		
27.	Pain felt in the wrist	.642
28.	Pain felt in the thumb	.817
	Eigenvalue	1.22
	Variance (%)	70.27
Factor 7: Text Entry Speed		
29.	Speed of composing SMS based on text entry method used.	.849
	Eigenvalue	1.01
	Variance (%)	73.74

Table 3. Varimax rotated factor loadings matrix for independent variables.

Approximately 74 per cent of the expressed variance was contained in these seven factors with 29 items included. Factor one contained all the items used to measure mobile phone screen design satisfaction; therefore it was named Screen Design. Similarly, all six items measuring users' keypad design satisfaction loaded into a single factor, named Keypad Design. Text Entry factor was split into two: speed of messaging loaded separately into factor seven, thus it was named Text Entry Speed, while the rest of the items loaded into factor three, named Text Entry Usability. Support for incoming and outgoing messages and audio support to indicate successful key presses were dropped due to low factor loadings (< 0.5). Factor four was named Mobile Phone Design, as it contained all items measuring users' satisfaction towards mobile phone physical design. Health Effect factor was also split into two: Health – Lower Extremity was related to wrist and thumb pains, whereas Health – Upper Extremity was related to health effects on human body upper dimensions.

Factor analysis for Users' SMS Satisfaction

Table 4 shows the results of the second factor analysis that was performed on the five items measuring users' overall satisfaction in using SMS. These five items loaded into a single factor, and it was named Users' SMS Satisfaction as they measured users' satisfaction towards each of the Mobile Phone Design and Health Effect factors. Approximately 51 per cent of the total variance was contained in this factor and a Cronbach alpha value of 0.745 validates the internal consistency of these five items.

Items	**Factor Loading**
1. Health effect on SMS satisfaction	.540
2. The overall mobile phone design effect on SMS satisfaction	.788
3. The mobile phone screen design effect on SMS satisfaction	.782
4. The physical aspects of the keypad and the keys effect on SMS satisfaction	.675
5. The overall text entry aspects' effect on SMS satisfaction.	.742
Eigenvalue	2.53
Variance (%)	50.58
Coefficient α	.745

Table 4. Varimax rotated factor loadings matrix for dependent variable.

General predictors

Stepwise regressions were used to identify the significant predictors for Users' SMS Satisfaction based on the Mobile Phone Design and Health Effect factors. The results were considered significant at $p < 0.05$.

Model	**B**	**Beta**	**t-statistics**	***p*-value**	**VIF**
Text Entry Speed	.225	.26	2.85	.005*	1.000
Text Entry Usability	.189	.23	2.57	.012*	1.000
Mobile Phone Design	.130	.13	1.86	.066	1.016
Keypad Design	.108	.12	1.89	.062	1.047
Screen Design	.069	.07	0.85	.397	1.008

Health – Lower Extremity	-.005	-.01	-.046	.964	1.000
Health – Upper Extremity	-.014	-.02	-.556	.580	1.003

*= Significant ($p < 0.05$); F = 7.52 ($p < 0.001$) $R^2 = 0.226$

Table 5. Stepwise regression on users' SMS satisfaction based on mobile phone design and health effect factors.

In Table 5, the adjusted R^2 clearly explains 22.6 per cent of the variance associated with Users' SMS Satisfaction. The F-statistics for the model was also found to be significant (F = 7.52; $p < 0.001$). Text Entry Speed and Text Entry Usability were found to be significantly associated with Users' SMS Satisfaction. A higher beta weight (0.26) and *t*-statistics (2.85) for Text Entry Speed makes it more influential to Users' SMS Satisfaction than Text Entry Usability (Beta = 0.23, *t*-statistics = 2.57). Both factors are positively associated with Users' SMS Satisfaction. An increase in any of these factors therefore results in a significant increase in Users' SMS Satisfaction. The rest of the factors were not found to be significant predictors for Users' SMS Satisfaction. Low VIF values confirm that Mobile Phone Design and Health Effect factors in this study are not correlated. As some of the results are significant, H1 is partially rejected.

Gender and Mobile Phone Design and Health Effect factors

An Analysis of Variance (ANOVA) test was used to analyze the gender differences for Mobile Phone Design and Health Effect factors and Users' SMS Satisfaction. The results were considered significant at $p < 0.05$.

Factors	**Gender**	**Mean**	**df**	**F-ratio**	***p*-value**
Text Entry Speed	Male	3.36	1	8.24	.005*
	Female	3.73			
Keypad Design	Male	3.27	1	8.16	.005*
	Female	3.72			
Mobile Phone Design	Male	3.57	1	6.06	.015*
	Female	3.86			

Screen Design	Male Female	3.59 3.48	1	.921	.339
Text Entry Usability	Male Female	3.45 3.47	1	.038	.846
Health – Lower Extremity	Male Female	2.51 2.57	1	.091	.764
Health – Upper Extremity	Male Female	2.27 2.48	1	1.83	.179

df = Degrees of freedom; * = Significant at $p < 0.05$.

Table 6: ANOVA test for Mobile Phone Design and Health Effect Factors Satisfaction based on gender.

In Table 6, the low *p*-values for Text Entry Speed, Keypad Design and Mobile Phone Design satisfaction indicate significant differences between the genders. The higher mean values for the females indicate that they are more satisfied with Text Entry Speed, Mobile Phone Design and Keypad Design than males are. The gender differences, however, were not found to be significant for Screen Design, Text Entry Usability, Health – Lower Extremity and Health – Upper Extremity. H2 is thus partially rejected.

Gender and Users' SMS Satisfaction

Table 7 shows that there are no significant differences between the genders for Users' SMS Satisfaction. As the *p*-value is more than 0.05, H3 is not rejected.

Factor	**Gender**	**Mean**	**F-ratio**	***p*-value**
Users' SMS Satisfaction	Male Female	3.35 3.43	1.51	.222

Table 7. ANOVA test for users' SMS satisfaction based on gender.

Discussions

General predictors

Table 5 revealed Text Entry Speed and Text Entry Usability to be significantly associated with Users' SMS Satisfaction. The adjusted R^2 value of approximately 0.23 was as expected, as other studies showed a higher adjusted R^2 value for users' satisfaction in using mobile phone (Yeow *et al.* 2008). The majority of the respondents perceived Text Entry Speed to be the most important factor that determines their messaging satisfaction. A similar finding was reported based on a survey by Cellular Online among 15 to 40 year-old mobile phone users in the U.S., whereby speed was highlighted to be an important factor in sending and receiving messages (Lyons *et al.* 2004).

Many studies have been conducted focusing on Text Entry Speed (Friedman *et al.* 2001; Mackenzie & Soukoreff 2002), while others have searched for an improved text entry mechanism that promises a better text entry rate, e.g. voice input (Cox & Walton 2004; Cox *et al.* 2007), indicating that Text Entry Speed is of paramount important to the mobile phone users. Research has also involved re-designing the keypads to achieve a better Text Entry Speed. One notable example is the Fastap keypad which provides the conventional 12-key keypad plus a full alpha keyboard with punctuation (Cockburn & Siresena 2003). Text Entry Speed has also been used as the focus in a study that involved the redesigning of the conventional 12-key keypad, in order to make messaging easier and faster for the disabled people (Tanaka-Ishii *et al.* 2002). The prototype included only four buttons, and experiments showed the speed of text entry to be higher for both multitap and predictive methods. However, it puts a heavier cognitive workload on the mobile phone user because of the reduced number of keys.

The world is getting fast paced, and it is not surprising for the youths to emphasize on the Text Entry Speed of messaging. Youths today prefer technologies that are efficient, cool, and notably fast. Therefore, it is not a surprise to find Text Entry Speed to be the most important factor affecting the respondents' satisfaction in the present study. This finding opens a possibility for the mobile phone manufacturers to differentiate their products with text entry methods that are faster, easier to learn, less physiologically stressful and more convenient.

Text Entry Usability was also found to be positively associated with Users' SMS Satisfaction. This factor includes items that measure learnability, simplicity, selection of special characters, conversion of the letters to upper-case and lower-case, and traversing through the menu hierarchies to compose messages. Learnability becomes an important issue when it comes to learning the art of messaging, especially the predictive method. Unlike the multitap technique that requires users to make successive key presses, the predictive method attempts to predict the words entered. Users therefore need to monitor the screen and make the necessary key presses in order to make selections. When the words entered are not recognized by the phone, the users must switch back to multitap technique. It is interesting to note that although multitap is deemed to be simpler (Mackenzie 2002) than predictive text entry, experiments have showed similar levels of frustrations among participants for both text entry techniques (Friedman *et al.* 2001).

In addition, it is also important for mobile phone users to know the mappings of each of the overloaded keys for an efficient text entry. This is especially important among the younger users, as they have a higher tendency to use abbreviations, emoticons, and dialects, requiring them to constantly access the special characters. In Soriano *et al.* (2005) middle-aged mobile phone users were found to have difficulty in locating the navigation key to access the menu that allows the user to change between different character input types (e.g. from numerical to alphabetical, or from alphabetical to symbols). Their result was however based on the Samsung T400 model only.

Mobile phone users should also be able to traverse through the menus easily without having to remember too many sequences of actions (deep hierarchy menus). Menus that are simple and easy to use have been emphasized by some mobile phone users in studies that focused on elderly people (Ziefle & Bay 2004, 2006). Another study by Ziefle (2002) among 60 university students revealed that the highest performance measures were accomplished with the phone that has the smallest menu complexity, i.e. Nokia 3210 (as opposed to Siemens C35i and Motorola P7389).

Other factors such as Keypad Design, Screen Design, Mobile Phone Design, Health-Lower Extremity and Health-Upper Extremity were not found to be important predictors for Users' SMS Satisfaction (Table 5). Perhaps the young respondents in the study feel speed and usability to be more important than any physical aspects (i.e. keypad, screen, and mobile phone design) of the mobile phone. Similarly, the reason for Health-Upper Extremity and Health-Lower Extremity factors not to be crucial for Users' SMS Satisfaction could be due to the majority of the young respondents in the study being unaware of the health implications after messaging for a prolonged period. Generally, health impacts on mobile phone users are associated with radio frequency radiations while making phone calls. For example, prolonged exposure to radio frequency radiation has been shown to cause insomnia, dizziness, headaches, and earaches (Yeow & Yuen 2004). In Malaysia, information on health effects caused by mobile phones are not widespread, unlike in other countries such as England where national guidelines have been generally accepted and implemented by government departments and agencies (Independent Expert Group on Mobile Phones 2000). A similar pattern is observed for health effects due to prolonged messaging whereby issues such as wrist and thumb pain among mobile phone users have been addressed extensively in most Western countries (Batista 2001; Cannon 2005).Thus far, however, SMS and health effects have not been covered by research in Malaysia, except for Balakrishnan *et al.* (2005) and Yeow and Balakrishnan (2007), although these were preliminary studies involving 30 respondents only.

Gender

The gender differences for Users' SMS Satisfaction were not found to be significant (Table 7), but significant differences were noted for satisfaction towards Text Entry Speed, Keypad Design and Mobile Phone Design (Table 6), with females being more satisfied than males.

Having to press keys repetitively to enter text causes frustrations among the users, especially the males. About 56.4 per cent (31/55) of the males reported that messaging using the current text entry methods can be tedious and time consuming, especially when they couldn't pay full attention to the screen and keys while messaging (walking, looking elsewhere, etc.). This finding accords with Brewster *et al.* (2003) who observed that users typically focus their visual attention on navigating the environment, making visually demanding interface designs hard to operate. Both multitap and predictive mechanisms require a significant amount of visual searching to find a needed letter or word. This is further aggravated by the poor design of the mobile phone interface for messaging. Trying to enter messages via the tiny keys while being on the move makes messaging a tedious process for the males (larger hand measurements), resulting in them not adopting SMS from time to time, when making a call might be much faster and less cumbersome.

Despite being slow, eight males who used both text entry techniques interchangeably stated that they prefer multitap to predictive text entry. This is because no unnecessary interruptions take place while messaging using multitap. If the words being entered are not recognized by the mobile phone, predictive text entry can be frustrating and slow. This tends to happen quite frequently, as the youngsters very often used abbreviations, emoticons and dialects in their text. For instance, it is a common practice to type "C U" instead of "See You". Furthermore, predictive text entry is a particular problem when an English keypad is used to enter non-English text.

That females were more satisfied than males in the study might also be due to the fact that females generally have smaller fingers, thus being able to make multiple key presses on the tiny keys with lesser error and much faster (Balakrishan & Yeow 2007).

About 24 per cent (13/55) of the males specifically highlighted during the interviews that having more keys would increase their satisfaction in messaging, as this would reduce key overloading (having more than one character per key). Having additional keys in mobile phones will no doubt reduce the number of key presses on the same key that one has to make in order to compose a message. However, the respondents were also quick to point out that an increase in the number of keys should not considerably increase the size of the mobile phones. Moreover, a good keypad layout (e.g. sufficient space in-between keys) also may reduce the possibility of hitting the wrong keys, resulting in the users making lesser errors and corrections while messaging, especially the males who have larger hands and thumbs than females.

Conclusion

The present study was motivated by the lack of studies investigating Mobile Phone Design and Health Effect factors that could specifically affect Users' SMS Satisfaction, both at a national and an international level. This study investigated the crucial factors affecting mobile phone Users' SMS Satisfaction, based on an extensive survey particularly targeting the heavy users of SMS: youths. Other results from the same study have also been reported, namely, in Balakrishnan (2009) and Balakrishnan & Yeow (2007).

Factor analysis resulted in high variance explanations by the independent (73.74 per cent) and dependent (50.58 per cent) variables, including a total of 29 items related to the Mobile Phone Design and Health Effect factors' impact on Users' SMS Satisfaction. The high variances proved that the instrument used to test the research framework in Figure 1, i.e. the interview questionnaire, has a high degree of validity. Therefore, the interview questionnaire can be used by researchers to replicate this study in other countries or of other age groups (e.g. middle age and old people). Moreover, the factor analysis results indicate that all the seven Mobile Phone Design and Health Effect factors (independent) and the Users' SMS Satisfaction (dependent) factor had items that scored high factor loadings. Hence the results of this study are deemed to be in congruence with many other studies.

In general, two important predictors were found to be positively associated with Users' SMS Satisfaction: Text Entry Speed and Text Entry Usability. With this knowledge, the mobile phone manufacturers and designers can put more effort into improving the more important factors, and give less priority to those factors deemed less important, and hence improve user satisfaction. User satisfaction, in turn, results in usage (Isrealski & Lund 2003).

Gender differences were also noted for Text Entry Speed, Mobile Phone Design and Keypad Design, with females being more satisfied than males. Females generally have smaller hands and thumbs, and therefore find e.g. messaging via tiny keys easier than males do. Mobile phone manufacturers and designers can design customized mobile phones for the male population.

Limitations of the Study

The present study only focused on youths between 17 and 25 years of age, as this group is where we find the most active SMS users. This enabled the collection of data from the more skilled and knowledgeable users, as compared to other groups of users who rarely use SMS, such as the elderly. Future work may include users from other age groups.

The findings presented in this study were based on a sample size of 110 respondents. Although this number may seem small, a total of 110 respondents is to be considered large when compared to that of many other studies involving interviews (Mykletun 1985; Davis 2004). In addition, the respondents in the present study are quite homogeneous, in the sense that the majority of them were college and university students (76.3 per cent, 84/110). This is because convenience sampling was used in this study, whereby respondents were recruited and interviewed in Melaka and Perak only as it was not feasible to conduct interviews in all the 13 states in Malaysia. Future work could address a more heterogeneous community.

It is also to note that the present study focused on the physical keypad design, particularly the 4x3 keypad layout design. This is because the majority of the mobile phones in the Malaysian market employ this layout. Mobile phones with the QWERTY layout are also available. Such phones are however mainly used by working adults due to their steep prices. Similarly, mobile phones with virtual or dynamic keypads were not included in this study, as they as well are catered mostly to working adults. Perhaps these keypad layouts can be included in future studies.

Vimala Balakrishnan has a PhD in the field of human-machine interaction/ ergonomics. Her research is particularly focused on mobile devices, especially mobile phones and their applications. She is currently affiliated with University Malaya, Malaysia. E-mail: vimala.balakrishnan@um.edu.my

Paul H.P. Yeow, PhD, is an associate professor of e-business in Monash University. His areas of expertise include e-business, e-commerce, and human factors. He has published over 60 international refereed journal articles and conference papers, and is in the editorial board of Journal Computer Information Systems and Journal of Urban Technology. E-mail: paul.yeow@buseco.monash.edu.my

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