Mobile QWERTY User Research

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Abstract. In this paper, we describe the methodology and the activities of mobile QWERTY research and give examples of different pieces of research and some of the results and insights. To minimize confounding effects of different aspects of QWERTY design, we use virtual keyboard layout tools to construct/replicate different keyboard layout designs so that both human performance and user satisfaction can be captured by systematically varying design parameters in the same testing environment. In addition, we also conduct usability testing by varying specific hardware design parameters and keeping all others constant whenever possible. By using this 2-pronged approach, an empirical performance model of mobile QWERTY keyboard in relation to different design attributes (both perceptual and mechanical) can be built over time. The approach we have adopted in virtual keyboard testing also helps to improve virtual QWERTY keyboard design on touch devices as well as physical QWERTY keyboard layout on devices with physical QWERTY.

Keywords: mobile QWERTY, human performance, user satisfaction, performance model.

1 Introduction

Usability of mobile QWERTY keyboard is determined by many different design variables: the overall size of the keyboard, the number of lines, the size, height, trip force, travel of individual keys, the geometry of key shape etc. Samsung Design Group at Korea and Samsung Telecommunications America jointly conducted systematic QWERTY ergonomics and usability evaluations of existing as well as prototype mobile devices to unravel the relationship between different design variables and establish best practices of mobile QWERTY keyboard design.

1.1 Research Goals

The primary goal in this program is to guide the development of new QWERTY devices by best practices informed by research and to test and improve new QWERTY keyboard design prototypes in development. These include the design and development of both physical and virtual QWERTY keyboards. By benchmarking typing performance, subjective user satisfaction and assessment of usability, we will continually improve our design recommendations and best practices.

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1.2 Research Methodology

In order to provide research supporting a wide spectrum of situations, different research techniques have been used, ranging from low-fidelity paper prototyping using simulated typing to relatively large scale competitive text entry with different QWERTY devices in the market. In addition, competitive text entry research using virtual QWERTY keyboards has been conducted routinely to compare different QWERTY layouts from different device vendors or carriers and keyboards from third-party developers.

1.3 Measurements

In most cases, dependent measures included human performance (speed and accuracy of typing), user satisfaction, and evaluation of the ease of entering text, symbols, and numbers. Within-subjects counter-balanced experimental designs have been used when possible in most of the research studies conducted. In all the research done, the branding information of the devices or prototypes was hidden to avoid potential bias of the respondents.

The speed of typing was captured by having respondents type a template string as fast and accurately as possible within one minute without correcting any mistakes. The speed was measured by the number of characters typed per minute (cpm) including spaces, numbers and symbols.

The accuracy of typing was derived from the mean string distance (Levenshtein distance) between the typed string and the template string [1].A composite performance index (reflecting both speed and errors) was defined from the relative percentage of correct matches with the template string.

Subjective assessments of ease of text, number and symbols entry, clarity of marking on the QWERTY keys and overall typing satisfaction were recorded on 1-5 Likert scales. The devices under comparison were also ranked in terms of overall QWERTY design preference by the respondents.

In the study of the relationship between performance, user satisfaction and physical design characteristics, the following QWERTY keyboard design characteristics were measured: key size (height, width), key travel, trip force, keyboard width, keyboard height, center-to-center key distance (both width and height), number of key rows, and the space bar width. Subjective assessment of the physical design characteristics were captured by a 7-point scale with “too small” on the left, “just right” in the middle (at 4) and “too big/large” on the right.

2 Physical Mobile QWERTY Evaluations

From these subjective evaluations as well as objective measurements of human performance, the optimum range of physical design characteristics can be determined. The primary research activities in this area include competitive performance benchmarking of devices with physical QWERTY keyboard, collection of qualitative feedback and ratings with mockups and wax models.

The various physical design parameters (typical measurements include trip forces, key travel, key sizes, spacing between keys etc.) are measured and correlated with both performance and subjective evaluation of the different physical design characteristics. Example research in this area includes an investigation of the relative roles of different physical parameters using mobile physical QWERTY devices in the market with varying design characteristics, comparison of key trip force by using two identical keyboards with different trip forces, and comparison of key depth (the height of the key from the adjacent surface) using wax models.

2.1 Competitive Mobile Physical QWERTY Performance Benchmarking

Competitive mobile physical QWERTY performance benchmarking studies were conducted frequently on representative devices in the market as well as Samsung pre-launch devices. Typically, participants would perform typing tasks on a number of devices with physical QWERTY keyboard. The order of the devices would be counterbalanced and the respondents would type 1 and/or 2 predefined strings (one would consist of mostly words while another would be a mix of words, number and symbols). They were instructed to type the string as fast and as accurately as possible within one minute without correcting any mistakes. The results were analyzed against the template strings. The number of characters typed was counted and the mean string distance from the template strings was calculated.

The results from a recent QWERTY performance and user satisfaction of LG Ally, HTC G2 and Samsung Epic Android smartphones is shown below [2].

Respondents (N=54) completed a typing task with mixed input entry (letters/symbols/number) using LG Ally, HTC G2, and Samsung Epic. Both LG Ally and Samsung Epic keyboards were ranked significantly higher than the keyboard of HTC G2. The same significant results applied to overall satisfaction. respondents also typed significantly faster and more accurately with both LG Ally and Samsung Epic Keyboards, and the key markings of Samsung Epic were rated significantly better in clarity than the other devices.

HTC G2 was rated significantly worse than other devices in the ease of typing symbols, the ease of text entry and the ease of number entry.

Table 1. Competitive QWERTY performance and usability scores

QWERTY Benchmark	LG Ally (A)	HTC G2 (B)	Samsung Epic (C)
Speed (cpm)	49.29*	45.02	52.15*
Accuracy (	0.34*	0.30	0.36*
Ease Text (1-5)	3.52*	3.04	3.69*
Ease Symbols (1-5)	3.13*	2.37	3.28*
Ease Numbers (1-5)	3.93*	2.78	4.13*
Clarity (1-5)	3.91	3.22	4.06*
Satisfaction (1-5)	3.52*	2.81	3.41*

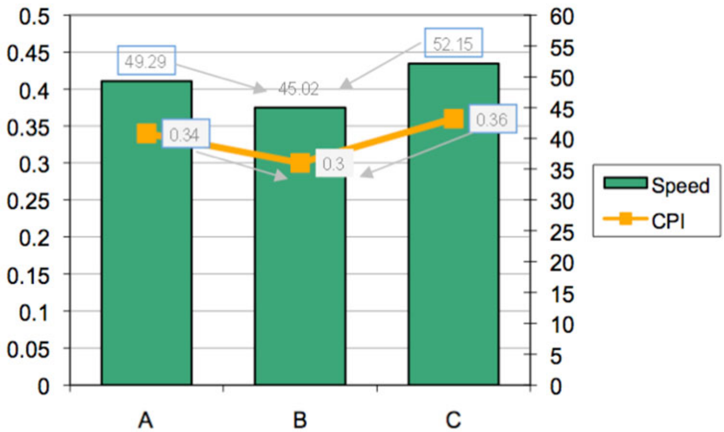

Fig. 1. Speed and Composite Performance Index of LG Ally (A), HTC G2 (B) and Samsung Epic (C)

2.2 Physical Design Attributes and QWERTY Performance/Satisfaction

The primary purpose of this research is to build a performance/user satisfaction model of QWERTY based on salient physical design characteristics. This line of work also spurred interests from the carriers on the usability of QWERTY keyboards and their own investigation of QWERTY comparisons.

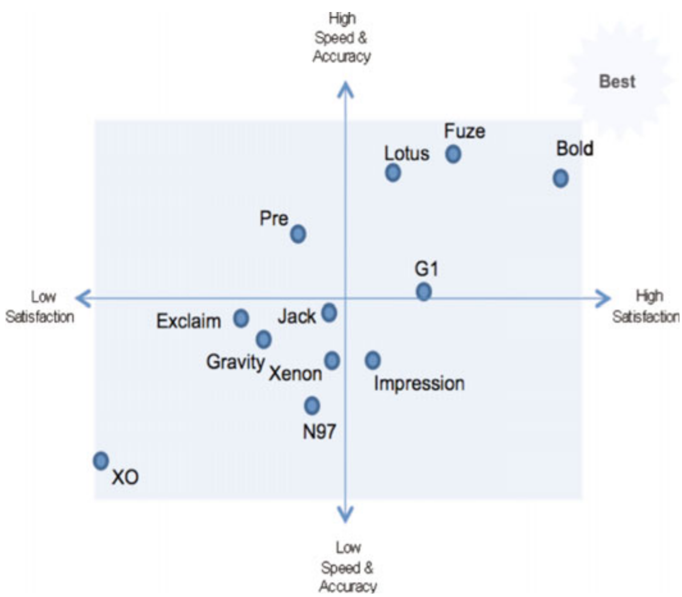

Fig. 2. Speed/accuracy and satisfaction of 12 different physical QWERTY devices

The following example study [3] was used to develop a set of design parameter recommendations and guidelines. A QWERTY performance and user satisfaction study (N=119) was conducted with 12 different mobile phones with physical QWERTY keyboards. The physical design characteristics of each keyboard were measured. The performance data (speed and accuracy) and user satisfaction data were used to identify critical physical design characteristics of mobile QWERTY keyboard.

The baseline analysis was a conservative Partial Linear Square Regression on 12 QWERTY devices (2 Components were used for model quality) in this study:

1. Dependent Variables: Speed, Accuracy, Ease of Typing and Satisfaction.
2. Independent Variables: The following baseline physical design variables have been identifiedin decreasing order of importance: spacebar width, travel, key gap height, key gap width, vertical center-to-center-distance between keys, number of rows, trip force, key curvature and tactile slope.
3. Spacebar width has been identified as the <u>most important</u> physical design variables affecting performance as well as users' satisfaction (from both quantitative and qualitative analyses).
4. Component t1: high negative correlations of gap width and gap height and strong positive correlation of curvature, spacebar width, tactile slope and trip force with t1. The dependent variables speed and accuracy also correlated highly with t1.
5. Component t2: The correlation of accuracy was negative while the other dependent variables (speed, ease of typing and typing satisfaction) were positive. Thus, the linear variate of the independent variables affected accuracy in an opposite direction than the speed, ease of typing and typing satisfaction. Travel, Trip force, height, tactile slope, letter key height and curvature varied negatively with speed, ease of typing and satisfaction.

Table 2. Standardized coefficients of physical variables from PLS Regression (2 components)

Physical Variables	Speed	Accuracy	Ease	Satisfaction	Rank
FMax(grams)	-0.027	0.101	-0.122	-0.107	7
Tallness(.001)					
Travel(.001)	-0.165	0.018	-0.282	-0.258	2
TactileSlope	0.046	0.142	-0.035	-0.025	9
TactileRatio			-0.155	-0.141	
Letter Key Width			0.141	0.13	
Letter Key Height					
CCD Key horizontal					
CCD Key vertical	-0.153	-0.11	-0.163	-0.155	5
Keyboard Width					
Keyboard Height					
Spacebar Width	0.266	0.16	0.308	0.29	1
Gap Width	-0.193	-0.164	-0.186	-0.178	4
Gap Height	-0.206	-0.174	-0.199	-0.191	3
Curvature	0.098	0.148	0.045	0.048	8
# of keys					
# of rows	0.131	0.098	0.138	0.131	6

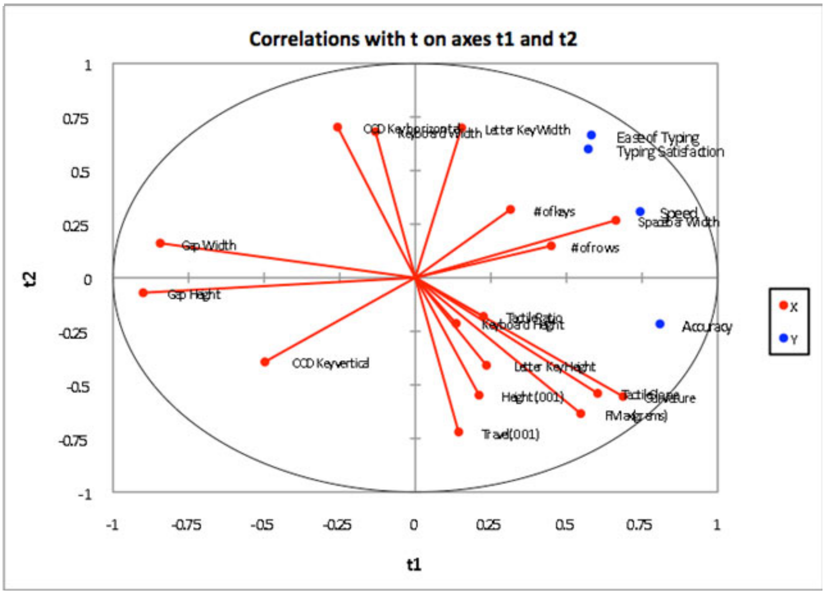

Fig. 3. Correlations of dependent and independent variables with t on axes t1 and t2

3 Mobile QWERTY Keyboard Layout Research

For mobile QWERTY keyboard layout research, the layouts can be constructed from either paper/foam models or from a QWERTY keyboard construction tool to be used in hand-held Windows XP and Android devices. The use of these tools allows for systematic variations and control of different design parameters and layouts to minimize confounding results. Ultra Mobile PCs with 4" touch display have been used to study different layouts keeping the form factor of the testing devices constant.

Fig. 4. Example of QWERTY layout on an ultra mobile PC with touch display

Example research topics include keyboard size [4], number of rows and columns of QWERTY keys, symbols and numbers placement and mapping, staggered and grid layout. The intent of using virtual QWERTY keyboards in these research studies is to isolate the layout of the keyboard from the effects of the physical, mechanical construction of the keys (e.g., trip force, key height and 3-D contour).

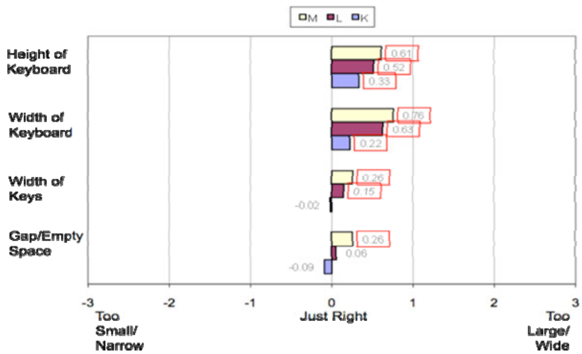

Fig. 5. Example findings of key design assessment. Layouts M, L and K correspond to QWERTY keyboards of decreasing size.

Findings from these research studies suggest that users prefer a separate number row like PC keyboard and 5-row mobile QWERTY keyboards are generally more design “fault-tolerant”. Respondents also performed better in grid layout than staggered layout.

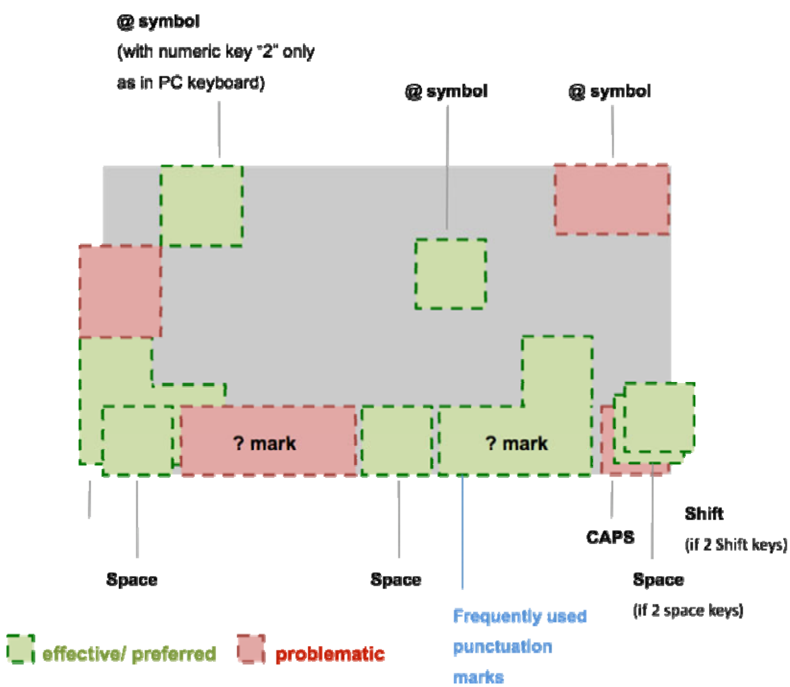

Fig. 6. Example findings of key placement locations in a typical QWERTY layout study

We also used this approach extensively to benchmark QWERTY performance and satisfaction scores of different QWERTY layouts from competitive devices as well as from the requirements of different carriers.

4 Virtual Mobile QWERTY Layout Research

User performance and preference of mobile virtual QWERTY keyboards with different display sizes (and/or varying from factors) were investigated consistently by using the same set of smartphones/tablets (with different display sizes). In order to isolate the impact of differences in touchscreen performance, general user interface as well as the influence of branding, the Keyboard layouts from Apple iphone and iPad were prepared with Samsung virtual keyboard layout designs (for Galaxy S smartphones and tablets). Human performance and satisfaction with typing were captured by having respondents (N=48) enter mixed text, number and symbols sentences in devices of different size display [5].

The virtual keyboard layouts of Samsung Galaxy S smartphones and tablets typically outperformed Apple iphone 4 and iPad keyboard layouts in both satisfaction and ease of use ratings as well as ranking except in typing speed of “words” (letters, numbers and period). Even in these circumstances, the error rate of Apple iphone4 and iPad keyboard layouts was typically larger than Samsung keyboard layouts.

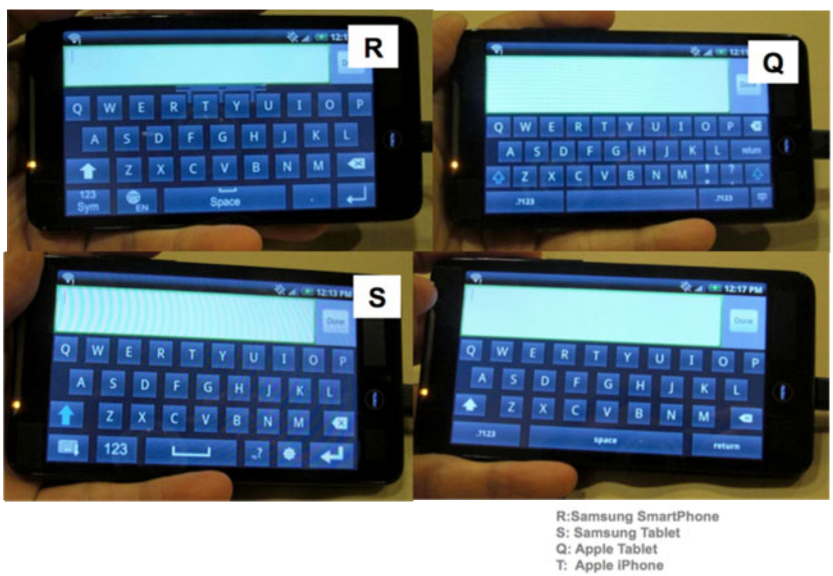

Fig. 7. Examples of different keyboard layout on a 4.3” display smartphone

User satisfaction for portrait virtual keyboard layouts increased significantly or directionally with increasing touch display size (significant results were observed in all the keyboards tested). The effect was much less pronounced with landscape virtual keyboard layouts (significant results only observed in Samsung Tablet).

Respondents made significantly or marginally less errors using Samsung Smartphone and/or Tablet keyboard layouts compared to Apple iPad and/or iphone keyboards.

Display size as a factor is also significant in the number of errors of both Samsung Smartphone and tablet Portrait layouts from 4” to 4.3” display. These results pointed towards the use of 4.3” display for portrait QWERTY layout would significantly reduce the number of typing errors compared to 4.0” display in typical text typing task (but not in mixed entry).

5 Future Direction

We will continue to benchmark performance and user satisfaction of mobile QWERTY keyboards when new devices are launched into the market and also test new keyboard layouts and input paradigms through the techniques we covered above. One possible direction for future research is to investigate the use of new predictive or adaptive text input methods on top of the QWERTY keyboards.

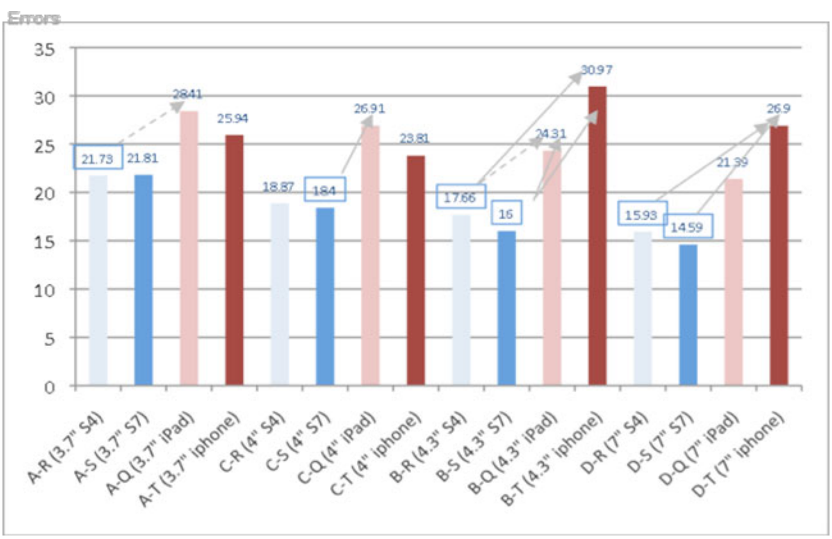

Fig. 8. Typing errors of Samsung keyboards significantly lower than Apple keyboards (Landscape mode, text/symbols/numbers entry). S4 Samsung Galaxy Handset, S7 Samsung Galaxy Tab.

Acknowledgments. The research studies were conducted and analyzed either by the user research staff from STA or through third-party vendors – HumanCentric, Gist Design or Strategy Analytics.

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