Eric Hagen
Case Study – The Keyboard

Overview:

The QWERTY keyboard has become a ubiquitous device for many daily and necessary tasks that are completed in the English-speaking world. Whether the interactions with these keyboards take place on physically independent keyboard devices, or on a touch screen, so many of life's daily tasks are performed through keyboard access. Since the QWERTY keyboard has prevailed as a de facto standard for over a century, we often do not consider the organizing principles that have gone into the arrangement of its keys. This case study will focus on the principles that govern the arrangement of the physical keys on the keyboard, considering the key and its symbol to be the description resources being organized. Different layouts have been proposed, governed by different organizing principles, throughout the reign of the QWERTY keyboard. We will examine how these organizing principles allow for the resource descriptions to serve as a means for physical interaction within the presentation – logic – storage model.

What is being organized?

The keys on the keyboard serve as the description resources being organized within our organizing system. It is instructive to think in terms of the presentation, logic, storage model when considering the arrangement of these description resources. The goal of this organizing system is to provide the user with a presentation with which they can interact in order to communicate a desire that can be carried out by the computer. When considering the keyboard within this framework, the frequency of use organizing principle becomes immediately evident as being a critical consideration in key organization. We will revisit that principle in the coming sections.

The QWERTY keyboard arrangement devised for typewriters in 1873 by Christopher Scholes remains largely unaltered today. Each key on the keyboard represents a letter, number, character, or action/function. Many of the physical space limitations remain today. The majority of desktop and laptop keyboards feature key spacing of roughly 19 millimeters between key centers (Pereira, 2013). This is true regardless of the keyboard configuration being considered.

Other keyboard layouts have been proposed and tested over the last century. By comparing the organizing principles that govern the layouts of the DVORAK, and also different variations of alphabetical arrangements, we can discuss the strengths and weaknesses of each while trying to determine if there is an optimal arrangement of theses resource descriptions that facilitates optimal user interaction.

Why is it being organized?

The goals behind the organization of keys on the QWERTY keyboard have been debated through the years. Many have argued that the layout is seemingly arbitrary and requires a great deal of mental processing for new users to became proficient typists. This argument suggests that the main goal of the QWERTY resource description organizing system was to reduce mechanical interference between bars of successive keystrokes. Due to this interference, keys found to be selected in sequence were moved to different sections of the keyboard. There is not consensus on this mechanical interference being the actual deciding factor in key arrangement, but the idea of identifying common key sequences nonetheless is an important consideration in QWERTY layout. Frequently used pairs of keys should logically be separated so that different hands and fingers necessarily access them. Within this framework, the QWERTY layout becomes less arbitrary, and even more so when one considers that much of the early use of QWERTY typewriters centered on translating Morse code transmissions.

The optimal keyboard should be organized so that users can most efficiently (speedily) interact with the description resources. The current QWERTY keyboard layout is the result of the de facto standardization of the layout of the Remington No. 2 typewriter of 1878. Due to this de facto standardization, competitors to the QWERTY layout have been unsuccessful in achieving any kind of major market penetration in the English-speaking world. The most commonly cited competitor to the QWERTY layout has been the DVORAK keyboard, which was devised in the first half of the twentieth century and tested extensively during World War 2. The goal of the DVORAK was that it be an improvement over the QWERTY layout by focusing on time and motion study revelations (Norman, 1982). We will examine these ideas in the next section.

How much is it being organized?

While the layout of the QWERTY keyboard allows for ambiguity in defining exactly how much it is being organized, the DVORAK keyboard has a more concrete origin story. The DVORAK was designed with the primary goal being reduction of distance traveled by fingers during typing. The frequency of use principle for organizing the keys on the DVORAK is plainly evident. August Dvorak, the primary designer of the keyboard, redesigned the QWERTY layout in order to move the most commonly accessed characters to the 'home' row of the keyboard. Beyond that rearrangement, the DVORAK layout also emphasizes assignment of frequently sequenced keys to alternating hands (similar to the QWERTY). The results of this organization can be simply reduced to one comparison – it has been observed that roughly 70% of key interactions occur with keys on the home row of the DVORAK layout, compared to 32% on the home row of the QWERTY (Noyes, 1988).

Donald Norman at UC, San Diego, conducted an interesting study on the effectiveness of various keyboard layouts. Norman conducted the study on both

novice and experienced typists, and tested to see how typing speed differed between the QWERTY, DVORAK, and alphabetic layouts (alphabetic layouts were suggested as being a logical layout for a beginner, as the user would be able to most easily map their understanding of the alphabet onto a keyboard). The findings of the study suggested that alphabetically arranged keyboards were slightly easier to understand and type on than a randomly arranged keyboard, but not more so than the DVORAK or the QWERTY. The QWERTY also fared better than the DVORAK in testing, which is likely attributable to its ubiquity even among novice typists. The Norman study concluded the same thing as many of its predecessors – the de facto standardization of the QWERTY layout has created too much inertia for the QWERTY to be replaced by a similarly designed competitor.

When is it being organized?

The fundamentals of the QWERTY layout, as devised and patented in 1873, remain largely the same. Due to its de facto standardization, major improvements and alterations have never been successfully made to the QWERTY keyboard. The DVORAK keyboard was developed and patented in 1936. The alphabetical keyboards discussed as part of the Norman study in the previous section were developed for the purposes of that experiment in 1982.

How, or by whom, or by what computational processes is it being organized?

The QWERTY layout was principally designed and patented by a small group of entrepreneurs led by Christopher Scholes. The design of the QWERTY was slightly modified and subsequently 'standardized' by Remington.

The DVORAK keyboard layout was designed and patented by August Dvorak.

The alphabetic keyboards discussed in the preceding sections were organized by a team of human factors engineers led by Donald Norman and Diane Fisher at the University of California, San Diego.

Where is it being organized?

This case study limited the investigation to the layout of physical keyboards, especially those that are currently used as part of a laptop or a personal computer. Thus, certain elements were common – physical keys, a three rows of letters representing the alphabetic characters, a single row of numbers above the rows of letters, and a space bar below the bottom row of letters.

Other considerations

While this case study was primarily a historical overview of keyboards as an organizing system, the question of how to improve the layout is more relevant today than ever before. With the presence of the ever shirking computing device (phones,

watches, etc.), there are completely new typing styles being employed by the users of these smaller devices. Thumb or single finger typing has become pervasive on many of these new devices. In this new environment, there will be opportunities to radically change the arrangement of keys in order to more easily facilitate user interactions with the resource descriptions.

References: The following references relate to this case study.

1. Norman, Donald, and Fisher Diane. Why Alphabetic Keyboards Are Not Easy to Use: Keyboard Layout Doesn't Much Matter. *Human Factors,* 1982*, 24(5)* 509-519.
2. Pereira, Anne, et. al. The Effect of Keyboard Key Spacing on Typing Speed, Error, Usability, and Biomechanics: Part 1. *Human Factors,* June 2013, 557-566.
3. Noyes, Jan. The QWERTY Keyboard: A Review. *International Journal of Man-Machine Studies,* August 1988, 265-281.

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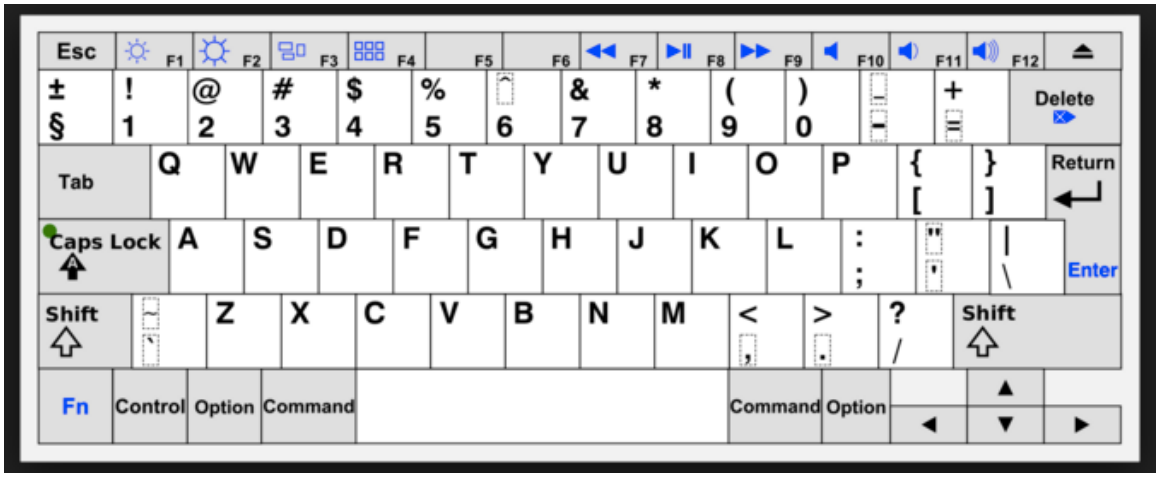
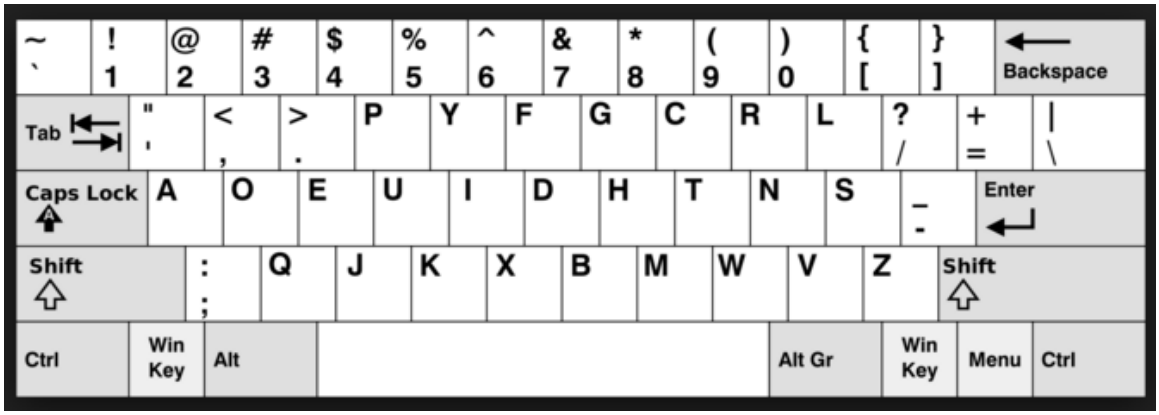
Case Study Artifact – Keyboard



The QWERTY keyboard layout. Effort was made to separate common key combinations so that different hands would necessarily be required to make successive keystrokes where possible.



The DVORAK keyboard layout. Frequency of use principle played crucial role in determining which keys would keys were assigned to the home row, in order to reduce distance traveled by fingers during typing.

Attempts have been made to improve the ergonomic qualities of the QWERTY keyboard. This contoured keyboard purports to provide more natural resting and active hand positions in order to facilitate less stressful typing.

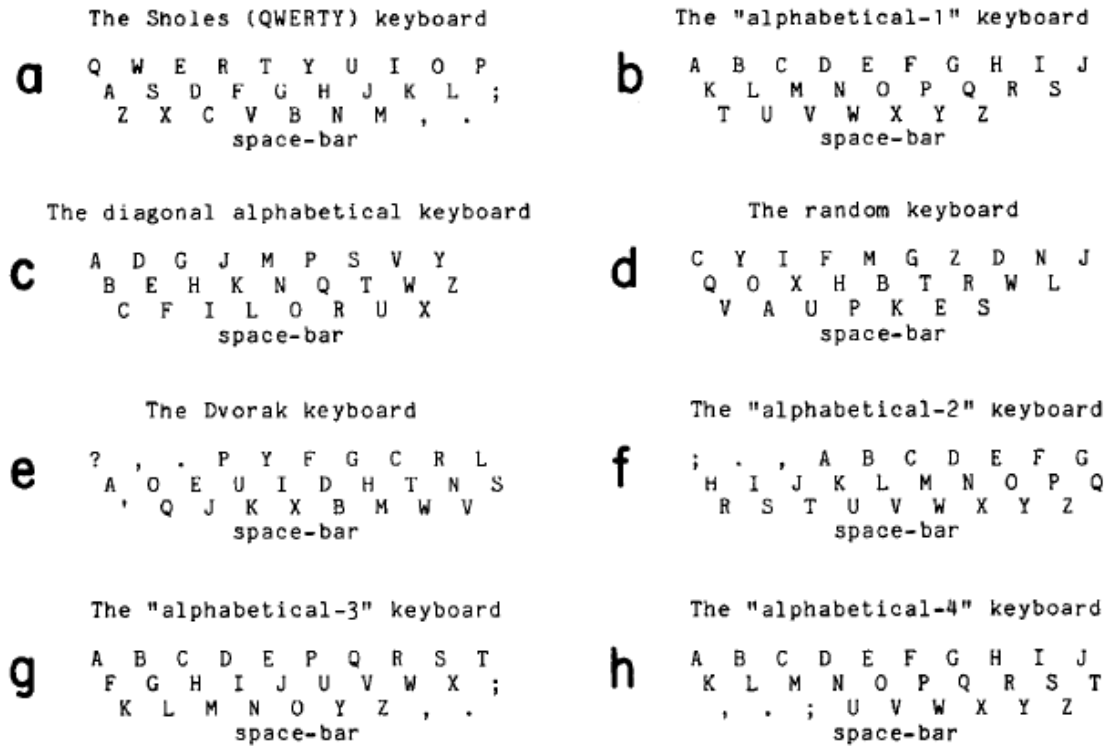


Figure 1. *Six experimental keyboard arrangements (A, B, C, and D for Experiment 1; A, B, C, D, E, F, G, H for the simulation.*

Examples of the keyboards used in the Norman study referenced in the case study. It was found that alphabetical keyboards placed a much greater cognitive stress on users than anticipated. Users were mentally working through the alphabet to ascertain order, and furthermore, the users had no way of knowing at what letter a particular row ended on, thus further increasing the cognitive load and the need to look down at the keyboard to verify key location.

TABLE 1

Letters Typed in 10 Minutes by Nontypist Subjects (Not Including Spaces and Punctuation)

	KEYBOARDS			
	Sholes	*Alphabetical-1*	*Diagonal*	*Random*
Mean	648	388	391	356
Letters/s	1.08	0.65	0.65	0.59
Words/min	13.0	7.8	7.8	7.1

TABLE 2

Typing Speeds Calculated from the Rumelhart and Norman (1982) Typing Model*

Keyboard	*% Row Use* Top	Middle	Bottom	*Space*	*% Left Hand*	*% Right Hand*	*Model words/min*	*% Deviation from qwerty*
Qwerty	42	27	15	16	57	43	56	—
Dvorak	21	56	7	16	47	53	58	+5.4
Alphabetical-1	37	30	17	16	64	36	52	−7.1
Alphabetical-2	29	29	24	16	54	46	55	−1.8
Alphabetical-3	43	18	23	16	66	34	51	−8.9
Alphabetical-4	37	38	9	16	57	43	55	−1.8
Diagonal	23	29	32	16	55	45	55	−1.8

* In these computations, the space key is assumed to be typed with the right thumb

Tables of results from the Norman study. While there are advantages to the DVORAK layout in a purely theoretical sense, there is agreement that it is not advisable to deviate from the current QWERTY de facto standard. The QWERTY is simply too ubiquitous to be overtaken by anything short of a radical paradigm shift in keyboard layout and function.