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THE KEYSTROKING ABILITY OF COMMERCIAL PILOTS

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16 Abstract

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SUMMARY

Several area navigation systems for large aircraft have appeared on the market recently. The more complex of these include both numeric and alphabetic keyboards. The alphabetic keyboards used are generally arranged ABC....Z in a square or rectangular array. However, previous studies have shown advantages for the standard (QWERTY) arrangement for data entry, even if the user population has a very low level of typing ability. The typing ability of commercial pilots was not known. A sample of airline and commercial pilots was tested on a standard computer keyboard (QWERTY). They were found to have a useful level of proficiency in operation of this keyboard. Implications for the design of alphabetic keyboards for airborne use are discussed.

*This research was conducted while the author held an NRC resident research associateship.

INTRODUCTION

Several area navigation (RNAV) systems for large aircraft have been placed on the market recently by such manufacturers as Bendix, Collins, Garrett, and others. The more sophisticated of these include both numeric and alphabetic entry capability. The inclusion of an alphabetic entry keyboard allows such desirable features as free entry of intersection names without consulting code lists, elimination of many index pages, and quicker operation. However, the letter keyboards adopted by the manufacturers have so far been arranged alphabetically, in a square or rectangular array. The reasoning for this arrangement would seem to be that since the user population (pilots) are not typists, no advantage is gained by arranging keyboards in standard (QWERTY) format. However, two studies (Hirsch, 1970; Michaels, 1971) have shown that, even for untrained typists, there are advantages for the QWERTY arrangement.

Hirsch (1970) compared the performance of nontypists on two typewriter keyboards, alphabetic and QWERTY (standard). He defined nontypists as those who scored less than 2 strokes/s on a pretest with the standard keyboard. The group of 40 such was divided randomly into two groups of 20, each of which practiced for approximately 7 h on one or the other type of keyboard. At the end of this time, the group which had practiced on the standard keyboard was significantly ($p < 0.01$) faster than on the pretest, as expected. The group which had practiced on the alphabetic keyboard, however, had not yet quite reached the speed on that keyboard that they initially did on the standard keyboard without any practice.

Michaels (1971) used a similar set of keyboards, but used 30 subjects ranging in skill from unskilled to skilled secretaries. The QWERTY keyboard

was found to be superior for all but the least skilled, and for them, neither keyboard showed any advantage. Michaels concluded, "Operators with little or no typing skill, for whom alphabetic arrays are frequently intended, were as fast or faster with the standard typewriter arrangement, while skilled typists turned out nearly twice as much work on the standard arrangement as they did with the alphabetic" (p. 425).

We could infer from these studies, then, that, if there is any typing skill at all in a sample of typical users of an area navigation system, it would be advantageous to arrange a keyboard for them in the standard (QWERTY) order. If they had little or no typing skill (average of less than 1.25 keystrokes/s) it would make little difference which keyboard arrangement was used, except that we would not expect them to improve much with practice on the alphabetic version.

What speed and accuracy would be attained by a sample of pilots using a standard keyboard? The answer would have a bearing on the design of keyboards, for, if a significant speed and accuracy were attained, it would tend to indicate that pilots were already familiar with the QWERTY arrangement, and that negative transfer might occur if they were to use any other arrangement. Certainly, no other 26 letter arrangement would be faster on the average without extensive training of the pilot population, since Michaels and Hirsch have shown that even untrained typists do better on QWERTY keyboards. Also, those with training on the standard arrangement would need to unlearn it, thereby making their learning curves slower to reach an asymptote; therefore, the overall effect would be poorer performance for any nonstandard arrangement. The skill level of airline and commercial pilots as typists was not known.

METHOD

Commercial- or airline-rated pilots were brought from another experiment into the Life Sciences' PDP-12 computer room at Ames Research Center. It was explained that they would be using computers extensively in future aircraft, and it was necessary to find out how quickly and accurately typical pilots could enter data into a computer. One of the PDP-12s was then set by the experimenter to echo whatever was typed on its Decwriter, that is, it operated like a standard electric typewriter, except for the flashing lights and normal hum and clatter of a typical small computer.

This method was chosen over use of a standard typewriter for the greater "face validity" and interest it would hold for pilots. Asking a typical airline pilot to take a typing test could be viewed by them as insulting. However, acceptance of the "computer operating" task was good.

Practice text was provided, and the pilot was allowed to practice until he felt he had "gotten as good as he was going to get" in a short time on the machine, typically about 5 min. The number of practice characters they typed varied from fewer than one line to two or three paragraphs. When the subject stated his readiness, the practice text was replaced with similar test material. Both practice and test materials were taken from the introduction of a paper by Fenwick (1970) and consisted only of letters and punctuation.

RESULTS

The results are shown in Table 1. Except as noted, all pilots were employed by airlines, flying jet transports. The mean number of keystrokes/s was 1.54, thus placing the ability of these subjects between Michaels "low" (1.24/s) and "middle" (2.19/s) typing ability groups.

DISCUSSION

The results show that a sample of pilots will have a small, but useful amount of typing skill. Michaels (1971) demonstrated that an alphabetically ordered keyboard showed no advantages over the standard arrangement in output rate, error rate, or speed of learning, for skilled or unskilled typists. Hirsch (1970) concluded that the alphabetical keyboard is certainly not better than, and may not be as good as, the standard keyboard for relatively low-skilled typists. This finding does not change after 7 h of practice on the alphabetic keyboard. Therefore, from the findings of these two studies, together with the results of the present study, it follows that:

1. For pilots, a QWERTY arrangement of keys would be preferred for future systems that require more than very limited use of an alphanumeric keyboard.

2. For any key arrangement, a designer should minimize inflight use of such a keyboard, due to the high error rates shown in this study, and the higher ones expected with any keyboard under vibration conditions (Fenwick, 1970).

3. Even on the ground, and with a QWERTY keyboard, designers should expect that pilots will not greatly exceed the approximately 1.5 keystrokes/s found in this study.

4. The error rates (4.3 errors/min, average) shown in this study imply that a quick, simple means of verifying and correcting alphabetic entries should be provided in future systems.

It can be argued that these RNAV system keyboards will be little-used, and usually will be punched one-handed. As Hirsch pointed out, one of the advantages of the QWERTY keyboard is that it concentrates the most-used keys toward the center of the keyboard area, and therefore no matter how many fingers are used, it would probably show some superiority due to the smaller visual search area. Also, anyone who had had some experience with the QWERTY format would have little or no search problem.

Designers of these systems might also give some thought to locating a keyboard on an umbilicus or in a location such that it could be easily used with one or both hands. In this way, large volume entry (typical of preflight preparation) could be quickly performed on the ground; but if something had to be changed in flight, such minor changes could be done with one hand.

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TABLE 1

Results of the 5-Minute Keystroking Task

Subj	Age	Flight h	Total char	Char/s	Errors
1 *	23	1000	357	1.19	2
2 *	21	1250	319	1.06	7
3	33	7000	372	1.24	8
4	35	3200	587	1.95	27
5	29	5500	479	1.60	25
6	36	5000	737	2.45	159
7	40	7000	320	1.06	10
8	37	4000	480	1.60	7
9	36	6000	389	1.30	7
10	37	9000	480	1.60	21
11	38	12000	511	1.70	2
12	38	10300	375	1.25	4
13	35	7000	612	2.04	14
14	36	5600	532	1.77	25
15	32	4000	419	1.40	5
Averages				1.54	21.5

*Commercial pilots only.