An Analysis of Users' Preference on Keyboards through Ergonomic Comparison among Four Keyboards

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**Abstract.** The usability of four kinds of keyboards as regards touch and feel was evaluated by measuring the performance and eliciting the preferences of a total of 24 Japanese participants in a test that consisted of typing English text. It was found that quiet keyboards with an indistinct tactile feedback tend to give higher uncorrected error rates than keyboards with a distinct tactile feedback and clicking sound, while no significant difference in throughput was found among the four keyboards. As regards preference, the test participants were divided into two groups: those who preferred keyboards with a distinct tactile feedback and clicking sound, and those who preferred keyboards with an indistinct tactile feedback and no sound. Analysis revealed that these two groups also showed different sensations and preferences with respect to several aspects of the touch and feel of keyboards. This result suggests that suppliers of computer keyboards should provide two kinds of keyboards, with distinct and indistinct tactile key switches, in order to satisfy as many users as possible.

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**Keywords:** user preference, key switch, typing performance, tactile feedback, keyboard usability

**Introduction**

User interface is attracting increasing attention these days. Although in the area of computer usability it is most fashionable to discuss graphic user interfaces and hypertext programs, the keyboard still plays a considerable role in the user interface of a computer system as an input device. The usability of a keyboard has many aspects, such as the layout and size of the keys, the shape of the keyboards, and the characteristics of the key switches. Several guidelines and standards (ISO/DIS 1995, ANSI 1988, JIS 1987, DIN 1980–84) to help designers make keyboards usable are already available or being prepared. However, they do not define a specific value for each requirement, and they describe a range of required values. Therefore, even though a keyboard may meet the guidelines, it does not always satisfy its users, because the most suitable design is often affected by various factors such as the users' typical tasks, work environments, and preferences. The ergonomic guidelines usually seem merely to provide suppliers and designers with the minimum design requirements to ensure that products are not actually uncomfortable to use. To satisfy as many users as possible, it is necessary to analyze the preferences and performance of real users.

The purpose of this study is to compare four kinds of keyboards, all with different key switches, in terms of the performance and preferences of users typing English text, and to discuss the relations between the users' preferences and performance and the usability characteristics of the key switches on these keyboards.

**Experiment Method**

**Participants**

A total of twenty-four subjects (male: 9, female: 15) participated in the study. All the test participants were Japanese and could touch-type at speeds ranging from 35 to 80 words per minute (gross).

**Tested keyboards**

All of the four keyboards tested in this evaluation were manufactured by four major companies in Japan, and these keyboards have been in the market place since the beginning of 1990s. It is considered that these keyboards represent the typical keyboards used at the time. Table 1 summarizes the characteristics of the four keyboards. All the keyboards had the same OADG (PC Open Architecture Developers' Group) layout, and the same 19 mm key pitches between adjacent keys. KBD-A was an IBM 5576-A01 keyboard with spring key switches. KBD-B and KBD-C also had spring key switches, but their touch and feel were different. The key switches of KBD-A and KBD-B had a distinct tactile feedback, whereas that of KBD-C had an indistinct tactile feedback. Another difference was in the sound. KBD-C made very little sound at the snap point of the key travel, while KBD-A and KBD-B made a distinct clicking sound at this point.
This clicking sound seemed to enhance their tactile feedback, making it felt more distinctly. The key switch mechanism of KBD-D was quite different from those of the other keyboards, and the tactile feedback was generated by a rubber dome rather than a spring.

Typing task

A special text presenter/editor was designed for this evaluation. The program presents English text, one line at a time, in the middle of the screen. Input characters are displayed on the bottom line of the screen as they are typed. When a line of text is typed and the Return key is depressed, the screen is cleared and the next line appears.

All keys other than the inboard block are deactivated by the program. The only way of correcting a typing error is by using the Backspace key. The underscore cursor moves one column backward and erases one character each time the Backspace key is depressed. Corrections can be made only on the typing line, and only after the Return key is pressed. The typematic function is allowed for all the inboard keys, as usual.

A few articles were selected from an book in English as the sample text to be typed. The sample text included only alphabetic characters (upper and lower cases), numbers, spaces, hyphens, commas, periods, colons, semicolons, and quotation marks.

Procedure

At first, the test participants were encouraged to familiarize themselves with the four keyboards, typing freely for a total of some five minutes. They then had a warm-up session. This allowed them to familiarize themselves with the appearance of the screen during typing sessions and the way in which the presenter/editor program worked.

During the warm-up session, the test participants were instructed as follows:

- Type the sample text as it is presented.
- Type at a speed that you can continue comfortably.
- Do not attempt to break any kind of record.
- If you notice a typing error, correct it immediately, and do not read the typed line again to find mistakes.

The participants then had four speed-typing sessions. They were asked to type the sample sentences for five minutes on each keyboard. The order of the four keyboards was randomized according to the Latin square design. The throughputs and uncorrected error rates collected over a period of five minutes were evaluated as the users’ performances.

After the speed-typing sessions, a subjective evaluation was carried out to collect users’ perceived levels of sensation and preferences as regards key touch. Schefle’s paired comparison method was used in the design of the experiment. The combination and the order of the pairs of keyboards were randomized according to the Latin square design. The participants were asked to fill out a set of questionnaire sheets. The questionnaire consisted of five questions about perceived level of sensation and six questions about their preference regarding the touch of the four keyboards’ key switches. Figure 1 shows the rating scales used in this experiment. During and after this experiment, free comments were also elicited.

Results

Performance

Table 2 shows the average throughput of each keyboard. No significant differences were found between them (p>0.05). The uncorrected error rate for each keyboard is shown in Figure 2. Uncorrected errors were found to occur in typing sessions on KBD-A with a significant lower frequency than on KBD-C and KBD-D (p<0.01). KBD-B showed a significantly lower error rate than KBD-D (p<0.01). KBD-B also showed a lower error rate than KBD-C, but with only a 90% level of confidence.

Preference

According to the paired comparison method, average perceived levels of sensation and average preferences regarding the five aspects of key switches as well as overall preference were calculated from the data provided by the participants in their responses to the questionnaire. Figures 3 and 4 show the average perceived levels of sensation and average preference, respectively, of all participants as regards the key switches on the four keyboards. Although the participants noticed the differences in feel among the keyboards, there was no significant difference in their preferences as regards key pressure, tactile feedback, and key travel. Accordingly, it was found through analysis of the data that the test participants could be divided into two groups, one consisting of 11 people who liked keyboards with a distinct tactile feedback such as KBD-A and KBD-B, and the other consisting of 13 people who preferred keyboards with an indistinct tactile feedback. The grouping was done by the polarity on the preference scale in tactile feedback. To test if the participants in each group agreed on the preference in tactile feedback, the coefficients of agreement were calculated regarding the tactile feedback. Participants in each group agreed
on the preference of the tactile feedback (p<0.05), although all participants did not agree (x=0.036). Therefore, it was confirmed that the participants could be divided into two groups to perform further analysis. Namely, 11 people showed positive preference in tactile feedback for KBD-A and B, and 13 people showed the negative preference. These two groups should be considered to have different preferences regarding the touch and feel of keyboards. In addition to preferences regarding various aspects of the feel of keys, an interesting difference in sensation was also found regarding key pressure. Figures 5 and 6 show the average preferences of the distinct and indistinct tactile feedback groups, respectively, as regards the key
switches on the four keyboards, while Figure 7 shows the average perceived levels of sensation regarding the degree of key pressure in each group.

**Discussion**

**Performance**

Although recent studies of keyboards (Cakir, 1995; Yoshitake, 1995; Smith and Cronin, 1993; Akagi, 1992) also collected performance data, significant differences in throughput seem to have been induced only by comparing keyboards with radically different features, such as split keyboards and keyboards with reduced key pitch. As this study indicates, the differences between the key switches do not seem to produce a large difference in total throughput. On the other hand, significant differences in the uncorrected error rate were found. KBD-A and KBD-B showed a lower error rate than KBD-C and KBD-D. The test participants felt a more distinct tactile feedback, a louder click, and a longer key travel on KBD-A and KBD-B than on KBD-C and KBD-D, as shown by the data collected by paired comparison. These differences in the touch and feel of the keyboards may account for the difference in the uncorrected error rates, since they affect the feedback on typing tasks through various sensors. Akagi (1992) reported that a lighter key resistance (i.e., key pressure) produced more errors, and that the tactile feedback was not related to the error rate. Though this result appears inconsistent with our study, it should be interpreted as indicating that the feedback from key switches is important in reducing the number of typing errors. Since most of the subjects who participated in Akagi’s experiment normally used keyboards with no tactile key switch, we consider that they placed more emphasis on the key resistance than on the tactile feedback.

**Preference**

The most important result of our analysis of the preference data was that the test participants fell into two groups. It is natural that individuals should have different preferences; however, there has been little discussion about the classification of preferences regarding the “feel” of keys. In this study, the...
participants could be clearly divided into two groups, one consisting of people who liked keyboards with a distinct tactile feedback, and the other consisting of people who liked keyboards with an indistinct tactile feedback.

According to the data on the average degree of sensation, both groups had much the same sensory impressions regarding the degree of distinctness of tactile feedback and the distance of key travel. In analyzing the average preference data together with the average sensory degree data, it is interesting to note that the test participants in each group liked the touch and feel of a keyboard for the same reasons that those in the other group disliked it, and vice versa.

- Participants in the distinct tactile group significantly preferred KBD-A and KBD-B to KBD-C and KBD-D, because the former two keyboards had a more distinct tactile feedback than the latter two.
- Participants in the indistinct tactile group significantly preferred KBD-C and KBD-D to KBD-A and KBD-B because the former two keyboards had a less distinct
tactile feedback than the latter two.
- Participants in the distinct tactile group preferred KBD-A and KBD-B because these keyboards were felt to have a longer key travel.
- Participants in the indistinct tactile group preferred KBD-C and KBD-D because these keyboards were felt to have a shorter key travel.

Both groups also had much the same impression regarding the loudness of the clicking sound, while they showed significantly different preferences in this respect. Those who preferred distinct tactile feedback did not seem to have any particular preference as to whether the keyboard was loud or quiet. In sharp contrast, those who preferred indistinct tactile feedback significantly preferred the quiet keyboards to the louder ones. On the basis of the participants’ free comments, it may be inferred that the reason for this is that the distinct tactile people were insensitive or indifferent to the sound, but that they were taking advantage of the clicking sound as a form of auditory feedback while they were typing. They knew, or thought they knew, that more distinct (and thus louder) clicks would give fewer errors with better feedback. On the other hand, the indistinct tactile people did not seem to attach much importance to auditory feedback.

The two groups showed different perceived levels of sensation regarding key pressure, as shown in Fig. 7. The data in the figure should be interpreted as indicating that the distinct tactile group felt KBD-C and KBD-D to be as heavy as KBD-A and significantly heavier than KBD-B, while the indistinct tactile group felt them to be as light as KBD-B and significantly lighter than KBD-A. The scales in this figure show only the relative position of each keyboard within each group.

No specific reasons have yet been put forward with any confidence for this discrepancy in the average perceived levels of sensed key pressure between the two groups with different preferences. It can be conjectured that this discrepancy is due to the different typing styles of the two groups. The participants in the distinct tactile group tend to type with their fingertips, keeping the distal phalanges more or less upright. This typing style may lead to a tendency to use the entire length of the key travel, and can thus be considered compatible with the data on average perceived level of sensation and average preference as regards key travel. In fact, the people in this group preferred KBD-A and KBD-B because these keyboards were felt to have longer key travels. It may be reasonable to consider that the distinct tactile people interpret deeper strokes as indicating greater key pressure.

In contrast, the indistinct tactile group of typists tend to type with their fingerpads, keeping their hands flatter. According to the data on their sensory degree and average preference as regards key travel, as well as the free comments they made, they seem reluctant to depress keys deeply. They preferred KBD-C and KBD-D because these keyboards were felt to have shorter key travels. They might interpret shallower strokes as indicating less key pressure, because of their typing style.

The average preference values for the distinct and indistinct tactile groups were used for further separate analysis by the multiple regression analysis method. A multiple regression equation for each group of test participants was established for each keyboard, with a 95% or 99% level of confidence. The dependent variable was overall preference, and the explanatory variables were key pressure, tactile feedback, key travel, sound, and shakiness. Unfortunately, no regression equation could be obtained with confidence for KBD-A in the distinct tactile group. Standardized partial regression coefficients were calculated for the explanatory variables appearing in each regression equation. The partial regression coefficients of the two groups are shown in Tables 3 and 4, respectively. The greater the standardized partial regression coefficient of a factor of a keyboard, the greater the factor’s influence on the overall preference for the keyboard.

The test participants in the distinct tactile group were found to have a tendency to place top priority on tactile feedback in judging the touch and feel of the keyboards. No significant multiple regression equation, and thus no significant partial regression coefficient, was found for KBD-A; however, the members of the group showed the same tendency in evaluating it. The raw data on the average preferences for KBD-A showed 23 coincidences between tactile preference and overall preference out of the total of 33 comparisons between KBD-A and the other keyboards; that is, if a participant liked the tactile feedback of a keyboard, he/she liked the

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<th>Table 3</th>
<th>Standardized partial regression coefficients of each keyboard in the distinct tactile group</th>
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<td>Keyboard</td>
<td>KBD-A</td>
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<tr>
<td>Key pressure</td>
<td>–</td>
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<td>Tactile feedback</td>
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<td>Key travel</td>
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<td>Sound</td>
<td>–</td>
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<td>Shakiness</td>
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<th>Table 4</th>
<th>Standardized partial regression coefficients of each keyboard in the indistinct tactile group</th>
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<tr>
<td>Keyboard</td>
<td>KBD-A</td>
</tr>
<tr>
<td>Key pressure</td>
<td>0.687</td>
</tr>
<tr>
<td>Tactile feedback</td>
<td>–</td>
</tr>
<tr>
<td>Key travel</td>
<td>–</td>
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<td>Sound</td>
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<td>Shakiness</td>
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keyboard overall. Only 4 cases showed disagreement between these two preferences; that is, if a participant disliked the tactile feedback of a keyboard, he/she generally disliked the keyboard overall, and vice versa. The rest of the 33 cases included neutral attitudes regarding either the tactile feedback or the overall preference, and could not be classified as either coincidence or disagreement. This analysis clearly reveals that the poor tactile feedback of KBD-C and KBD-D was the main reason for the significant dislike of these keyboards by people in the distinct tactile group.

The participants in the indistinct tactile group did not seem to have a consistent tendency in evaluating the touch and feel of the keyboards; however, they sometimes placed a strong emphasis on key pressure and key travel. Obviously, KBD-A was disliked because of the strong key pressure required or because it was too heavy. It is interesting that the average perceived levels of sensation and the average preferences regarding sound indicated that this group tended to prefer a quiet keyboard consistently. Nonetheless, sound was only the second most important factor in the evaluation of KBD-B, and seems to have played no significant role anywhere else.

**Conclusion**

- No significant differences were found among the four keyboards as regards typing speed.
- The uncorrected error rates on keyboards that participants felt to have a more distinct tactile feedback, a louder click, and a longer key travel were significantly lower.
- The test participants fell into two groups, one consisting of those who preferred KBD-A and KBD-B (the distinct tactile group), and the other consisting of those who preferred KBD-C and KBD-D (the indistinct tactile group).
- It was found that the distinct tactile people and the indistinct tactile people tended to have different sensations and preferences regarding the touch and feel of keyboards.

To summarize, from the viewpoint of performance, KBD-A, with key switches that provide distinct tactile feedback, was the best keyboard of the four. From the viewpoint of preference, it was shown that there are two kinds of people: those who prefer keyboards with a distinct tactile feedback enhanced by a clicking sound, such as KBD-A and KBD-B, and those who prefer quiet keyboards with an indistinct tactile feedback, such as KBD-C and KBD-D. This study suggests that suppliers of computer keyboards should provide at least two kinds of keyboards, with distinct and indistinct key switches, in order to satisfy as many users as possible, and that they should avoid selecting keyboards designed to satisfy the "average" preference as regards the touch and feel of keys.

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