TEXT CORRECTION IN PEN-BASED COMPUTERS: AN EMPIRICAL COMPARISON OF METHODS

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ABSTRACT

Three methods for correcting text in pen-based computers were compared in an experiment involving 30 subjects. In spite of simulated virtually perfect character recognition, the two methods involving handwriting proved 25% slower than the method involving a "virtual keyboard". There was essentially no difference between the execution times with the two handwriting methods, which differed in the way of determining *when* to display the results of symbol recognition: after a certain delay vs. after an explicit request by the user.

KEYWORDS: Pen-based computers, text editing, handwriting, input devices.

INTRODUCTION

Pen-based computers support various methods for entering characters and invoking common text editing commands (such as "delete"). Most of these involve handwritten (actually handprinted) characters as well as special editing symbols (*gestures*). There exists as yet little data on the relative merits of these methods. We here present experimental results on three such methods, as applied to the task of *text correction*, i.e., correcting obvious input errors in a displayed text. (The experiment also involved other methods and a second task, as summarized below and described fully in [1].)

When a method involves handwriting, one issue is: At what point in time should the system display the results of its *interpretation* of the characters and gestures entered by the user? (I.e., at what point should the handwritten characters be replaced on the screen by their equivalents in the computer font, and should the commands invoked by the user be executed?) With what may be called the *delay method*, the interpretation is displayed as soon as the user has failed to touch the screen within a certain time interval. With the *button method*, the user taps a special "button" (i.e. a soft key) on the screen in order to invoke interpretation. The button method requires more operators to be executed by the user, but the delay method sometimes requires the user to wait for the computer's interpretation before proceeding. It is hard to determine, without empirical research, which method will be generally faster.

A third method, the use of a *virtual keyboard*, bypasses altogether the problem of interpreting handwritten symbols: A window, depicting a keyboard, is present on part of the screen. Its use is analogous to that of a normal keyboard: After using the pen to position a cursor within the text, the user taps one or more keys to insert letters or invoke editing commands. An advantage is that tapping on a soft key is potentially faster than handwriting a symbol. Also, the result of each user action can be displayed instantly. On the other hand, this method can hardly match the directness of, e.g., replacing an incorrect letter by simply handwriting the correct letter on top of it. So it is not obvious whether text correction with the virtual keyboard will generally be faster or slower than with the two handwriting methods described above.

METHOD

Tasks Each task in our experiment involved correcting a sentence comprising 69 characters (including spaces). Sixteen such sentences were selected from a Dutch-language novel. Each sentence was changed so that it contained 6 easily

detectable errors: 2 missing between-word spaces, which were to be inserted using a "space" gesture or a space key (on the virtual keyboard); 2 superfluous within-word spaces, to be removed using a "delete" gesture or key; and 2 incorrect letters which were to be overwritten with the correct letter (with the handwriting methods) or deleted prior to insertion of the correct letter (with the virtual keyboard).

Apparatus A Philips Advanced Interactive Display (PAID), was used as the pen-based computer. It had a VGA (640 × 480 pixel) 11" LCD (backlit) display with a stylus attached to the display by a thin cable. Subjects wrote directly on the screen, and immediate feedback was given of the resulting "electronic ink". With the two handwriting methods, the sentence was displayed in a window comprising 6 rows of 15 boxes (one for each letter, each box measuring 1 × 1 cm); changes to the sentence were reflected in the same window. A Wizard-of-Oz technique was used to simulate essentially perfect character recognition, so as to eliminate the noise that would be introduced into the data by imperfect automatic character recognition: The experimenter worked at a hidden desktop computer whose screen showed the same display as that of the pen-based computer. With the help of specially written software, the experimenter caused the symbols written by the subject to be handled exactly as if the computer had (correctly) interpreted them; for example, in the delay condition, the results of the subject's actions were displayed after each delay of 1.5 secs. With the virtual keyboard method, the screen displayed at the top the sentence to be corrected and at the bottom the virtual keyboard, in which each key measured 0.8 ×0.8 cm.

Subjects The 30 paid subjects (mean age: 25) had no previous experience with pen-based computing, but all had experience with the use of a keyboard.

Design Each subject performed 1 correction task with each of the 3 methods (as well as with 5 other methods not discussed here, of which 4 involved handwriting and 1 involved a different type of virtual keyboard). For each subject, the order of using the different methods was randomized, as was the selection of the sentence to be corrected with each method.

Procedure Subjects were first given a general introduction and a practice session lasting 20 minutes to acquaint them with all of the variants used. Then each subject performed, with each method, 3 tasks: 2 (not analysed here) that involved only entering a given sentence, followed by 1 text correction task as described above.

RESULTS

The time to execute each text correction task was measured between presentation of the sentence and completion of the last correction. The mean times (and standard errors of the means) for completing a correction task are as follows: handwriting with button: 44.4 ±.3 secs; handwriting with delay: 42.1 ± 3.0 secs; virtual keyboard: 33.6 ± 2.7 secs. The times for the two handwriting methods do not differ significantly according to a paired t-test ($t(29) = 0.45, p = .65$). But each of these mean times is more than 25% higher than the mean time for the virtual keyboard method, both differences being significant ($t(29) = 2.24$ and $t(29) = 2.59$ for the differences with the button and the delay methods, respectively, $p < .05$).

The stability of these results is supported by the appearance of the same pattern in the other conditions of our experiment, which included five further methods and involved text entry tasks as well as correction tasks: Nowhere was there a reliable difference between methods that differed only in their use of a button vs. a delay; and the virtual keyboard was always substantially faster than handwriting.

DISCUSSION

The similarity of the execution times for the two handwriting methods suggests that designers can base their choice between these two methods on other considerations (such as the higher rating of "naturalness" that our subjects gave to the button method).

The substantial speed advantage of the virtual keyboard over the handwriting methods may not of course reappear with more experienced users of pen-based computers. But the result cannot easily be explained solely in terms of the our subjects' familiarity with the use of a keyboard: Tapping on a virtual keyboard is in some respects different from using a real keyboard, and the handwriting methods are in part highly familiar from experience with writing on paper. So the relatively good results for the virtual keyboard in this text correction task—which does not make the optimal use of its strengths—suggests that the virtual keyboard method may long remain a useful alternative to handwriting methods.

REFERENCE

1. van Gelderen, T. *Interaction conventions for text entry and editing with pen-based computers.* Master's thesis, University of Nijmegen, Department of Cognitive Science, 1992. (Available from the author.)