Melioration and the Transition from Touch-Typing Training to Everyday Use

Eldad Yechiam, Ido Erev, Vered Yehene, and **Daniel Gopher,** Technion – Israel Institute of Technology, Haifa, Israel

Previous research shows that success in touch-typing training does not ensure its continuation into everyday use. It is postulated that an important contributor to this problem is melioration – that is, maximizing local rates of reinforcement. In the context of typing, melioration implies an intuitive tendency to choose typing strategies that lead to a better immediate performance level than that obtained by touch-typing. One such strategy is visually guided typing, in which the performer looks at the keys to locate their position. The present research describes a training approach that changes the reinforcement structure by increasing the attractiveness of looking at the screen while typing. This approach is implemented by using a secondary task that requires typists to respond to signals appearing on the screen. In an experiment that evaluated this solution, 22 students were given a touch-typing training course followed by a period in which they had to type their own homework. The results showed that under a modified reinforcement condition, the effect of melioration on touch-typing scores in the posttraining phase decreased. In addition, the experimental manipulation facilitated the acquisition and maintenance of the touch-typing skill. Actual or potential applications of this research include research in training, choice behavior, and human-computer interaction.

INTRODUCTION

Studies of typing behavior differentiate between two basic strategies: visually guided typing and touch-typing (Long, 1976a; Long, Nimmo-Smith, & Whitefield, 1982; West, 1969). The visually guided strategy tends to be less efficient, as it requires alternation of the gaze between the source text and the keyboard in order to see which keys to press. Touch-typing tends to be more efficient, as visual search of the keys is replaced by knowledge of key location and proprioceptive feedback. This mode of behavior thus enables simultaneous reading and typing. Interestingly, many typists (including the authors of the present paper) who use keyboards regularly and who have even participated in touch-typing training do not use touch-typing. Previous research suggests that one reason for this phenomenon is the difficult transition from touch-typing training to everyday use of the skill (Baddeley & Longman, 1978; Cooper, 1983). It appears that in many cases people who undergo touch-typing training do not continue to touch-type afterward but revert to their former visually guided typing style.

This observation is supported by studies that show a dramatic decrease in touch-typing ability soon after training (Baddeley & Longman, 1978; Larochelle, 1983). In the study conducted by Baddeley and Longman, trainees practiced touch-typing for 60 to 80 h. Retention of typing skills for trainees who had not used the typewriter following training was assessed after periods of 1, 3, or 9 months after training. The results showed a decrease of about 30% in words per minute (wpm), starting as early as 1 month after training. The main goal of the present research is to highlight one factor that may contribute to deterioration of touch-typing skill following training and to propose a method that addresses its influence.

Address correspondence to Eldad Yechiam, Department of Psychology, Indiana University, 1101 E. 10th St., Bloomington, IN 47405; eyehiam@indiana.edu. **HUMAN FACTORS,** Vol. 45, No. 4, Winter 2003, pp. xxx–xxx.

The factor considered here is *melioration* (Herrnstein & Vaughan, 1980), the sensitivity of behavior to local rates of reinforcement. In many cases, melioration predicts the tendency to allocate behavior in the direction of alternatives that produce better immediate performance and to underweight delayed performance (see Herrnstein, Loewenstein, Prelec, & Vaughan, 1993). Although this effect has been known to psychologists for more than 100 years (e.g., see Hilgard & Marquis, 1940; Skinner, 1936) and has been extensively studied and modeled (see Davison & Nevin, 1999; Herrnstein et al., 1993; Herrnstein & Prelec, 1991), we feel that in the current context its contribution has been undervalued.

The paper is organized as follows: The first section discusses the two competing strategies of typing: touch-typing and visually guided typing. The second section presents a simple model of the effect of reinforcement on the transition from touch-typing training to everyday use. The model leads to the derivation of a simple manipulation, presented in the third section, which is expected to reduce the likelihood of transition failures. The last section contains an experiment that evaluates the suggested solution.

TOUCH-TYPING VERSUS VISUALLY GUIDED TYPING

One main distinction of the touch-typing strategy appears to be the ability to look at the screen while typing and to devote a minimal level of visual search to the keyboard (Cooper, 1983). This ability is gained through the memorization of key positions and finger trajectories, which makes touch-typing a difficult skill to acquire. Other differences between touch-typing and visually guided typing include touch typists' (a) use of all fingers of both hands, as opposed to the use of one hand or only some of the fingers; (b) fixed assignment of fingers to keys; (c) reduced arm movements; and (d) fixed locations of the palms (Crooks, 1964).

The performance of touch typists, relative to the performance of visually guided typists, is contingent on the level of touch-typing skill. For expert touch typists the ability to type without having to visually search for each key is the basis of their capacity to work on different keys simultaneously, thus increasing their typing speed (Cooper, 1983). The ability to use proprioception in keying is beneficial for two reasons. First, proprioception allows simultaneous processing of displays that are far apart (the keys of the keyboard). In contrast, visual search is a serial, time-demanding process (Meyer & Kieras, 1999). Second, the use of proprioception in keying frees visual search resources. These can be used to improve performance in other simultaneously executed subtasks. In touch-typing, visual search can be dedicated to the task of reading the source text, which eliminates the necessity to constantly switch between the screen and the keyboard.

The performance of visually guided typists also improves over time. Experienced visually guided typists do not search for each and every letter; rather, they use touch-typing for familiar and well-rehearsed trajectories (Larochelle, 1983). In addition, the number of fingers used for the typing task increases with expertise, from using two fingers to using most or all of the fingers of the hand. However, these solutions still involve a visual search for keys and consequential performance delays.

Now that computer keyboards of all kinds are so prevalent in daily use, most trainees (young or old) attempting to acquire touch-typing skills have some proficiency in visually guided typing. For the novice touch typist, the price of not looking at the keys while typing involves a relatively high error rate and an initially slow typing speed. For example, in a preliminary study in our laboratory (Yechiam, Erev, Gopher, & Yehene, 2000), we instructed experienced computer users with many hours at the keyboard, but with no touch-typing experience, to type without looking at the keyboard. The results showed a decrease of about 90% in typing speed.

A SIMPLE MODEL OF THE ROLE OF IMMEDIATE REINFORCEMENTS

A claim that oversensitivity to immediate reinforcements is one reason for the failure to continue using touch-typing after training can be derived from three basic assumptions/observations, which imply a simple model:

> Assumption 1: Prior to touch-typing training, the touch-typing strategy is less efficient than visually guided typing. Following an adequate period of training, touch-typing becomes more efficient.

The first part of this assumption is consistent with the preliminary study described earlier. Without explicit training, attempting to use touch-typing impairs performance. The second part of the assumption is in line with a wide set of findings (e.g., see Baddeley & Longman, 1978; Rumelhart & Norman, 1982). Following a long period of touch-typing training, typists reach an average speed of 60 to 70 wpm, whereas the average speed of very experienced visually guided typists is much lower (approximately 30–40 wpm).

> Assumption 2: The relative efficiency of visually guided typing is normally lower in touch-typing training (using nonwords) than in everyday use.

This assumption combines two observations. The first is that the majority of touch-typing training materials are based on the typing of letters and characters that do not have a semantic structure (i.e., nonwords, or random sequences of letters; e.g., see Farmer, 2001; Ginat, 1992). The second observation is that the efficiency of visually guided typing is significantly reduced when typing nonwords. In such a task the typist can remember less of the material to be typed, as compared with meaningful text, and the typist's attempts to follow the text require more alternations between the screen and keyboard. These alternations reduce the visually guided typing speed. Moreover, it is more difficult for visually guided typists to refocus on the target text on the screen after typing a portion of text because there are no semantic cues to indicate the position of the target (Flowers & Lohr, 1985; Madden, 1987). Touch-typing, however, is relatively robust to the difference between words and nonwords. Research shows that the motor schemas learned in touch-typing involve association between digraphs rather than whole words (e.g., Gentner, 1983; Shulansky & Herman, 1977). For example, Gentner found the associations between letter pairs to be high even if the letters belong to two different words (e.g., the letters *e* and *r* in "use rapidly").

> Assumption 3: Under normal conditions, typists tend to apply the method that yields better immediate reinforcements.

The third assumption is a consequence of the sensitivity of choice behavior to local rates of reinforcement. Herrnstein and his associates (e.g., Herrnstein et al., 1993) have called this sensitivity *melioration.* It implies that individuals do not explore much of the range of possible ratios of different alternatives but, rather, settle quite rapidly on the ratio calculated by the successes of using one alternative compared with the successes of using another. If one alternative is usually more efficient than another in the immediate range, melioration implies the choice of that alternative as a function of the initial efficiency rate.

Implications

Assumptions 1 and 2 imply that during extensive touch-typing training, trainees undergo three major stages. In the initial stage, touch-typing is less efficient than visually guided typing, regardless of the task. In the second stage, touch-typing is better than visually guided typing in the training context (training material) but not in everyday text. Finally, in the third stage, touch-typing outperforms visually guided typing in every task. Thus if training is stopped at the first or second stage, Assumption 3 implies that trainees will tend to stop using touch-typing.

According to Assumption 3, the tendency of trainees to stop using touch-typing is a function of the advantage of the visually guided typing method over the touch-typing method in everyday use. Thus it implies that individuals with a large difference between visually guided typing and touch-typing skills would be particularly vulnerable to a relapse to visually guided typing. This assumption is supported by a study (Wichter, Haas, Canzoneri, & Alexander, 1997) that compared seventh-grade children who went through a computer application course and then learned to touch-type with sixth graders who learned touch-typing prior to the computer application course. After a 6-week touch-typing training course, 45% of the sixth graders began to use touch-typing, as compared with only 24% of the seventh graders. (Note, however, that these results may be attributable to the fact that participants were drawn from different populations.)

It appears that the more people are experienced in visually guided typing, the larger the gap between this method and touch-typing and the greater the problem of relapse.

The common solution to this problem involves attempting to ensure that the period of touch-typing training is sufficient to prevent relapse (see Baddeley & Longman, 1978). It seems that this solution works well when touch-typing is taught in schools (see e.g., Bartholome, Lloyd, & Long, 1986), but it is much less effective when trainees learn independently. The present research examines an alternative method that appears less intuitive but may be more appropriate when extended training is too costly or cannot be implemented.

THE SUGGESTED METHOD

In order to overcome the melioration problem, we developed a method that changes the immediate feedback environment in a regular text (a similar method was used by Seagull & Gopher, 1997). The method includes the addition of a secondary task to typing. The task requires a response to an event that occurs on the screen: a brief presentation of a blue wire square. A lack of response to the event results in a momentary darkening of the screen. Thus the method produces a moderate and immediate punishment for not looking at the screen. Visually guided typing, which depends on visual search of the keyboard, implies failure to look at the screen and is therefore punished. (To address the known shortcomings of training methods that involve immediate punishments [e.g., Powell & Azrin, 1968], we used very mild punishments that can easily be avoided, in a constructive fashion.)

Touch-typing, however, does not require the typist to look at the keyboard while typing (Cooper, 1983; Long, 1976b). Therefore the touch-typing strategy leads to success in performing the secondary task and is negatively rewarded by the penalties imposed on the alternative strategy. This method therefore increases the relative reinforcement to performance from the use of touch-typing. Presumably this leads to more use of touch-typing in normal text typing, even when visually guided typing is advantageous (i.e., following a short touch-typing course).

The effect of the method was verified in a pretest (Yechiam et al., 2000), in which we tested the behavior of 4 secretaries at the Technion – Israel Institute of Technology, of whom 2 used touch-typing and 2 used visually guided typing. The secretaries were told to type a text (the days of the week, followed by months of the year and the Jewish holidays). In addition, they were asked to respond to the square that appeared on the screen. We found that the 2 secretaries who did not touch-type had to look at the screen in order to respond to the stimuli. One of them intuitively began to touch-type, and the other, who continued to look at the keyboard, did not respond to most of the squares (and got "black" screens). In contrast, the 2 secretaries who touch-typed responded easily to the presentation of the blue square.

EXPERIMENT

The aim of the experiment was to examine the three assumptions raised earlier and the effect of the proposed method on the transition from a touch-typing course to real-world typing. Participants were first taught preliminary lessons in touch-typing using nonwords. The lessons were taught using the Rabbit application (Ginat, 1992; Hobby Maker, 1997) until the participants' touch-typing level on a fixed test (days of the week) matched their initial visually guided level on that limited text. Participants were then divided into two matched groups. Both groups were asked to use Microsoft Word to type their homework and projects while continuing to use touch-typing. The experimental group was also requested to perform the secondary task, described earlier, while typing their regular homework.

Assumption 1 predicts simply that before the touch-typing course, the touch-typing performance level would be lower than the visually guided performance level. Assumptions 2 and 3 indicate that participants with a large difference between visually guided typing and touch-typing would tend to practice touch-typing in the typing course and would have no performance decrements at this stage. However, these participants would demonstrate a lesser tendency to practice touch-typing while in the homework phase. Hence, at this stage their achieved competence in touch-typing is expected to decrease.

In addition to these three assumptions (which refer to the control condition), the suggested method was assumed to lower the effect of melioration in the homework phase by improving the relative immediate outcomes of touch-typing. It was assumed to decrease the effect of the initial difference between visually guided and touch-typing modes. Moreover, as the experimental group would, on average, practice more touch-typing, this group was expected to improve its touch-typing performance to a greater extent than the control group. For the same reason, it was expected that following the experimental phase, the control group would experience faster extinction of the touch-typing skill taught in training.

METHOD

Participants

We advertised a free touch-typing course for students. Twenty-two students (7 men and 15 women) participated in the experiment. The participants were either from the Technion – Israel Institute of Technology or from Haifa University. They were paid a sum of NS340 (about $80 U.S.) plus NS12 ($3 U.S.) per hour. The average age of participants was 24 years, ranging from 21 to 28 years. One participant from the control group left the experiment 4 h before completion of the experiment. We retained the results of this participant because he explained that he left because of difficulties in coping with the demands of the touch-typing task (and not for an external reason). Additionally, he agreed to come to further tests.

Task and Apparatus

The Rabbit application. A touch-typing course was conducted using the Rabbit on-line tutorial (Ginat, 1992; the same layout of 20 lessons, basic exercise, and test exercise also appears in Hebrew in Hobby Maker, 1997). The tutorial consists of 20 lessons, each teaching the location of two new keys. The first 14 lessons were employed in the present study. These teach the location of all letter keys. The program is made of two parts: the lessons, in which the location of letters and correct finger positions are shown; and exercises, in which the letters taught in the lesson and those taught in previous lessons are rehearsed and practiced.

Three of the exercises are very similar. In all three there is a line of nonwords, averaging three letters units, which the typists must copy by typing. Each time a correct letter is typed, the cursor moves to the next letter in the line. If an incorrect letter is typed, an audible "beep" sounds and the cursor does not move forward. The *basic exercise* consists of typing nonword strings; the number of lines is unlimited. In the *rabbit exercise,* a rabbit figure moves in the direction of typing and "competes" with the player. A cycle is terminated when either the typist or the rabbit reaches the end of one line. There are different rates of rabbit movements, ranging from a very slow rabbit (8 wpm) to a very fast rabbit (36 wpm). In the *test exercise* the typist is required to type three lines of nonwords with a maximum of three mistakes. If more than three mistakes are made, the test ends. If a test is successfully completed, typing speed (in words per minute) is presented.

A fourth exercise, the *missile game,* is a computer game in which the typist is required to hit missiles descending from the top of the screen. Each missile has a letter attached to it. A missile is hit by typing the corresponding letter. A successful shot increases the number of points by 1. If a missile reaches the bottom, the game is over. The speed of missiles gradually increases, staring from about 12 letters/min and progressing to more than 100 letters/min. Unlike the other exercises, in the missile game the missile letters are chosen at random.

The blue-square program. This experimental program was constructed using Visual Basic (Version 5) and was run on Pentium II computers with 17-inch (43-cm) 800 × 600 pixel screens. It was resident in a word-processing application (Microsoft Word 97).

The program consists of a blue square appearing on screen for 400 ms at a prefixed, slowly decreasing rate. The size of the blue square is 1 cm in diameter (2.5 visual angles, assuming a 70-cm distance). The initial rate of appearance is one every 20 s. Following six presentations, the rate decreases to one every 50 s. If no key is pressed during a 2-s interval prior to a scheduled appearance of the square, its presentation is delayed for 5 s. This last feature was implemented to allow rest periods in which the square does not appear.

The blue square is a wire frame with 2-mm thick sides. The visibility of the text inside the square is not impaired, thereby minimizing its interference with the typing process. The square appears randomly in different locations. Pressing the "[" key in the 2 s following the appearance of the blue square leads to no penalty. No response leads to the immediate presentation of a dark screen, which covers the word processor window and can be removed only by pressing the "Alt" key (see Figure 1).

The angle from the keys to the upper part of the screen is about 70°, depending on the exact seating position. This angle is, of course, beyond the acute central vision. Accordingly, because the color of the square is not bright and its location changes intermittently, visual search is needed to locate it (Coren & Ward, 1989; Rensink, 2000). The typist presumably has to shift his or her gaze over the screen in order to locate the symbol.

Other devices. Typing was performed with a standard Chicony QUERTY keyboard. The Chicony is an IBM-compatible keyboard. The keyboard has soft touch with an audible click and 108 functional keys. The *F* and *J* keys are identifiable by touch. In the present study, as in many touch-typing courses (e.g., Farmer, 2001) performers used only 31 letter and punctuation mark keys, which are standard in all keyboards.

In the second part of the experiment (free typing) participants were also allowed to use a standard computer mouse. Five identical computers were available for trainees. The computers were separated by dividers that restricted performers from seeing the screens of their neighbors.

Performance Measures

At the end of every hour, trainees were tested in a speed-and-accuracy typing test. The source text, which was identical at each repetition, consisted of the days of the week written three times. In addition, 2 weeks after the experiment, a different source text was used (the Gregorian months written three times).

The testing procedure was as follows: Performers press a key to start. Next they type the required text. Pressing another key ends the test. If the text has been typed correctly, a score of typing speed (in words per minute) is displayed. If the text has not been entered correctly a message appears, requiring the performer to correct the mistake, and the line containing the mistake is highlighted. Correction time is added to the accumulative score of typing speed.

Procedure

Touch-typing course. This stage consisted of training with the Rabbit touch-typing tutorial (Ginat, 1992; Hobby Maker, 1997). The language of instruction was Hebrew. Typing in Hebrew takes place from the right to the left. There are 22 letters in the Hebrew alphabet, 4 of which take on a different form when appearing at the end of a word (a total of 26 keys). Punctuation keys are as in English.

Trainees could come to the lab at their leisure. (We tried to imitate the conditions of trainees working at home with a touch-typing tutorial. In order to do so, we eliminated many of the normal laboratory constraints.) The lab was open each working day between 4:30 and 7:30 p.m. Limitations on the training schedule included a rule that training would be carried out in time intervals of whole hours (1, 2, or 3 h) and a requirement that trainees would come to the lab at least once a week. Trainees were also advised to practice two to three times a week for a maximum period of 2 h at a time. No constraints were imposed regarding progress in the Rabbit lessons. However, participants were advised to move on to a new Rabbit lesson only after the previous lesson had been successfully completed. Specifically, it was recommended that participants beat the 18-wpm rabbit (in the rabbit exercise) and successfully finish the test exercise of the lesson.

The course continued until the trainees' touch-typing score in the hourly test exceeded their score in the initial typing test using the visually guided strategy. Trainees who reached this point were told that they could move on to the next stage of training, in which they would type their own material. They could also continue in stage one to finish the 14 lessons of touch-typing.

Matching. A matching procedure was used in the allocation of participants to the experimental and control groups. It consisted of a

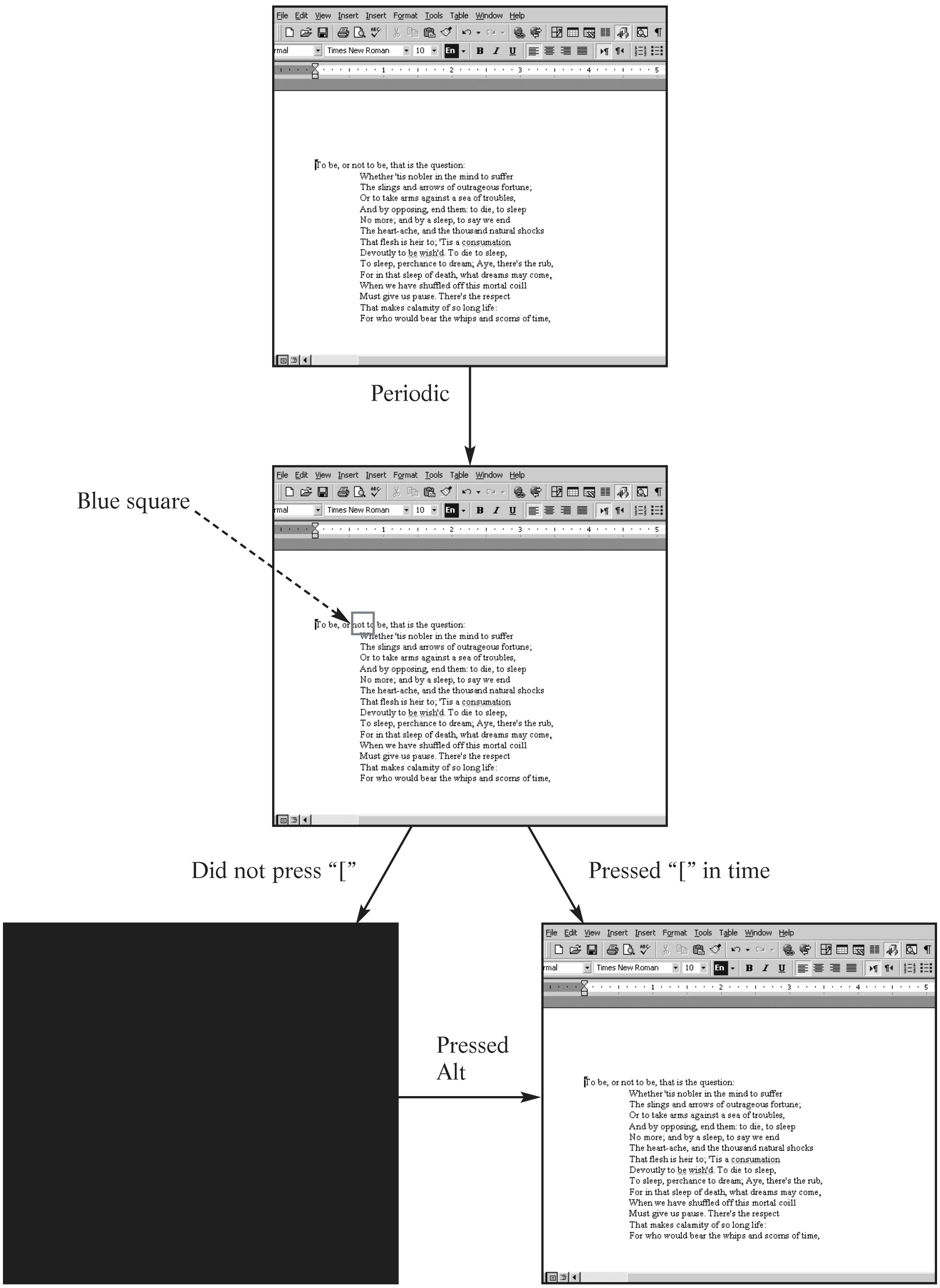

Figure 1. An illustration of the blue square secondary task

three-factor linear equation (Lovasz & Plummer , 1986). Trainees' similarities in their initial touch-typing score, initial visually guided typing score, and number of hours taken to reach the experimental phase were used to match pairs of participants. The average age of matched participants in both conditions was 24 years. The control group had 1 more male participant (4 vs. 3) than did the experimental group, which does not constitute a significant gender proportion difference between the two conditions ($z = .46$, $p = .32$).

Experimental phase. In this stage participants were divided into experimental and control groups. Trainees in both groups were asked to continue training by typing their homework or projects in Hebrew using Microsoft Word. They were asked not to use any word formatting (such as aligning words or using graphics), so that the main task in this phase would be a typing task rather than other word-processing tasks.

Trainees in the experimental group were also informed that they had to perform an additional task while typing. The additional task was a secondary assignment requiring a response to blue squares appearing on the screen. Trainees were instructed to respond to the blue squares by pressing the "[" key in the 2-s period following its appearance. Failure to do so would result in a darkening of the screen. Pressing the "Alt" key would return the screen to normal. The entire process was demonstrated to the trainees by the experimenter.

The total duration of the experimental phase was 6 h. Participants were asked to complete these 6 h within 2 weeks and to type for no more than 2 h at any one session (following Baddeley & Longman, 1978). Participants were called back to the laboratory 2 weeks after the experimental phase. They were then given two further typing tests: a delayed test (using the same text as before) and a transfer test (using a different text).

RESULTS

Descriptive Statistics

Table 1 presents the averages, standard deviations, and intercorrelations of the typing tests conducted at the beginning and end of the touch-typing course, at the end of the experimental phase, and at the delayed test.

Participants' pretraining typing speed of a novel text (the weekdays) using the visually guided strategy was relatively poor, at about 20 wpm. Their initial speed with the same text using touch-typing was much lower, at about 8 wpm. Another interesting feature was the high variability in the initial typing speed ($SD = 8.8$), which ranged from 10 to 44 wpm. There were no significant differences between the control and the experimental groups in these performance measures.

Trainees took an average of about 8 h in training to finish the touch-typing course and reach a touch-typing score that exceeded their initial non-touch-typing score. The average time for the experimental group (8.4 h) was not significantly different from that for the control group (7.8 h). The variability was about 3 h in both conditions.

TABLE 1: Averages, Standard Deviations, and Intercorrelations of Typing Measures

	Mean wpm (*SD*)			Correlation Matrix				
Measure	All	Control	Exper.	TT-P	VGT-P	TT-C	TT-E	TT-D
pTT pretraining	8.1 (4.2)	8.0 (4.4)	8.0 (4.3)	1.0				
VGT pretraining	18.4 (6.7)	18.9 (8.1)	17.9 (5.2)	.58**	1.0			
TT course	21.1 (7.5)	21.5 (7.2)	20.8 (8.1)	.76***	.77***	1.0		
TT experimental	28.7 (9.0)	27.1 (9.5)	30.3 (8.7)	.73***	.70***	.84***	1.0	
TT delayed	25.8 (9.7)	23.3 (8.2)	28.2 (10.9)	.62***	.47**	.73***	.84***	1.0
TT delayed transfer	14.4 (5.3)	13.4 (5.8)	15.3 (4.9)	.61***	.39*	.53**	.69***	.68***

Note. Typing measures: pretraining touch-typing (TT) and visually guided typing (VGT) level; touch-typing level at the end of the touch-typing course, at the end of the experimental phase, at the delayed test, and at the delayed transfer test ($n = 22$ for all measures). Averages and standard deviations also appear separately for the different conditions ($n = 11$).
* $p < .1$. ** $p < .05$. *** $p < .01$.

The average time between sessions in the touch-typing course was also similar for both groups, although it was slightly higher for the control group (3.3 days) than for the experimental group (2.5 days). Consequently, it took the control group slightly longer to finish the course (about 25 days, compared with 21 days for the experimental group). None of these differences was significant. The same comparisons were also made for the experimental phase (in which participants had less freedom to determine their schedule) and revealed no significant differences between the two conditions.

Figure 2 presents the experimental and control groups' end-of-hour test performance in the experimental phase and in the test conducted 2 weeks after the experiment. Performance scores are presented as a percentage of improvement beyond the average score in the last 2 h of the touch-typing course. As the figure shows, in the first hour of the experimental phase the experimental group's scores were not much higher than those of the control group, whereas in the last hour of training with the blue squares the experimental group surpassed the control group by about 25%. This difference is analyzed statistically in the next section.

Evaluations of the Basic Assumptions: The Role of Melioration

Assumption 1 states that visually guided typing is initially more efficient than touch-typing. This initial advantage is important because it implies that melioration favors visually guided typing. To evaluate this assumption we examined the difference between the pretraining visually guided and touch-typing speeds. This difference was positive for 21 of the 22 participants. The mean advantage of visually guided typing among the 22 participants was 10.4 wpm (SD = 5.50). Thus, in support of Assumption 1, visually guided typing was initially more efficient, $t(10) = 6.85$, $p < .01$. One participant performed equally well in touch-typing and visually guided typing. Consequently, she was excluded from the subsequent analysis together with her matched participant.

Assumptions 2 and 3 state that the initial advantage of visually guided typing impairs touch-typing during free typing but not in a touch-typing course. Under these assumptions people tend to meliorate, and in free practice touch-typing is impaired. To evaluate this prediction we computed a "melioration potential" (MelPo) index

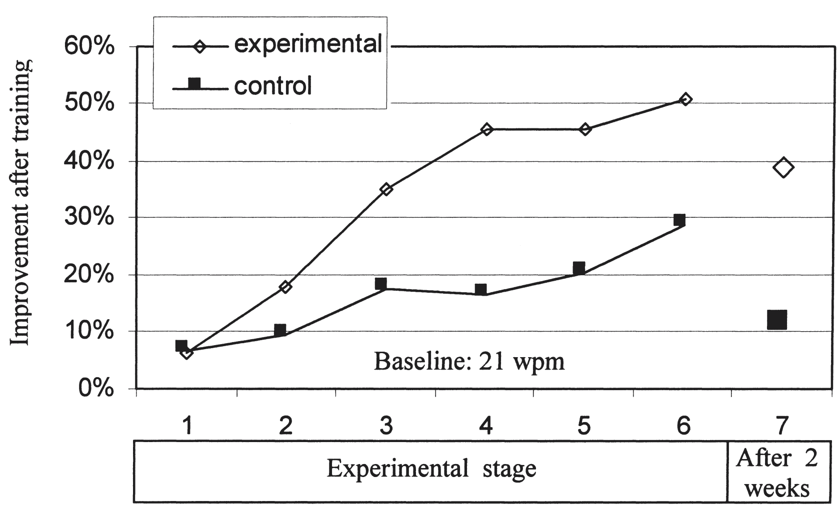

Figure 2. Touch-typing scores in the six hourly tests conducted during the experimental phase and 2 weeks after the experiment. Comparison of the experimental and control groups in percentages of improvement beyond the touch-typing course.

for each participant, expressed as the relative advantage of visually guided typing:

$$MelPo = (VGspeed - TTspeed)/VGspeed,$$

in which *TTspeed* is the measured typing speed (in words per minute) in the first touch-typing test and *VGspeed* is the pretraining visually guided typing speed. Values close to 1 imply a large melioration potential. In addition, we computed two touch-typing learning indices for each participant, expressed as the improvement during the experimental phase (from before the experimental phase to its last hour) and during the touch-typing course. As expected, in the experimental phase, the results reveal negative correlation ($r = -.63$, $p < .05$) between MelPo and touch-typing improvement in the control group. Thus a large gap between visually guided typing and touch-typing was associated with inefficient touch-typing performance under normal typing conditions.

As predicted by Assumption 2, however, there was no correlation between MelPo and improvement in the touch-typing course ($r = .16$, *ns*): Unlike the normal typing condition, during the touch-typing course melioration did not affect the progress of touch-typing performance.

The Effect of the Manipulation

The blue-squares method was expected to change the influence of melioration in the experimental phase. With the addition of blue squares (the experimental condition), visually guided typing is less likely to be reinforcing. Thus a high score in the MelPo index is not expected to have a detrimental effect on the acquisition of touch-typing competence. In support of this prediction, the correlation between MelPo and touch-typing learning in the experimental group was .53 ($p = .12$). In this group, those participants who were relatively skillful in visually guided typing did not obtain lower touch-typing performance levels.

In order to examine whether the difference between the effects of MelPo in the experimental and control conditions is significant, we constructed a regression model,

$$TT\text{-}Learning = \beta 0 + \beta 1 \cdot Cond + \beta 2 \cdot MelPo + \beta 3 \cdot Cond \cdot MelPo,$$

in which *TT-Learning* denotes touch-typing improvement in the experimental phase and *Cond* is a dummy variable that takes the value +1 in the control condition and 0 in the experimental condition.

The results of a stepwise regression (see Table 2) revealed a significant interaction, $F(2, 17) = 8.86$, $p < .01$, $MSE = 21.5$ – that is, there was a significantly different effect of MelPo in the two conditions. The interaction is plotted in Figure 3. It demonstrates that the experimental treatment improves learning only if MelPo is higher than .44 (the average MelPo was .56, $SD = .18$). The analysis also indicates a main effect of the experimental condition, $F(2, 17) = 4.40$, $p = .05$, $MSE = 21.5$ – namely, that the blue-squares manipulation enhanced touch-typing improvement. (The effect of the blue squares was also examined in a repeated-measures analysis of covariance, with MelPo as a covariant. The between-subjects factor, condition, was examined with repeated performance measures [six tests] during training. The results revealed a significant three-way interaction of MelPo × Condition × Time, $F[5,16] = 5.19$, $p < .01$, $MSE = 7.9$, as well as a two-way interaction of Experimental Condition × Time, $F[5, 16] = 4.41$, $p < .01$,

TABLE 2: Results of the Stepwise Regression Analysis

	Model			Increment	
	Cum. R^2	F	β	R^2	F_I
Cond	.15	4.40*	12.0	.15	4.40*
Cond × MelPo	.42	8.86**	–27.3	.27	6.72*

Note. Table shows the effect of condition, melioration potential, (MelPo), and their interaction on touch-typing learning (TT-learning) in the experimental phase ($df = 2, 17$). Regression equations are as follows. Complete: TT-Learning = 9.6 + 12·Cond – 27.3·Cond·MelPo; Control (Cond = 1): TT-Learning = 21.6 – 27.3 · MelPo; Experimental (Cond = 0): TT-Learning = 9.6.
* $p \le .05$. ** $p < .01$.

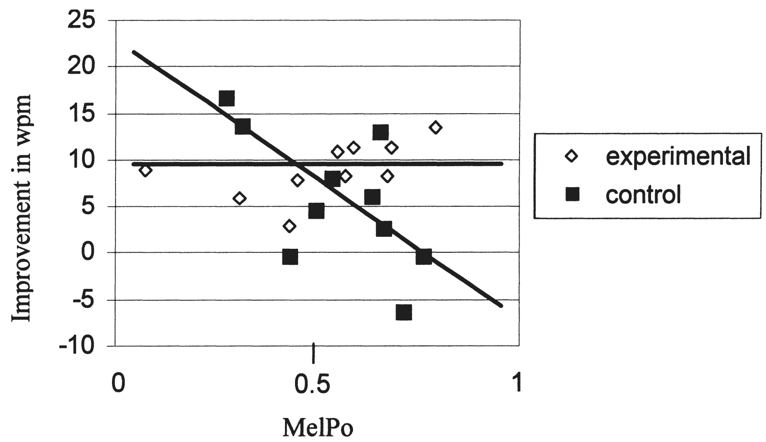

Figure 3. Regression plot of predicted and actual improvement in the experimental phase as a function of melioration potential (MelPo): comparison of the experimental and control groups. The lines indicate the regression model's prediction. The dots show the actual distribution.

MSE = 7.9.) Cohen's *d* of the differences between conditions in terms of improvement during the experimental phase is .84, which is considered to be a substantial difference (Cohen, 1962).

Delayed Tests

The results of the delayed test conducted 2 weeks after the experiment showed a small decrease, about 3 wpm, as compared with the last hour of the experiment (15% as a percentage of improvement; see Figure 2). The decrease was significant in a Student's *t* test, $t(19) = 2.29$, $p < .05$.

The difference between the control and experimental groups increased to about 30%. A new regression analysis, as described earlier, was carried out for the delayed test (the dependent variable being improvement from before the experimental phase to the delayed test). The results of the analysis showed a marginal interaction between MelPo and typing improvement, $F(1, 18) = 4.16$, $p = .06$, $MSE = 46.2$. A post hoc paired *t* test of the differences between conditions (matched pairs) in touch-typing improvement indicated a significant effect, $t(9) = 1.80$, $p < .05$, one-sided in the predicted direction. Cohen's *d* of the improvement advantage in the experimental condition equaled .81 (a large difference).

The results of the delayed transfer test indicated a further decrease of about 11 wpm (12%), which was significant in a Student's *t* test, $t(19) = 6.75$, $p < .01$. The difference between the training and experimental groups decreased to about 10%, $d = .42$. (In a recent replication of the experiment [Yechiam, 2003], in which the full typing task was replaced by a simple assignment with the numeric keypad, a significant effect of the manipulation was found in a transfer test.)

DISCUSSION

The current results support two basic assertions. One assertion is that oversensitivity to immediate reinforcement (melioration) is one of the factors that may impair the transition from touch-typing training to everyday use. We consider the touch-typing course and the experimental phase of the present experiment as representative of training and normal use, respectively. As predicted by the present model, the high initial advantage of visually guided typing (melioration potential) in the control group was associated with low touch-typing improvement scores during the experimental phase. Supposedly, participants who scored relatively high in visually guided typing reverted back to this strategy. (Note that this effect of melioration did not appear during the touch-typing course.)

It seems, then, that the initial advantage of visually guided typing may not be salient in training, in which it is common to use nonword material and performers are specifically motivated to use touch-typing. The effects appeared in the transition to normal typing material, in which semantic meaning reduces text orientation problems as well as the number of required transitions from the screen to the keyboard and back during typing. Under this condition, the performance advantage of visually guided typing over touch-typing can be restored.

According to the second assertion, the negative effect of the melioration tendency can be overcome with a change of the overall task incentive structure. Indeed, in the experimental group, an initial advantage of visually guided typing did not have a negative effect on touch-typing performance during the experimental phase. Moreover, the introduction of the blue-squares task, designed to impair the attractiveness of visually guided typing in the general task context, led to improved touch-typing performance. Touch-typing scores were 25% higher in the experimental group than in the control group at the end of the experimental phase and 30% higher at the test conducted 2 weeks later.

Thus, although participants in both groups came with the intent to learn and use touch-typing, control group participants were successful in the touch-typing course but not in the experimental phase. In the control group, long-term goals (acquiring competence in touch-typing) were offset by the pressure of short-term outcomes of the chosen strategies, so that the more competent a person was in visually guided typing, the worse he or she performed in typing. A simple manipulation that changed the immediate reinforcement structure was sufficient to eliminate this effect.

Potential Limitations

The effect of the manipulation subsided in the transfer test. Although this may indicate that the effect of the experimental manipulation is limited, it is well in line with the present model. We do not contend that the initial training plus 6 h of manipulation would be sufficient to lead to a touch-typing advantage capable of overcoming a strong and well-practiced advantage of normal text semantic structure. However, the manipulation did increase the use of touch-typing in the relatively constrained environment of the experiment, in which the motivation and reward for touch-typing were relatively high. According to the present model, encouragement should continue until touch-typing performance in everyday typing tasks, rather than fixed tests, exceeds the performance level attained using visually guided typing. At this point, the immediate reinforcements from using the touch-typing strategy would be stronger and touch-typing should become the dominant mode of behavior.

Note that there are more direct means of changing the immediate feedback environment. For example, occluding the sight of the keyboard eliminates the visually guided typing strategy altogether. However, the nonprescriptive nature of the present method seems more suitable for performers who attempt to acquire touch-typing on their own and are thus most susceptible to the melioration problem. In the present method the decision to change a strategy is self-initiated, and this may lead to less suspiciousness and resistance in the change process. Self-initiated strategy change appears to be beneficial in non-supervised environments, both in the training of complex skills (see Erez & Zidon, 1984; Gopher, Weil, & Siegel, 1989) as well as in corresponding methods in psychotherapy (see Watzlawick, Weakland, & Fisch, 1974).

Potential Generality

It seems that the main difference between touch-typing and visually guided typing involves the "division of labor" between different sensory modalities. Touch-typing uses the visual sense to observe the source and target text and proprioceptive feedback to supervise finger movements. In contrast, visually guided typing relies primarily on visual information in processing the different components of the typing task: reading from the source display, pressing keys, and correcting mistakes in the target display.

This observation implies that the current findings may be generalized to other training problems that involve inefficient usage of multiple modalities. The importance of this problem is highlighted in a contemporary multiple-resource model (Wickens, Vidulich, & Sandry, 1984), which advocates the idea that different sensory processes may proceed in perfect time sharing. Sharing implies that a person can devote his or her time to working on two tasks without having one task interrupt the other. For example, Allport, Antonis, and Reynolds (1972) found that performers could read music notes and engage in an auditory shadowing signal detection task at the same time.

Given the capability of human performers to efficiently use time sharing, it is interesting to observe that in many daily tasks performers do not allocate sensory modalities to a greater effect. For example, novice dancers tend to look at their feet rather than rely on proprioception (Yechiam, 2003). Likewise, in typing, the visually guided typing strategy, which relies solely on visual processing, is the intuitive method of choice. This empirical reality can be understood by the observation that the immediate efficiency of a strategy based on the use of the visual mode to process all of the subtasks is usually higher than the efficiency of a shared-modality strategy.

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Eldad Yechiam is a postdoctoral research fellow at Indiana University. He received a Ph.D. in psychology in 2003 from the Technion – Israel Institute of Technology.

Ido Erev is an associate professor of psychology at the Technion – Israel Institute of Technology. He received a Ph.D. in psychology in 1990 from the University of North Carolina.

Vered Yehene is head of the Application Unit in the Human Factors and Safety Laboratory at the Technion – Israel Institute of Technology. She received a Ph.D. in psychology in 2001 from Ben Gurion University, Beer-Sheva.

Daniel Gopher is a professor of cognitive psychology and human factors engineering at the Technion – Israel Institute of Technology. He received a Ph.D. in psychology in 1972 from the Hebrew University of Jerusalem.

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