Exploration of Passive Haptics Based Learning Support Method for Touch Typing

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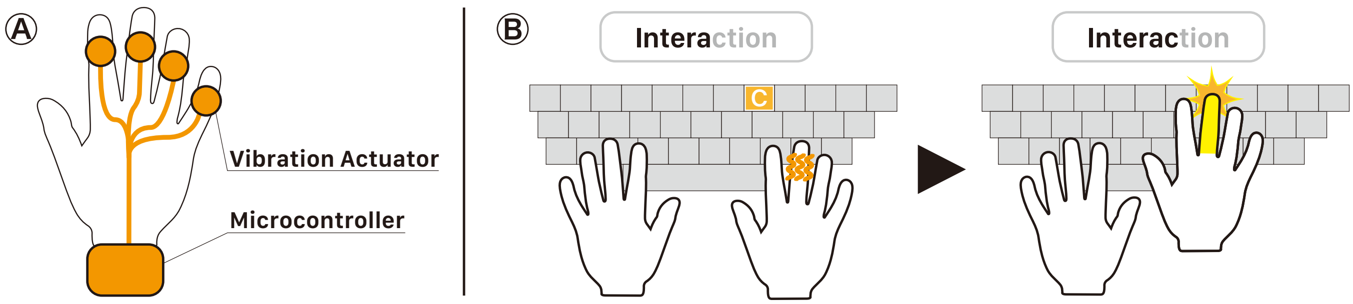

Figure 1: Overview of the proposed method. A) Haptic glove used in our method. A vibration actuator is attached to each finger except the thumb (for a total of four) and controlled by a microcontroller. B) Typing using passive haptics. The user, with his hand hidden, types using the vibration received immediately before as a clue.

ABSTRACT

Touch typing is a keyboard input method whereby the user types without looking at the keyboard. Because by touch typing users can keep looking at the screen, they can concentrate on what the screen shows and edit text. However, learning touch typing is difficult because it requires the memorization of all key placements. In this paper, we propose a passive haptics based learning support method for touch typing. Because the user is given a stimulus to the finger to be used for the next keystroke, our method encourages users to keep looking at the screen, helping them memorize all key placements. To investigate the effect of using our method, we conducted a pilot study with the users typing English phrases. As a result, our method has a possibility that the users can take less time to acquire touch typing.

CCS CONCEPTS

• **Human-centered computing → Haptic devices**; *User studies*; *Text Entry*;

KEYWORDS

training, tactile, haptics, haptic presentation, text entry, wearable

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1 INTRODUCTION

Touch typing is a keyboard input method whereby the user types without looking at the keyboard. Because, when using it, he can keep looking at the screen, not shifting his gaze between the keyboard and the screen, he can concentrate on what the screen shows and on editing text. Therefore, touch typing is an important method that enables the user to interact efficiently with the computer. However, touch typing is difficult to acquire because it requires memorizing all key placements and finger motions [12]. Touch typing training systems exist that display visual information about the key to be typed and the finger to be used for the next keystroke [4, 11]. However, because a user of these systems needs to look at information on the screen other than the text to be edited to know about the next keystroke, there is an issue with the user not being able to concentrate on his editing text. Therefore, a learning support method that displays information on the finger to be used for the next keystroke while the user concentrates on his editing text is necessary.

In this paper, we propose a passive haptics based learning support method for touch typing (Figure 1). Our method gives the user a passive vibrotactile stimulus (passive haptics) that indicates the finger to be used for the next keystroke while the user types *with his hands hidden*. With this design, our method encourages the user to keep looking at the screen, helping him memorize all key placements. In order to investigate the effect of using our method on a full keyboard (with Dvorak keyboard layout [3]), we carry out a pilot study.

2 RELATED WORK

Few studies have been carried out on using passive haptics to improve learning efficiency.

Seim et al. [10] examined whether learning by using passive haptics could improve the users' typing performance on a randomized numeric keypad. They reported that the users trained with passive haptics could reduce typing errors even if they were typing without looking at the keypad.

Huang et al. [5] investigated the effect of using passive haptics on learning piano. In their experiments, the users, who had no experience of playing the piano, learned two songs in the presence and absence of tactile sensation, respectively. The training time, which was 30 minutes for each song, was the same under both conditions. However, the authors reported that the users could play the song trained with passive haptics with almost no errors, while errors were detected in the song trained without passive haptics.

These results suggest that passive haptics could reduce a user's typing errors and the time he needs to learn touch typing. In our study, we investigate the effect of passive haptics for learning touch typing on a full keyboard.

3 EXPERIMENTAL APPARATUS

The system we used consists of a pair of haptic gloves and a typing application.

3.1 Haptic Glove

The haptic glove (Figure 2) consists of a cotton glove, a microcontroller (Arduino Nano) sewn on it, and four vibration actuators. Similarly to Huang et al. [5], we cut the fingertips of the glove to improve manual dexterity and finger sensation. For the vibrotactile stimuli we chose vibration actuators (Nidec Copal Corporation, LBV10B-009), which are eccentric rotating mass (ERM) motors driven with 3 V DC and providing the user with a clear vibrotactile stimulus. A rectifier diode is connected to each vibration actuator in parallel to prevent back electromotive force. Each actuator is attached with masking tape to a finger of the glove, excluding the thumb, between the first and second phalanx.

3.2 Typing Application

We implemented a typing application for the user to learn the Dvorak keyboard layout. The typing application works on a personal computer (in our pilot study, we used a 13-inch Apple Macbook Pro with a 2.7 GHz Intel Core i5 CPU and 8 GB of memory). Figure 3 shows the application running. Because in our method we assume that the user types with his hands hidden, the keyboard layout is always displayed on the screen, so that the user can check the key placements while looking at the screen. Additionally, the keys are colored so that the user can see which finger to type with. In the application, the user types an English phrase (presented phrase), which is randomly selected from the Mackenzie dataset [7] and presented on the first line of the window ("buckle up for safety"

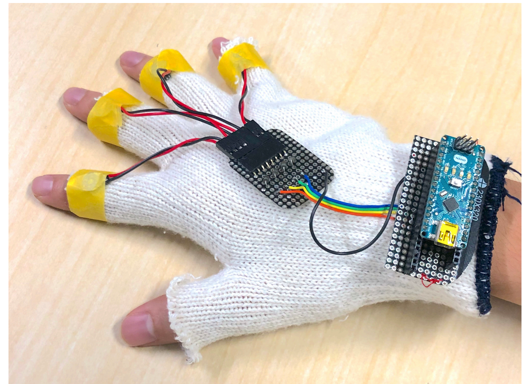

Figure 2: The haptic glove we implemented. It consists of a cotton glove, a microcontroller (Arduino Nano) sewn on it, and four vibration actuators. The fingertips of the glove are cut to improve manual dexterity and finger sensation.

Figure 3: The window of our typing application. the keys are colored so that the user can see which finger to type with. When the user enters an incorrect letter, the background of the transcribed phrase turns red to inform the user that the transcribed phrase contains error(s).

in Figure 3). When the user enters an incorrect letter, the background of the transcribed phrase turns red to inform the user that the transcribed phrase contains error(s). The user can only correct the error by typing the 'delete' key. As soon as the transcribed phrase is equal to the presented phrase, a new phrase is presented. Therefore, the transcribed phrase always has to match the presented phrase. The number of phrases that have been entered and that of phrases to be completed are always displayed at the bottom of the window (e.g., 0/3).

The typing application sends the next letter to be typed to each haptic glove when the last letter has been correctly typed. Then, the microcontroller drives the vibration actuator of the finger that should be used to press the letter key during 300 ms, which is the minimum vibration time in the study of Seim et al. [9]. For example, suppose that the user needs to type “interaction”. As shown in Figure 1, ‘c’ is a key to be typed with the right middle finger on a Dvorak keyboard. Thus, after ‘a’ is typed, the vibration actuator on the right middle finger vibrates once. This vibrotactile stimulus encourages the user to press the ‘c’ key using the right middle finger. If the user types an incorrect letter, the typing application does not send a vibration.

4 PILOT STUDY

To investigate the effect of our method, we conducted a pilot study with the users typing English phrases in our laboratory (Figure 4). In the pilot study, the participants used a Dvorak keyboard for the first time.

4.1 Participants

Six members (all males) of our laboratory who had never used the Dvorak keyboard layout before participated in this study as volunteers. The participants were all undergraduate or graduate students in computer science of ages ranging between 21—26 ($M = 23.00, SD = 1.67$). They all used a Qwerty keyboard in everyday typing.

4.2 Design

The pilot study used a between-subject design: half of the participants typed with passive haptics (PH), and the other half without it (Control). The participants typed with their hands hidden under a board in order not to look at the keyboard. All participants wore a pair of haptic gloves.

Two tasks were designed: a practice task and a test task. In the practice task, participants typed three English phrases randomly selected by the typing application from the MacKenzie dataset [7]. They were asked to type the presented phrases as quickly and accurately as possible. After the practice task, the participants performed a test task, which verified whether the participants learned the key placements. In the test task, the participants typed all the

Figure 4: The pilot study using our typing application. The participants typed task phrases with their hands hidden under a board so that they could not see the keyboard.

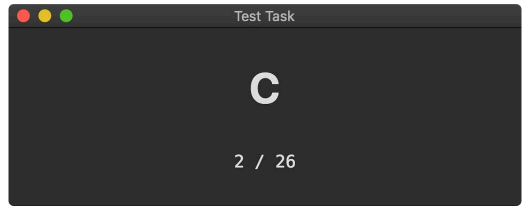

Figure 5: The screen for the test task in our typing application. The participants typed all the 26 letters of the alphabet, randomly presented one by one.

26 letters of the alphabet, randomly presented one by one (Figure 5). During the test task, the keyboard was not displayed on the screen.

A session consists of a practice and a test task. The participants performed five sessions, taking a break of at least one minute after each session. This pilot study took approximately 30 minutes per participant.

4.3 Results

We collected the data of 90 phrases (6 participants $\times$ 3 phrases $\times$ 5 sessions). To evaluate the learning effect, accuracy, and speed of touch typing, we used the following three metrics in the test task: the correct rate (CR), keystrokes per character (KSPC) [1], and characters per second (CPM). Figure 6 shows the results.

We analyzed the evolution of CR, KSPC, and CPM of both groups as the session progressed. The test of no correlation showed that in both groups CR ($r_{\text{PH}} = 0.645, r_{\text{Control}} = 0.751$; both $p < 0.05$) and CPM ($r_{\text{PH}} = 0.643, r_{\text{Control}} = 0.561$; both $p < 0.05$) had a positive correlation to the number of sessions. Instead, KSPC ($r_{\text{PH}} = -0.574, r_{\text{Control}} = -0.336$; both $p < 0.05$) had a negative correlation to the number of sessions in both cases.

To investigate whether the learning effect differed between the two methods, we used the Wilcoxon rank-sum test with the method as the independent variable. As a result, a significant difference was revealed on CPM ($p < 0.05$). Furthermore, the Friedman rank-sum test, with the number of sessions as the independent variable, showed that the number of sessions has significant effects on CR ($\chi^2(4) = 22.48, p < 0.001$) and CPM ($\chi^2(4) = 20.67, p < 0.001$). Finally, Steel-Dwass tests showed a significant difference in CR ($p < 0.05$) and CPM ($p < 0.05$) between session 1 and session 5.

5 DISCUSSION AND FUTURE WORK

In the 5th session, the CR of the PH and Control group was 59.0% ($SD = 18.2\%$) and 53.8% ($SD = 16.3\%$), respectively. This means that both groups could not learn touch typing in five sessions. To predict the number of sessions that the participants would need to correctly locate all key placements, we modeled a power regression of CR for both groups under the assumption that the user performance improves following a power law [2, 6] (Figure 6). As a result, the participants would be able to correctly locate all key placements (i.e., the curves reach 100.0%) after 9.84 sessions for the PH group and 13.46 sessions for the Control group. Therefore, passive haptics has a possibility of the effect to promote learning

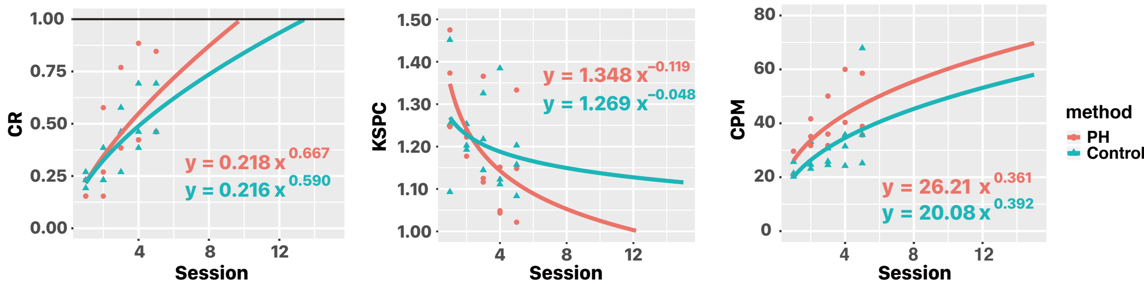

Figure 6: Results of the pilot study. Red represents the participants typing with passive haptics (PH), and blue represents those typing without it (Control). The power regression of each method until session 15 is also drawn. From left to right, the correct rate (CR), keystrokes per character (KSPC), and characters per second (CPM) in the test task are represented.

touch typing. However, these prediction curves for CR have to be verified experimentally.

In the evolution of KSPC, a clear difference between the PH and Control group was not observed. Modeling a linear regression, however, showed that although the KSPC of the PH group was higher than that of the Control group in the first session, it was lower in the fifth session. As a reason for this, we observed that the participants reflexively pressed the key where their finger was placed when receiving the vibration, possibly because they were at first not familiar with our method. Therefore, our immediate future work will be to design another user study observing the motion of hands to clarify whether users types intentionally or reflexively.

However, users of the PH group displayed a higher CPM in all sessions. This might be because users using passive haptics could rapidly find the target key, restricting the search to only near the finger that received a vibration. This suggests that the users with passive haptics can practice more touch typing than those without it in the same amount of time. Because many trials in a short period of time have a positive effect on learning [8], passive haptics could help learn touch typing

In the pilot study, two of the three participants of the PH group commented that they could not immediately determine which key to type, even though one of their fingers was stimulated by vibration. This is because users had to choose among at least three keys when receiving a vibration. Therefore, it appears necessary to distinguish between the upper, middle, and lower stages of the keyboard and to use different haptics, so that the user can identify the stage where the key is placed. To do this, we should use different vibration patterns or increase the number of actuators. Furthermore, four of the six participants commented that their finger motion was confused by that they have when typing on a Qwerty keyboard. From this, we considered that the current typing skills of the participants affect their learning of touch typing. Therefore, we need to investigate the relation between the participants' current typing skills and the learning effects of our method.

6 CONCLUSION

We proposed the passive haptics based learning support method for touch typing. In our method, the user types using passive haptics with his hands hidden. Because a stimulus is given to the finger to be used for the next keystroke, the user can type while looking at the screen, helping him memorize all key placements. Additionally, a user using passive haptics could rapidly find the target key because the search is restricted to only near the finger that received a vibration. This would help the user practice more touch typing in the same amount of time as those without it. To investigate the effect of using our method, we carried out a pilot study with the users typing English phrases. Our results show that, by our method, users could improve typing speed in a shorter time. Furthermore, from predicting the time the users need to correctly locate all key placements, we found that a user can locate all key placements after 9.84 sessions using passive haptics and 13.46 sessions without it. From these results, our method has a possibility that the user could take less time to learn touch typing.

REFERENCES

[1] Ahmed Sabbir Arif and Wolfgang Stuerzlinger. 2009. Analysis of text entry performance metrics. In *Proceedings of the 2009 IEEE Toronto International Conference Science and Technology for Humanity (TIC-STH '09)*. IEEE, 100–105. https://doi.org/10.1109/TIC-STH.2009.5444533

[2] Stuart K. Card, William K. English, and Betty J. Burr. 1978. Evaluation of Mouse, Rate-Controlled Isometric Joystick, Step Keys, and Text Keys for Text Selection on a CRT. *Ergonomics* 21, 8 (1978), 601–613. https://doi.org/10.1080/00140137808931762

[3] August Dvorak. 1943. There is a Better Typewriter Keyboard. *National Business Education Quarterly* 12, 2 (1943), 51–58, and 66.

[4] Jaroslaw Foksa. 2019. Type Fu – Typing training. https://type-fu.com/. Accessed: 2019-10-24 .

[5] Kevin Huang, Ellen Yi-Luen Do, and Thad Starner. 2008. PianoTouch: A Wearable Haptic Piano Instruction System for Passive Learning of Piano Skills. In *Proceedings of the 2008 IEEE International Symposium on Wearable Computers (ISWC '08)*. IEEE, Washington, DC, USA, 41–44. https://doi.org/10.1109/ISWC.2008.4911582

[6] J. R. De Jong. 1957. The Effects of Increasing Skill on Cycle Time and Its Consequences for Time Standards. *Ergonomics* 1, 1 (1957), 51–60. https://doi.org/10.1080/00140135708964571

[7] I. Scott MacKenzie and R. William Soukoreff. 2003. Phrase Sets for Evaluating Text Entry Techniques. In *Proceedings of the CHI 2003 Extended Abstracts on Human Factors in Computing Systems (CHI EA '03)*. ACM, New York, NY, USA, 754–755. https://doi.org/10.1145/765891.765971

[8] Walter Schneider. 1985. Training High-Performance Skills: Fallacies and Guidelines. *Human Factors: The Journal of the Human Factors and Ergonomics Society* 27, 3 (1985), 285–300. https://doi.org/10.1177/001872088502700305

[9] Caitlyn Seim, John Chandler, Kayla DesPortes, Siddharth Dhingra, Miru Park, and Thad Starner. 2014. Passive Haptic Learning of Braille Typing. In *Proceedings of the 2014 ACM International Symposium on Wearable Computers (ISWC '14)*. ACM, New York, NY, USA, 111–118. https://doi.org/10.1145/2634317.2634330

[10] Caitlyn Seim, Nick Doering, Yang Zhang, Wolfgang Stuerzlinger, and Thad Starner. 2017. Passive Haptic Training to Improve Speed and Performance on a Keypad. *Proceedings of the 2017 ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 1, 3, Article 100, 13 pages. https://doi.org/10.1145/3132026

[11] Teaching.com. 2019. typing.com. https://www.typing.com/. Accessed: 2019-10-24 .

[12] Eldad Yechiam, Ido Erev, Vered Yehene, and Daniel Gopher. 2003. Melioration and the Transition from Touch-Typing Training to Everyday Use. *Human Factors: The Journal of the Human Factors and Ergonomics Society* 45, 4 (2003), 671–684. https://doi.org/10.1518/hfes.45.4.671.27085