Tactile Cue Presentation for Vocabulary Learning with Keyboard

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ABSTRACT
This paper presents the results of a pilot experiment observing the effect of tactile cues on vocabulary learning. Considering that we generally memorize words by associating them with various cues, we designed a tactile cue presentation device that aids vocabulary learning by applying vibrations to the finger that is associated with the next key to press when typing on a keyboard. Experiments comparing tactile and visual cues indicated that tactile cues can significantly improve long-term retention of vocabulary after one week.

Author Keywords
Haptic; tactile cue; vocabulary learning; wearable device

ACM Classification Keywords
H5.2 [Information interfaces and presentation]: User Interfaces - Training, help, and documentation.

INTRODUCTION

Vocabulary learning is one of the most time-consuming aspects of language learning and known to be assisted by the association with various cues. Oxford et al. evaluated language learning for a second or foreign language assisted by visual, aural, tactile, and kinesthetic associations [1].

We focused on tactile association to support vocabulary learning when using a keyboard, because adults typically use typing more than writing and typing naturally involves an accompanying tactile sensation to each finger. Bojinov et al. designed a game using the keyboard to unconsciously memorize a password [2]. Huang et al. designed Mobile Music Touch as a means for learning piano key sequences [3].

In this study, we focused on adult first language speakers of Japanese who were learning English words. To present tactile cues to the keyboard, we designed a glove-type tactile device with eight vibrators situated at the root of each finger, excluding the thumbs (Figure 1).

In contrast to previous work that has used one-to-one mapping between fingers and keys [3, 4], our system used a one-to-many mapping feature, i.e., each finger can press a range of keys so that vibration to the finger does not uniquely determine the key to press. For example, if a tactile cue is given to the little finger of the left hand, the next key to press could be either A, Q, or Z. We speculated that this uncertainty does not hinder, but would rather facilitate learning.

Figure 1. Glove-type tactile device

SYSTEM

The system is composed of a glove-type tactile device, a PC and a keyboard. The device has eight small vibration motors (FM34FTokyo Parts Ind. Inc.), transistors to drive the motors, and a microcontroller (mbed NXP LPC1768 NXP Inc.) to control the motors and communicate with the PC. Users see the LCD monitor of the PC, which displays a Japanese word (the question) and its English translation (the answer).

EXPERIMENT

To determine if our system is effective for learning words, we performed an experiment comparing tactile with ordinary visual cueing. One hundred words required to yield 729 points or more in TOEIC (Test of English for International Communication) were selected and 40 words were randomly chosen from these for each participant. The set of 40 words was divided into two: 20 words for tactile cues and 20 words for visual cues.

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Procedure

We recruited seven participants consisting of four males and three females, 21–23 years of age. Each participant learned 20 words in tactile condition and 20 words in visual condition.

In the first phase, a Japanese word (the question) was displayed in a white font, and an English word (the answer) in gray font was displayed on the LCD against a black background. When the participants pressed the corresponding key, each gray letter was changed, one by one, to white. The participants were asked to input the 20 words once in this phase.

In the next phase (Training Phase), only the Japanese word was displayed, and the English answer was displayed in a letter-by-letter fashion when the participant typed the correct letter. After this phase, all words were tested (Test Phase) without tactile or visual cue. The Training and Test Phases were repeated five times. In the Training Phase, only the words that were missed in the previous Test Phase were used so that the experiment time was reduced. After one week, the Test Phase was performed to see the long-term effect.

In the Training Phase, the participants were either presented tactile or visual cue. The tactile cue was a vibration presented to the finger that should be used for the next letter (assuming general finger-keys mapping with a QWERTY keyboard). The visual cue was a gray color display of the next letter. In both cases, the cues were presented only when the participants could not press the next key for 0.5 s. The participants were randomly divided into two groups, A and B. Group A participated in the experiment with tactile cues given first, and group B in the experiment with visual cues given first.

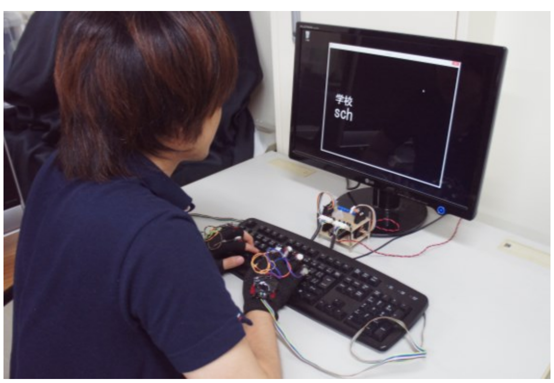

Figure 2. Overview of experiment

Result and Discussion

Figure 3 shows the results of the Test Phase for the two conditions. The horizontal axis shows the number of the Test Phase. We found a significant difference between the two conditions after one week (Wilcoxon matched-pairs signed-rank test, $p<.05$) with tactile cues outperforming ordinary visual cues. No difference was observed between group A and B.

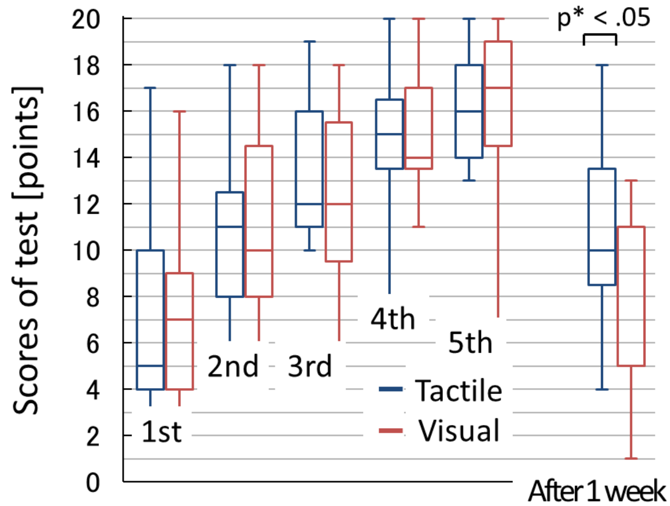

Figure 3. Result for the Test Phase using two different conditions

Results indicate that the tactile cues were effective for ensuring that information was retained for a long term. This may be owing to the fact that our tactile cue has ambiguity (i.e. the cue was presented to the finger and the user must still actively determine which key to press), while the visual cue gave a more complete cue (i.e. user can passively wait for the next letter to display). This difference in the nature of the cue might lead to the reinforcement of memory.

CONCLUSION

In this paper, we focused on the use of tactile cues to support vocabulary learning. The tactile cue was a vibration presented to the finger that should be used on the keyboard, to type the next letter in the appropriate English word.

We performed an experiment comparing tactile and ordinary visual cues. The tactile cue was more effective than the visual cue in terms of retaining the new vocabulary after one week.

Our future work includes comparison of tactile cues with incomplete (vague) visual cues, and an examination of ways in which multiple cues might be combined and optimized.

REFERENCES

1. Oxford, R. and Crookall, D. Vocabulary Learning - A Critical Analysis of Techniques. *TECL Canada Journal/Revue TESL Du Canada*, 7 (2), March, 1990.
2. Bojinov, H., Boneh, D., Sanchez, D., Reber, P. and Lincoln, P. Neuroscience Meets Cryptography. *USENIX Security 2012*. August 8-10, 2012.
3. Huang, K., Starner, T., Do, E., Weinberg, G., Kohlsdorf, D., Ahlrichs, C. and Leibrandt, R. Mobile Music Touch – Mobile Tactile Stimulation for Passive Learning. *CHI 2010*, April 10-15, 2010.
4. Kim, D., Johnson, B., Gillespie, R.B. and Seidler, R. Role of Haptic Cues in Motor Learning, *IEEE World Haptics Conference 2013*, April 14-18, 2013.