The Effect of a User's Search Strategy on Performance with Word Prediction

Heidi Horstmann Koester
Rehabilitation Engineering Program, University of Michigan
Koester Performance Research

Abstract
A previous study demonstrated that word prediction may not significantly enhance text generation rate (Koester and Levine, 1996). In that study, subjects were given explicit instructions on when to search the word prediction list. This paper presents results of a follow-up study, in which subjects were instructed to use the list whenever they felt it would be beneficial. The results concur with the original study in that word prediction only modestly enhanced text generation rate.

Background
The user's search strategy during word prediction use has received little explicit attention as a factor in user performance. Our most recent study focused on conditions under which subjects were given one of two specific strategies for when to search the prediction list (Koester and Levine, 1996). The rule for the "Always-search" strategy was to always search the list before every selection. The rule for the "Two-then-search" strategy was to ignore the list until the first two letters of the word have been selected, and then search the list before every subsequent selection. Word prediction provided no significant enhancement of text generation rate for able-bodied subjects in that study, and it provided significantly slower text generation rate (relative to letters-only typing) for the spinal cord injured subjects.

We attributed these results to the cognitive load required to use the word prediction system. Additional cognitive and perceptual processes mean that each selection takes extra time, relative to letters-only typing, and this extra time offsets the benefit of having fewer selections to make. Mathematically, it can be shown that use of word prediction will only enhance text generation rate if the benefit, measured as keystroke savings, exceeds the cost, measured as the decrease in item selection rate relative to letters-only typing (Koester and Levine, 1994).

Research Questions
One question in interpreting our previous results is whether following prescribed strategies may have hindered subjects' performance with word prediction. Allowing subjects to use a "natural" strategy (i.e., any way the subject thinks best) might yield better performance. This follow-up study addressed the following questions:

1. Are natural strategies more effective than the "Always-search" and "Two-then-search" strategies?
2. Do users who employ natural strategies also experience significant cognitive load with word prediction?

Methods
Research methods for this follow-up study were identical to those employed in a previous study of user performance with word prediction (Koester and Levine, 1996), except that subjects were not given specific rules regarding when to search the prediction list.

Subjects. The "natural strategy" group was comprised of four able-bodied subjects. All shared the following characteristics: at least some college-level education; high familiarity with the standard keyboard; and no significant prior experience with word prediction.

Systems. The "Letters-only" system involved letter-by-letter spelling on a standard computer keyboard, and the "Letters+WP" system used single letter entry augmented by a word prediction feature. A six-word prediction list with a fixed word order was used and presented vertically in the top left corner of the screen.

Experimental Design. Subject performance with and without word prediction was recorded in each of seven test sessions. Subjects used mouthstick typing.

Procedures. The study began with two training sessions, in which subjects practiced using the mouthstick with both systems. Each of the seven test sessions involved four sentences of warm-up using Letters+WP, an eight-sentence test with Letters+WP, then a two-sentence test with letters-only. Unique text blocks were developed for each session based on typing tests, revised to provide specific levels of keystroke savings. The keystroke savings in Sessions 1-4 approximated the level that might be expected with an "average" word prediction system, approximately 42% (Higginbotham, 1992). Session 5 reflects a higher level of keystroke savings (52%), with Sessions 6 and 7 providing successively poorer-than-average levels, at 32% and 22%, respectively. All items selected by subjects were timed and stored by the software in real time.

Dependent Measures. Text generation rate and item selection rate were measured in each session for both systems. Text generation rate was defined as the number of characters generated divided by the total time required to generate those characters. Item selection rate was defined as the number of items selected (including letter and word selections) divided by the total time.

Rate enhancement with word prediction was measured as the percentage improvement in text generation rate with Letters+WP relative to letters-only typing. The time cost associated with word prediction was measured as the percentage decrease in item selection rate with Letters+WP relative to letters-only. The motor benefit associated with word prediction was measured as the percentage of keystrokes saved with Letters+WP relative to letters-only.

Statistical Analyses. Differences in dependent measures for the natural strategy subjects were determined using an ANOVA, with system and session as repeated measures factors. Differences between strategies were assessed by comparing these data to that of the able-bodied subjects from the previous study, using an ANOVA with strategy as the between-subjects factor and session as a repeated measures factor. Statistical significance for each effect was judged at a familywise p-value of 0.05.

Results

Text Generation Rate. Natural strategy subjects' letters-only typing speed averaged 89 characters per minute (cpm) across sessions, while their average text generation rate with word prediction was 91 cpm. Across Sessions 1 - 4, which provided average keystroke savings, the text generation rate with word prediction averaged 5.8% faster than letters-only typing, which was not statistically significant ($p = 0.37$). When keystroke savings were higher than average, in Session 5, word prediction improved text generation rate by an average of 20.0%. Conversely, when keystroke savings were much lower than average, text generation rate with word prediction was 14.6% lower than rate with letters-only typing.

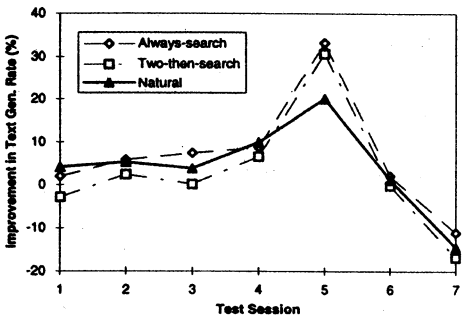

Figure 1. Percent increase in text generation rate with Letters+WP, relative to Letters-only, for each of the three strategy groups.

As shown in Figure 1, text generation performance with word prediction relative to letters-only typing was very similar for all three groups, averaging 4.4%, suggesting that none of the three strategies had a significant advantage ($p = 0.82$).

Item Selection Rate. Item selection rate for natural strategy subjects was 31% slower with word prediction as compared to letters-only typing (significant at $p = 0.002$). As shown in Figure 2, the cost in item selection rate was lowest for the "Two-then-search" strategy, followed by the "Natural" strategy, with the highest cost for the "Always-search" strategy. However, there was no statistically significant difference between the three groups ($p = 0.23$).

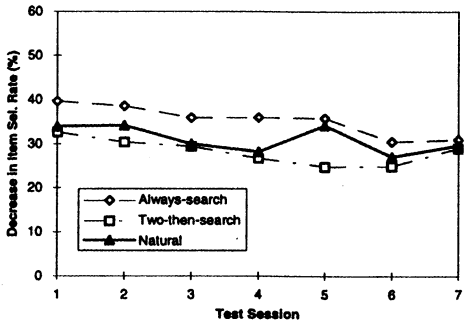

Figure 2. Percent decrease in item selection rate with Letters+WP, relative to Letters-only, for each of the three strategy groups.

Keystroke Savings. Figure 3 shows the average keystroke savings achieved by each of the three groups during use of word prediction, with a significant difference between the groups ($p = 0.001$). Subjects who used the "Always-search" strategy generally achieved close to the maximum possible keystroke savings, as would be expected. Subjects who used "Two-then-search" had a significantly lower keystroke savings, since ignoring the list for the first two letters of every word caused them to miss some early predictions. The natural strategy subjects fell in-between, suggesting that their search strategies were more effective than "Two-then-search" but not effective enough to gain the maximum keystroke savings.

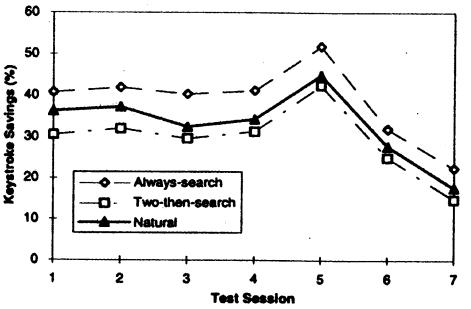

Figure 3. Percent of keystrokes saved with Letters+WP, relative to Letters-only, for each of the three strategy groups.

Discussion

The results provide another demonstration of how increased cognitive and perceptual loads can impact user performance with word prediction. Natural strategy subjects "broke even" with word prediction because the added cost of using the system, averaging 31%, was roughly equivalent to the keystroke savings these subjects achieved, averaging 33%. By following their own rules, natural strategy subjects did have a lower time cost than the "Always-search" subjects. But since the natural strategy subjects did not succeed in finding each word on its first occurrence, keystroke savings suffered.

Among the limitations of this study, the relatively short time course is one of the most significant. It's possible that natural strategies would develop an advantage over time, as the user became familiar with the system's prediction style, although we didn't see a trend in that direction in these subjects.

Conclusions

Word prediction exacts a cognitive load, whether a user follows a prescribed strategy or one of his or her own devising. None of the three strategies tested emerged as being clearly preferable, at least for the able-bodied subjects tested. The choice of the optimal search strategy continues to depend on the specific characteristics of the user.

References

1. Koester, H.H., Levine, S.P. (1996). The Effect of a Word Prediction Feature on User Performance. *AAC*, 12:3, 155-168.
2. Koester, H.H., Levine, S.P. (1994). Learning and Performance of Able-bodied Individuals using Scanning Systems with and without Word Prediction. *Assistive Technology*, 6:1, 42-54.
3. Higginbotham, D.J. (1992). Evaluation of Keystroke Savings across Five Assistive Communication Technologies. *AAC*, 8:4, 258-272.

Acknowledgments

This work was funded by the National Institutes of Health, through a long-term training grant to the University of Michigan PM&R Department.

Heidi Horstmann Koester
1721 Abbott Ave.
Ann Arbor MI 48103
email: hhk@umich.edu