Short Report

Raeding Wrods With Jubmled Lettres

There Is a Cost

Keith Rayner,1 Sarah J. White,2 Rebecca L. Johnson,1 and Simon P. Liversedge2

1University of Massachusetts, Amherst, and 2University of Durham, Durham, United Kingdom

Two years ago, a widely circulated statement on the Internet claimed that research at Cambridge University found that sentences in which letters were transposed (or jumbled up), as in the sentence you are now reading, were easy to read and that letter position in words was not important to the ability to read successfully. In actuality, the statement was a hoax in that no such research had been conducted at the University of Cambridge (see http://www.mrc-cbu.cam.ac.uk/personal/matt.davis/Cambridge/). We report here results from a study showing that although some variations of sentences with transposed letters are relatively easy to read, other variations are not, and that there is generally always a cost associated with reading words with transposed letters.

We asked 30 college students at the University of Durham, United Kingdom, to read 80 sentences in which letters were transposed. In each sentence, transpositions were consistently located at the beginnings, middles, or ends of words (see Table 1). About 40% of the words in the sentences (all content words longer than four letters) had letter transpositions. In addition, the students read sentences without any transpositions. Eye movements were recorded via a Fourward Technology Dual Purkinje eyetracker; the spatial resolution of this eyetracker is less than 10 min of arc. Comprehension questions were asked after 30% of the sentences. Readers were able to answer the questions with high accuracy, but 50% of them indicated that there were a few words that they did not understand.

Whereas the base reading rate for normal sentences was 255 words per minute (wpm), all of the variations involving letter transpositions resulted in some cost to reading. When internal letters were transposed, the reading rate was 227 wpm (an 11% decrement in reading speed). However, when the transpositions involved the ending letters of words, reading rate was 189 wpm (a 26% decrement), and when the transpositions were at the beginnings of the words, reading rate was 163 wpm (a 36% decrement).1 Readers made more and longer eye fixations (see Table 1) with the more difficult transpositions.

The Internet statement was correct in that some letter transpositions do yield words that are relatively easy to read. However, our results clearly demonstrate that transpositions always carry a cost. Furthermore, our research also shows that transpositions vary in their costliness depending on their location in the word: Transpositions of internal letters are much less costly than transpositions of ending letters, which in turn are less costly than transpositions of beginning letters. These results demonstrate the importance of beginning letters for word recognition (see Rayner & Pollatsek, 1989, for a summary). In other work (Christianson, Johnson, & Rayner, 2005), we have also demonstrated that letter transpositions that cross morpheme boundaries (even with internal letters) are associated with an additional cost. Thus, sunshine is more difficult to read than sunhsine.

Finally, a previous study showed that when letters are substituted rather than transposed, readers take much longer to read sentences (Rayner & Kaiser, 1975). In the case of substitutions involving visually similar letters, substitutions for internal letters (e.g., problem printed as pncblem) doubled reading time, as did substitutions for ending letters (e.g., problnc); substitutions for beginning letters (e.g., qroblem) were associated with reading times 2.5 times longer than normal. In the case of substitutions involving visually dissimilar letters, substitutions for internal letters (e.g., prkylem) or final letters (e.g., probkly) tripled reading time; substitutions for beginning letters (e.g., fyoblem) quadrupled reading time. In all cases (except when visually similar letters were substituted for internal letters), substitutions also reduced comprehension.

1The decrements reported are undoubtedly an underestimation of the true cost of reading text with transposed letters because we transposed letters only in content words. One might expect the cost to be even greater if transpositions occur in all the words of a sentence.

Address correspondence to Keith Rayner, Department of Psychology, University of Massachusetts, Amherst, MA 01003, e-mail: rayner@psych.umass.edu.

192
The fact that text with letter transpositions is so much easier to read than text with letter substitutions demonstrates that the specific letters of a word are critical for identifying what the word is (Grainger & Whitney, 2004) and that readers cannot rely exclusively on context for word recognition. In comparison to letter substitution, letter transposition makes it much easier for readers to recover what the actual form of the word should be. But the main point of our findings is that although it may seem that it is easy to read text with transposed letters, and although some transpositions do not entail as much added difficulty as others, there is always a cost involved in reading such text in comparison to normal text.

**Acknowledgments**—This research was supported by Grant 12/S19168 from the Biotechnology and Biological Sciences Research Council (United Kingdom) and by Grant HD26765 from the National Institutes of Health (United States).

**REFERENCES**


(Received 9/30/05; Accepted 10/3/05; Final materials received 10/5/05)