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Raeding wrods with jubmled letetrs: There's a cost

Keith Rayner[1], Sarah J. White[2], Rebecca L. Johnson[1], and Simon P. Liversedge[2]

[1] Department of Psychology, University of Massachusetts, Amherst, MA, USA

[2] Department of Psychology, University of Durham, UK

Correspondence to:

Keith Rayner

Department of Psychology

University of Massachusetts, Amherst, MA 01003, USA

Phone: 413-545-2175; FAX: 413-545-0996

rayner@psych.umass.edu

991 words (excluding references)

Two years ago, a widely circulated statement on the internet claimed that resarceh at *Cmabrigde Uinervtisy* fuond that sentecnes in whcih lettres weer transpsoed (or jubmled up), as in the setnence you are now raeding, were easy to read and that letter position in words was not important to read successfully. In actuality, the statement was a hoax in that no such research had been conducted at the University of Cambridge[1]. We report here results from a study which show that while 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 thirty college students at the University of Durham to read eighty sentences in which letters were transposed (see Table 1). About 40% of the words in the sentences (all content words longer than four letters) had letter transpositions. Eye movements were recorded via a Fourward Technology Dual Purkinje eyetracker; the spatial resolution of the 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 wpm, all of the variations involving letter transpositions resulted in some cost to reading. When the transpositions occurred to the internal letters, reading rate was 227 wpm (a 12% decrement in reading speed). However, when the transpositions involved the final or ending letters of words, reading rate was 189 wpm (a 26% decrement) and when the transpositions were at the beginning of the words, reading rate was 163 wpm (a 36% decrement)[2]. 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 there is also always a cost in relation to normal text. Furthermore, our research also shows that transpositions to different parts of the word vary in their costliness: transpositions to internal letters are much less costly than transpositions to final or ending letters, which in turn are less costly than transpositions to beginning letters. These results demonstrate the importance of beginning letters for word recognition (see Rayner & Pollatsek, 1989 for a summary). We have also demonstrated in other work (Christianson, Johnson, & Rayner, 2005) that letter transpositions that cross morpheme boundaries (even with internal letters) make words harder to identify. Thus, *susnhine* is more costly than *sunhsine*.

Finally, when letters are substituted rather than transposed, readers take much longer to read sentences (Rayner & Kaiser, 1975). When the letter substitutions were visually similar internal letters (so *problem* was printed as *pncblem*) reading time doubled; when ending letters were substituted (*problnc*), reading time also doubled, and when beginning letters were substituted (*qroblem*), reading time was 2.5 times longer than normal. When dissimilar letters were substituted for internal letters (*prkylem*) or final letters (*problky*), reading time tripled; when dissimilar letters were substituted for beginning letters (*fyoblem*), reading time quadrupled. In all cases (except for visually similar internal letter substitutions), comprehension also suffered when letter substitutions were used.

The fact that text with letter transpositions is so much easier 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 while it may seem that it is easy to read text with transposed letters, and while some transpositions do yield words that are easier to read than other transpositions, there is always a cost involved in reading such text in comparison to normal text.

Footnote

1. see http://www.mrc-cbu.cam.ac.uk/personal/matt.davis/Cmabrigde/

2. The decrements reported are undoubtedly an under-estimation of the true cost of
    reading text with transposed letters since we only transposed letters from content
    words. If transpositions occurred to all of the words, one might expect the cost to be
    even greater.

References

Christianson, K., Johnson, R.L., & Rayner, K. (in press). Letter transpositions within and across morphemes. *Journal of Experimental Psychology: Learning, Memory, & Cognition.*

Grainger, J., & Whitney, C. (2004). Does the human mind raed wrods as a wlohe? Trends in Cognitive Science, 8, 58-59.

Rayner, K., & Kaiser, J.S. (1975). Reading mutilated text. *Journal of Educational Psychology*, *67*, 301-306.

Rayner, K. & Pollatsek, A. (1989). *The psychology of reading*. Englewood Cliffs, NJ: Prentice Hall.

Table 1. Examples of normal text (N) and text with letter transpositions to internal letters (INT), ending letters (END), and beginning letters (BEG). The number of fixations (NFix), the percentage of fixations that were regressions (%Reg), and the average fixation duration (FD) when reading the sentences are also presented. Conditions with the same superscripted letter did not differ, while those with different letters did (all ps < .01).

		NFix	%Reg	FD
N:	The boy could not solve the problem so he asked for help.	10.4^a	$15.0\%^a$	236 ms^a
INT:	The boy cuold not slove the probelm so he aksed for help.	11.4^b	$17.6\%^b$	244 ms^b
END:	The boy coudl not sloev the problme so he askde for help.	12.6^c	$17.5\%^b$	246 ms^b
BEG:	The boy oculd not oslve the rpoblem so he saked for help.	13.0^d	$21.5\%^c$	259 ms^c

Note: There were two types of internal letter transpositions: either the beginning internal letters (as in *slove*) or the ending letters could be transposed (as in *problem*). In this table, we have collapsed across these two types of transposition since there was no difference between them.