Computer text line lengths affect reading and learning

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Grab a book from your bookshelf and open it to any page. Then grab a ruler and measure: How long is the longest line of text on the page? Chances are the text line measures no more than 5 or 6 inches. Grab another book and do it again. Chances are the line lengths are similar: about 5 inches. Nearly every book the same. Why?

Perhaps you'll say because most books with 5-inch line lengths are smaller and easy to hold. So to sell more books, book manufacturers keep them an easy-to-hold size. Okay, fair enough.

So now instead grab any newspaper or magazine and measure the line lengths of different stories or articles. These no doubt vary: some column widths of text are probably as narrow as 3 inches. Even with the larger overall width of the newspaper or magazine page, you'll be hard pressed to find columns of text running over 5 or 6 inches. Why don't newspapers and magazines use longer line lengths?

Because, according to research, short line lengths are easier to read.

Saccades, Fixations, Regressions, and Return Sweeps

Scientists who study reading in print media have learned that when we read, our eyes do not move smoothly across the page, as readers may assume. Instead, our eyes move in little hops—called "saccades"—and come to brief stops, about 250 milliseconds each—called "fixations." During a fixation our eyes see several words, not just one word at a time (that is, if the words are of average length like those in this sentence). Occasionally our gaze will experience "regressions"— slight backward movements if we're having difficulty reading or a problem understanding the material.

When our eyes finally get to the end of a line, they perform a "return sweep" to re-position our gaze to the beginning of the next line. The greater the line length and number of saccades required to reach the end of a line, the more difficult it is to return-sweep and re-position gaze at the start of the next line.

"…the greater the line length, the more difficult to… re-position to the next line…"

That's why research suggests 5-inch line lengths are best for reading print material. Is this also true for text on a computer screen? This is an important question, given not only the ever-growing abundance of Web site and e-learning text, but also the many e-mail applications that format text across the entire screen, in 10- to 12-inch line length.

Is screen-length text the most effective way for hundreds of millions of individuals to be transmitting and reading written communications? Isn't reading text on a low resolution computer monitor difficult enough? Do long line lengths make reading on computer even more difficult? Or doesn't it matter for the computer screen?

IBM Almaden Eye Gaze Tracking Experiments

IBM Learning partnered with scientists at IBM's Almaden Research Center in San José, California, to understand the physiological effects of different formal features—line lengths, paragraph depth, font size, line spacing, among others—on computer screen readability. This article explores line length.

The IBM research investigated these features' impact also on retention of material. Why retention? Because learning is, after all, about how well one remembers content. If a certain formal feature, such as line length, impacts a reader's memory of the material read, that's important for educators and instructional designers to know.

Eye gaze tracking provides a valuable tool for objectively measuring reading behavior. In eye gaze tracking systems, a tiny, unobtrusive camera mounted in the computer records the eye gaze of a user, which is then mapped to the words and lines of text being read. The results can be viewed only by the experimenter.

IBM has developed a tool, WebGazeAnalyzer, for recording and analyzing the eye gaze of a user reading a computer screen. This tool records the characteristic

horizontal pattern of eye fixations and saccades and intersects the eye gaze location with the location of words on the web pages. The experimenter can then tell what the user is reading, the reading speed, what they are re-reading, skipping, and so on.

The IBM tool records multiple data streams and creates a movie of the computer screen, all URLs visited by the user, and all Windows events such as scrolling and mouse clicks. After recording the data, experimenters can later review it as a movie using a playback tool, and can batch-analyze any number of sequences to analyze reading behavior across different experimental conditions, and aggregate any number of subjects' results in any one condition. In this experiment, IBM used WebGazeAnalyzer to study reading behavior under wide and narrow formatted paragraphs.

The Web-page material in this experiment contained identical text content. The only difference was width of the paragraphs. The two conditions in the experiments were:

***Wide paragraphs*.** Paragraphs width was 80% of screen width, measuring 9 inches on our monitor. This is the line length used by many Web sites and many e-mail programs.

Narrow paragraphs. Paragraph width was 40% of screen width, measuring 4.5 inches on our monitor. This is the line length used commonly by many book publishers and print magazines.

The researchers ran two sets of experiments: first a pilot with 16 adult subjects, then a follow-up with 114 adult subjects (70 males, 44 females). The following findings were significant and consistent across both experiments:

-- Subjects who read the narrow paragraphs read slightly faster than those reading the wide paragraphs.

-- The longer return sweeps in the wide paragraphs took more time than the narrow paragraphs, and required an additional positioning fixation.

-- The narrow and therefore longer paragraphs required greater number of sweeps.

"…text printed in shorter line lengths was read faster…"

While return sweeps for narrow paragraphs required less time, the narrower paragraph formatting created many more lines of text and therefore more return sweeps for the reader. This should have evened out the time difference. But surprisingly it did not. The wide paragraphs still took **significantly longer total time** to read. Why?

Reason: The subjects reading the wide paragraphs had a far higher rate of regressions. Regressions are a cue for reading difficulty – more difficult reading material will generate more regressions than less difficult material. In this case, because the material itself was identical, the difference in regression rate must have been because of the difference in line length. Indeed, eye gaze tracking confirmed this: Averaged, the regression rate for wide paragraph was 0.54 regressions/second, while it was only 0.39 regressions/second for the narrow paragraphs. The increased line length caused the eyes to make more tracking mistakes, which required backing up and re-reading. These experiments strongly suggest that it is the ***regressions*** that make the longer line lengths problematic— in print ***or*** on screen—and that slow reading speed. It is not necessarily only the longer return swings that create problems.

Surprising finding about content retention

The IBM researchers discovered two other important, unexpected findings:

Subjects reading the narrow paragraphs had better retention than those reading the wide paragraphs. After reading the material, subjects were given a surprise quiz: a multiple-choice test on the material they just read. On average, subjects reading the wide paragraphs answered 43% correct, while those reading the narrow paragraphs answered an average of 58% correct. This difference is significant, and surprising given that the narrow-width paragraph readers spent less time reading but had greater memory of the material. One may therefore suspect that the additional time required by the wide-width paragraph readers was devoted not to reading and processing the material, but rather to re-orienting fixation caused by the many regressions.

The other surprising finding was that many of the narrow-width paragraph readers did not complete reading to the end of the paragraphs. Yet even without reading to the end, they still scored higher on the post tests!

Soon after the second set of experiments validated the results of the first study, IBM Learning began redesigning its intranet learning programs to reflect the Almaden findings. More than 2000 individual Web pages across a variety of IBM Learning Web sites and IBM online learning programs have been altered to the shorter optimum line lengths, and more are continually being adjusted.

When editing Web pages to accommodate the new line lengths, designers' main concerns were (1) ensuring that line lengths would be resized appropriately to prevent horizontal scrolling if browser window size changes, and (2) providing a method that requires few, if any, modifications to the text content. To achieve these outcomes, a simple style attribute – a cascading style sheet -- was used to set maximum line length for the selected content. Both outcomes were thus successfully achieved, and so far, IBM has encountered few difficulties in moving to the new standard.

"…shorter line lengths produced significantly greater retention…"

Implications for email formats and Web designers

The experiments described here present basic tradeoffs in choosing paragraph width. Making paragraph width wider reduces the total number of return sweeps required for reading, but it increases regressions, increases time spent, and appears to decrease retention of the text material.

While the experiment presented here used two specific paragraph widths for testing, paragraph width can be finely tuned. IBM plans to repeat the analysis of return sweeps for a variety of widths to better understand when the "positioning" fixation begins to appear as a function of width. This would suggest creating a width just below this threshold.

Why didn't readers of the narrow widths continue reading as far to the end of the material as the readers of the longer widths? One possibility may be perception of a greater amount of material to be read in the tall columns. Another may be that

narrow-width text is associated with newspaper columns, which are typically written in the "inverted triangle" style. That is, newspaper stories put the most important information at the top of their column and becoming increasingly less important as the column grows longer. Readers familiar with newspaper-style writing associated the narrow column widths to be written the same way, and concluded that the material near the end of the column was far less important to read. If so, from a design and practice perspective, important information should not be put near the bottom of narrow-width paragraphs.

Perhaps the most important implication for text-message senders is that the shorter line lengths produced significantly greater retention. Instructional designers ought to know that certain configurations of text provide a greater opportunity for material to be remembered, because learning is directly correlated with retention. The importance of this finding alone warrants further investigation of the implications of wide versus narrow column length Web text.
