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Barbara S. Chaparro, Editor

Is Multiple-Column Online Text Better? It Depends!

By J. Ryan Baker

Summary: This study investigated the effects of multi-column displays and justification on reading performance and satisfaction of an online narrative passage. Participants read a short story displayed in one of six formats (one, two, or three columns, in either a full or left-justified format). Results showed a significant column x justification interaction with reading speed significantly faster for the two-column full-justified text than for one-column full-justified, and significantly faster for one-column left-justified than for one-column full-justified or three-column full-justified text. Post-hoc analyses indicate that the faster readers may have benefited most from the two-column justified format.

INTRODUCTION

Large high-resolution displays can now have resolutions of over 1900 pixels, resulting in extremely long lines of text. One way to resolve the problem of very long text lines is to divide the text into multiple columns, thus decreasing the width of each individual line. Some sites even allow users to customize pages into one, two, or three columns (for an example, see http://www.travelyellowstone.com).

To date, research investigating the optimal use of line length, multiple columns, and text justification is inconclusive. Longer line lengths typically result in faster reading times (Duchnicky and Kolers, 1983; Dyson and Kipping, 1997; Dyson and Kipping, 1998; Dyson and Haselgrove, 2001), but research suggests medium to short line lengths typically may result in higher comprehension (Tinker, 1963; de Brujin, de Mal, & van Oostendorp, 1992; Chaparro et al., 2004). In terms of columnar text, the research supports both long single columns of text (Dyson and Kipping, 1998), and multiple short columns (Lam et al., 2000) while preference seems to lie towards multiple short columns (Bouma, 1980; Dyson and Kipping, 1998; Andreyev & Martynov, 2000).

There has been little research done on the impact of text justification on online reading. Priestly (1991) and Hartley (1986) suggest that printed materials should be left-justified because the intra-word spacing remains constant, which helps slower readers identify words more quickly. However, Priestly notes that the question of whether instructional material is best presented in a full-justified or left-justified format is still debated. Full justification requires that both margins be aligned. To accomplish this, large spaces must sometimes be made between words, or words must be

hyphenated, both of which can reduce reading speed and comprehension. Left-justified text is generally preferred because it removes the need for hyphenated words.

In summary, the major findings regarding line length, justification, and multi-column displays and online reading have been:

Longer line lengths generally facilitate faster reading speeds.

Shorter line lengths result in increased comprehension.

The optimal number of characters per line is between 45 and 65.

Paging through online text generally results in better comprehension than scrolling.

Reading speed is faster for both single and multiple columns, but preference is for multiple short columns.

Left-justified text is read faster than full-justified text.

This study investigated the effects of multi-column displays and justification on reading performance and satisfaction of an online narrative passage.

METHOD

In this study, participants read text displayed either as a single column (90 CPL), a 2-column format (45 CPL each), or 3-column format (30 CPL each) presented using either full or left justification.

Participants

Sixty-six undergraduate students with normal or corrected vision participated in the study. Participants had an average age of 22.8 years. Data were collected on the participants' amount of online reading experience and types of materials read online. Eighty-nine percent reported using the Internet a few times per week or more. Forty-eight percent of participants indicated that they read online for two to six hours per week, 15% reported reading online for seven to fourteen hours per week, and nine percent reported reading online for fifteen hours or more per week.

Materials

H.H. Munro's ("Saki") short story "The Lumber Room," a passage of 2191 words, was used as the reading material. The story had a readability score of 9.6 on the Flesch-Kincaid Grade Level statistic. Six versions of the story were created: a single column with a width of 90 CPL, a 2-column format with column widths of 45 CPL, and a 3-column format with column widths of 30 CPL, each presented in either a full or left justification format (See Figures 1 – 6).

The children were to be driven, as a special treat, to the sands at Jagborough. Nichc the party; he was in disgrace. Only that morning he had refused to eat his wholesome b seemingly frivolous ground that there was a frog in it. Older and wiser and better peo there could not possibly be a frog in his bread-and-milk and that he was not to talk non nevertheless, to talk what seemed complete nonsense, and described with much deta markings of the alleged frog. The dramatic part of the incident was that there really wa basin of bread-and-milk; he had put it there himself, so he felt entitled to know somethin taking a frog from the garden and putting it into a bowl of wholesome bread-and-milk was length, but the fact that stood out clearest in the whole affair, as it presented itself to was that the older, wiser, and better people had been proved to be profoundly in error in they had expressed the utmost assurance.

Figure 1. One-Column Full-Justified Condition

The children were to be driven, as a special treat, to the sands at Jagborough. Nicholas was not to be of the party; he was in disgrace. Only that morning he had refused to eat his wholesome bread-and-milk on the seemingly frivolous ground that there was a frog in it. Older and wiser and better people had told him that there could not possibly be a frog in his bread-and-milk and that he was not to talk nonsense; he continued, nevertheless, to talk what seemed complete frog in my bread-and-milk; there was a frog in my bread-and-milk," he repeated, with the insistence of a skilled tactician who does not intend to shift from favorable ground.

So his boy-cousin and girl-cousin and his quite uninteresting younger brother were to be taken to Jagborough sands that afternoon and he was to stay at home. His cousins' aunt, who insisted, by an unwarranted stretch of imagination, in styling herself his aunt also, had hastily invented the Jagborough

Figure 2. Two-Column Full-Justified Condition

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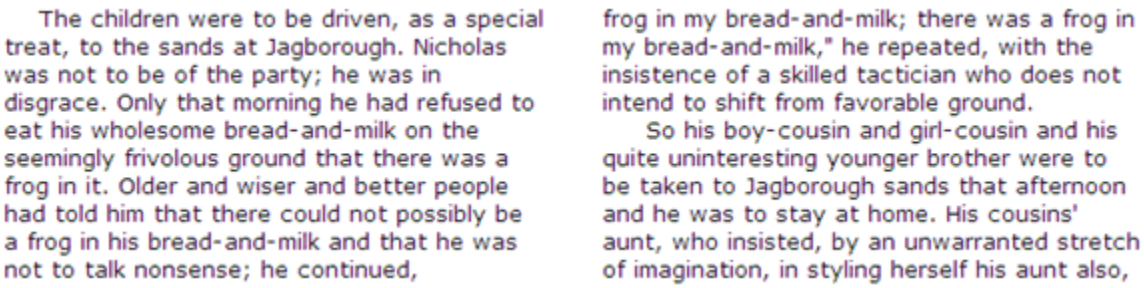
putting it into a bowl of wholesome bread-and-milk was enlarged on at great length, but the fact that stood out clearest in the whole affair, as it presented itself to the mind of Nicholas, was that the older, wiser, and better people had been proved to be

imagination, in styling herself his aunt also, had hastily invented the Jagborough expedition in order to impress on Nicholas the delights that he had justly forfeited by his disgraceful conduct at the breakfast-table. It was her habit, whenever one of the

Figure 3. Three-Column Full-Justified Condition

The children were to be driven, as a special treat, to the sands at Jagborough. Nichc the party; he was in disgrace. Only that morning he had refused to eat his wholesome b seemingly frivolous ground that there was a frog in it. Older and wiser and better people there could not possibly be a frog in his bread-and-milk and that he was not to talk non nevertheless, to talk what seemed complete nonsense, and described with much detail markings of the alleged frog. The dramatic part of the incident was that there really wa basin of bread-and-milk; he had put it there himself, so he felt entitled to know somethi taking a frog from the garden and putting it into a bowl of wholesome bread-and-milk wa length, but the fact that stood out clearest in the whole affair, as it presented itself to was that the older, wiser, and better people had been proved to be profoundly in error i they had expressed the utmost assurance.

Figure 4. One-Column Left-Justified Condition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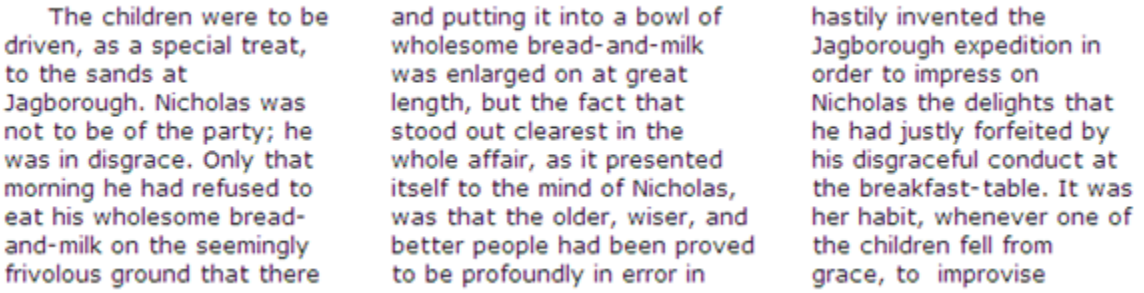
frog in my bread-and-milk; there was a frog in my bread-and-milk," he repeated, with the insistence of a skilled tactician who does not intend to shift from favorable ground.

So his boy-cousin and girl-cousin and his quite uninteresting younger brother were to be taken to Jagborough sands that afternoon and he was to stay at home. His cousins' aunt, who insisted, by an unwarranted stretch of imagination, in styling herself his aunt also,

Figure 5. Two-Column Left-Justified Condition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hastily invented the Jagborough expedition in order to impress on Nicholas the delights that he had justly forfeited by his disgraceful conduct at the breakfast-table. It was her habit, whenever one of the children fell from grace, to improvise

Figure 6. Three-Column Left-Justified Condition

Passages were presented on Dell Dimension 4600C desktop with a 17" display running 1024 x 768 screen resolution. Each of the passages was presented on six consecutive pages; users clicked on an arrow at the bottom of each page to advance to a subsequent page or return to a previous page. No scrolling was required. Users read the passages at a distance of approximately 60 cm and passages were displayed in 10pt Verdana font.

Procedure

The design of this study was a 2 x 3 randomized block design with matched subjects. Column format (single, 2-column, and 3-column) and Justification (Full, Left) were the independent variables.

Participants were matched across conditions based on reading speed predetermined by a online reading test. Participants were then asked to read the short story displayed in one of the six different column conditions (one, two, or three columns, in either a Full or Left-justified format). After reading the story, participants answered sixteen comprehension questions (fifteen multiple-choice and one recall question with ten units) about the story, modeled after those used by Dyson and Haselgrove (2001). The dependent variables of interest were:

- *Reading speed*, measured by the amount of time taken to read each story (converted to words per minute)
- *Reading efficiency*, measured by multiplying words per minute by the percentage correct on overall comprehension;
- *Reading comprehension*, measured by the number of questions about each passage answered correctly, as well as the type of questions answered correctly;
- *Satisfaction*, measured by participant response to a satisfaction questionnaire.

RESULTS

Reading Speed and Reading Efficiency

A 2x3 randomized block ANOVA found a significant interaction for justification x number of columns, $F(2,20) = 3.812$, $p = .040$. $\eta 2 = .276$, $1 - \beta = .624$ (see Table 1). Post-hoc Tukey's HSD comparisons showed that reading speed was significantly faster for *two-column full-justified* (M=269.33) than for *one-column full-justified,* (M=224.31), and significantly faster for *one-column left-justified* (M=266.43) than for *one-column full-justified* (M=224.31), or *three-column full-justified* (M=227.60) (see Figure 7).

Table 1. Reading Speed Means and Standard Deviations

	Columns		
	One	**Two**	**Three**
Full Justification	224.31 (39.76)	269.33 (61.43)	227.60 (41.77)
Left Justification	266.44 (40.52)	242.87 (35.14)	246.29 (70.31)

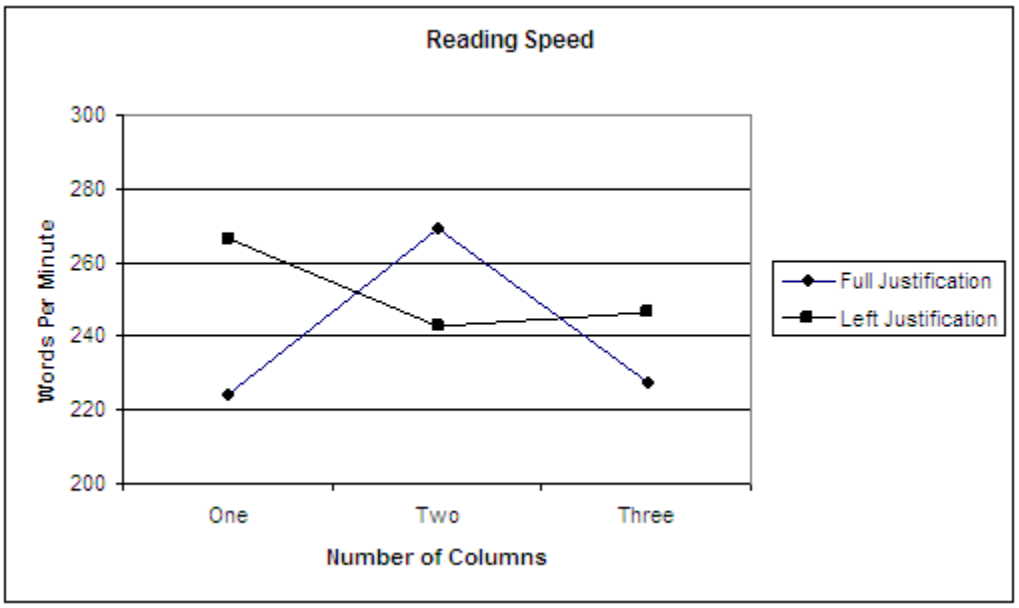

Figure 7. Participant Reading Speed

A 2x3 randomized block ANOVA found no significant main effects for reading efficiency though an interaction approaching significance for justification x number of columns was found, $F(2,20) = 3.124$, $p=.066$. $\eta 2 = .238$, $1 - \beta = .534$.

Reading Comprehension

To compute an overall comprehension score, raw scores were adjusted per question type to yield a total comprehension score of 6 (based on the six types of questions). A 2x3 randomized block ANOVA found no significant main effects or interaction for either justification or number of columns for total comprehension (Table 2).

Table 2. Total Comprehension Means and Standard Deviations

	Columns		
	One	**Two**	**Three**
Full Justification	4.64 (0.92)	4.25 (0.90)	3.99 (1.01)
Left Justification	4.28 (1.17)	3.77 (0.95)	4.14 (1.08)

Satisfaction

A 2x3 randomized block ANOVA found no significant main effects or interaction on overall satisfaction.

Examination of Fast versus Slow Readers

Originally, participant reading rate was not considered as an independent variable in this study. Dyson & Kipping (1997) propose that fast and slow readers use different reading strategies that may impact comprehension. They suggest that faster readers are able to scan narrow columns more efficiently and increase their comprehension. Based on this idea, the fastest readers in this study were compared to the slowest readers by condition. Reading speed, reading comprehension, reading efficiency, and reading satisfaction were then analyzed using a 2 x 2 x 3 ANOVA.

In general, results from these analyses indicate that the fastest readers benefited most from the 2-column justified text, while the slowest readers performed best at the 1-column left justified format (see Figure 8). In addition, satisfaction levels were found to be higher for the fast readers at the *two-column full-justification* condition than the other conditions.

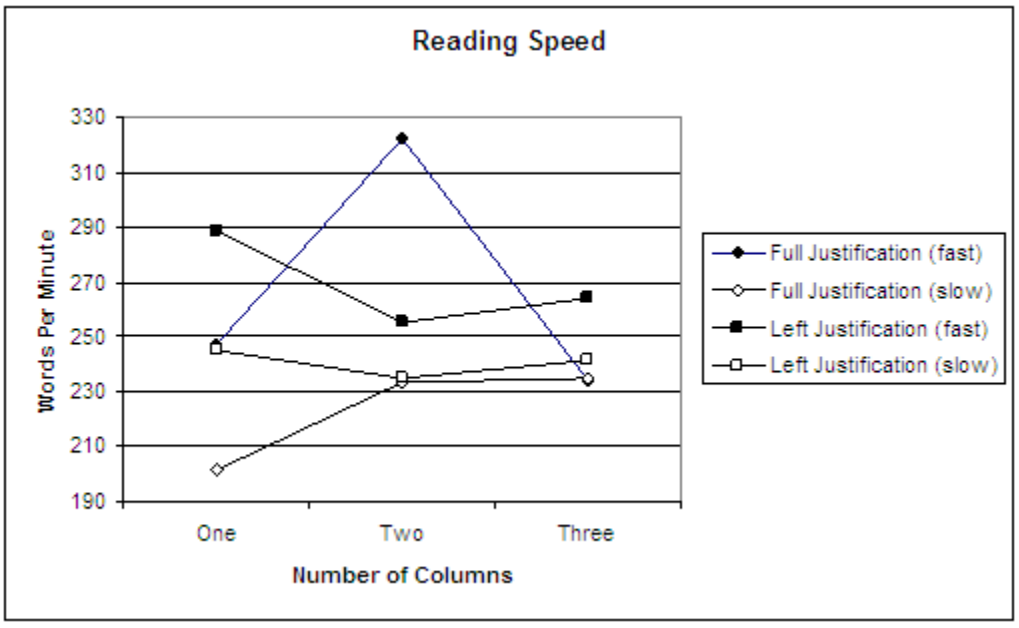

Figure 8. Average Reading Speed for Fast and Slow Readers

DISCUSSION

The purpose of this study was to examine how multiple columns and text justification impact online reading in terms of reading speed, comprehension, and satisfaction of a narrative passage. Results from this study showed that reading speed was significantly faster for two-column full-justified text than for one-column full-justified text. Post-hoc analyses showed that it was the fastest readers that benefited the most from this format.

Slower readers showed their fastest reading and highest reading efficiency at the one-column left-justification condition. This may be because the very short lines impeded the reader's ability to take in an optimal amount of information at each fixation. Gutherie & Wigfield (2000) assert that a slow reader may lose all information about the beginning of a sentence from short-term memory before he or she has read to the end. Slow readers may also have had difficulty "keeping their place" with the multiple line length conditions for this same reason.

Numerous factors contribute to the ease of online reading. As more types of documents become digital, and more people read from online sources, finding the optimal presentation of these materials will become critical in the near future. Reading and comprehension tests are moving into the digital domain and studies such as this one can help researchers and designers know which types of layouts are best for their audience. A two-column full-justified format is best for situations where fast readers are the primary audience. However, for more a more equalized setting, a layout with no strong advantages or disadvantages may be best.

The results of this study suggest that there is not one best way to present text online. Although fast readers performed best at the two-column full-justified condition, slow readers benefited from a single column non-justified layout. This suggests that users should have the option to customize web pages to suit their reading needs. To date, there are very few sites that allow users to tailor information displays into multiple columns or adjust justification styles or font types. Giving users these options can help increase their reading speed with the text, and eventually may lead to a more optimal online reading experience.

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