The Rivers Nobody Measured

The Rivers Nobody Measured

What the evidence says about typography and book design

PAGEPERFECT

First published in 2026 by PagePerfect. This edition: September 2026.

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The twenty-three essays in this book were first published at pageperfect.studio in February 2026. They were checked against their sources and rewritten for this edition.

Typeset in Alegreya and Alegreya Sans with Typst 0.15.1.

Cover design by PagePerfect, using a vintage engraving supplied by Patrick Guenette through Vecteezy.

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Where the rules came from

Ask why a book is set in a serif and you will be told it reads better on paper. Ask why a line should run to about sixty-six characters, or why the white channels that open down a justified page are a fault, and the answers come back just as quickly and just as firmly. They are repeated in studios, in style guides and in teaching, and they are repeated because someone was told them.

This book takes twenty-three of those rules and asks a narrow question of each one: what is it resting on. Where a study is named, the study is read. Where a specification is cited, the specification is checked. Where the rule turns out to rest on one printer's preference, or on a sentence copied from a manual nobody has opened since 1966, that is what the essay says.

Most of the rules came through it intact. Set a serif, keep the indent, hold the line to a comfortable length: the practice is sound. What did not come through is the reasoning. A convention that has served printers for five centuries was being defended with claims about the eye that nobody had measured, and the defence was weaker than the convention deserved.

These essays were published at pageperfect.studio in February 2026. In September every checkable claim in them was traced to its source, and they were rewritten to say what the sources support. Most now argue something different from the text they replace. The fact-check is printed here too, in the notes.

How to read this book

Each essay takes one rule, states it as it is usually given, and then reports what stands behind it. The essays are arranged by subject: typography, layout, visual communication, design systems and production.

A sentence a reader could dispute carries a note. The note names its sources and grades the evidence behind the sentence:

A strong or direct evidence
B one credible study, or evidence with limits
C professional practice or tradition
D a reasonable inference
E the sentence states the journal's own argument

The notes are at the back of the book, grouped by essay. Each one opens with the page and the last few words of the passage it supports, so the text itself carries no numbers. No sentence claims more than its grade allows. Where the evidence runs out mid-argument, the essay stops there and says so. Every source is listed in full at the back, so a reader who wants to check the working can.

TYPOGRAPHY

1

The Rivers Nobody Measured

In 1970 Gregory and Poulton tested 86 readers on text set two ways, justified and unjustified. For the good readers the setting made no difference, and the poorer readers did worse with justification only in short lines. That is about as close as the research comes to the pale channels that open up in a badly justified column. Their reputation is far larger: a severe physiological impediment to reading. When we checked the sources, the reputation was the part that did not hold.

The slack has to go somewhere

Justify a narrow column in a word processor and leave hyphenation off, and the word spaces on one line come out visibly wider than on the next. Every line of a justified paragraph has to end on the same vertical, so whatever room a line has left over goes somewhere inside it, usually into the word spaces. By default InDesign lets the word spaces of a justified paragraph shrink to 80 per cent of the font's own space and stretch to 133, aiming at 100. A line whose last word nearly fits takes spaces near the top of that range, and the next takes them near the bottom.

When wide spaces fall near one another on consecutive lines, they line up into pale channels running down the paragraph. Typographers call them rivers. Browser engineers use the same word: avoiding rivers is on WebKit's list of what good typography tries to do. The remedies follow from the mechanism. Hyphenation lets a line borrow the first syllable of the next word. A longer measure shares the slack among more spaces. A line breaker that can rework the earlier lines of a paragraph can spare a later line a bad break.

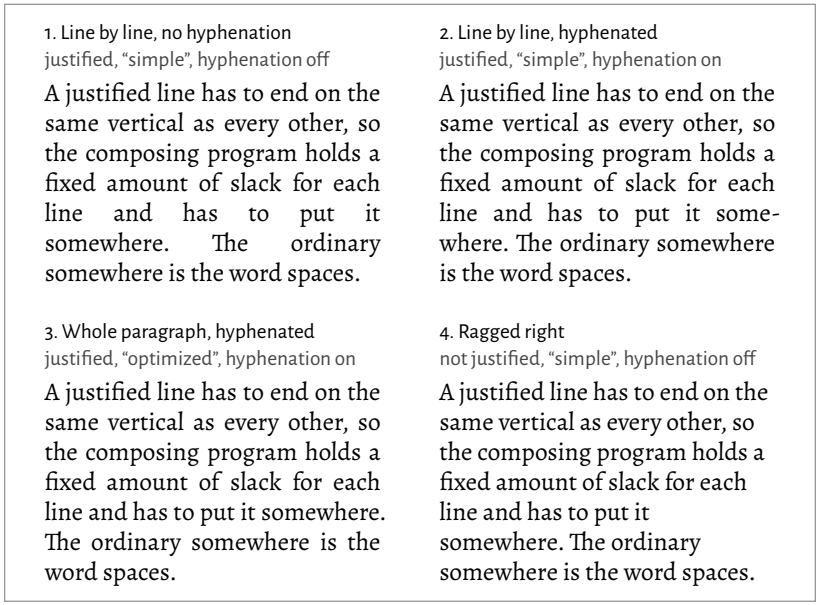


Figure 1: One paragraph at a deliberately narrow measure, set four times in Typst: line-by-line breaking without hyphenation, the same with hyphenation, paragraph-level breaking, and ragged right. The widest word space in the first three settings is 15.84, 5.70 and 3.98 pt; the ragged setting keeps its normal 1.88 pt throughout.

Short lines, weaker readers

The larger case against rivers is physiological. It holds that they make the line harder to track and tire the eyes, so that comprehension falls and the reader eventually abandons the text. No study we could reach measures rivers at all. The nearest experiments compare justified with unjustified setting, and their results are milder and partly contrary.

Gregory and Poulton's short lines held about seven words. When some of the poorer readers were tested again on lines averaging 12 words, the disadvantage disappeared. The authors put the effect down to the irregular spacing that justification produces in a short line, which is the closest the literature comes to a mechanism for rivers.

Justification done crudely, by inserting extra word spaces, was read significantly more slowly in both of Trollip and Sales's studies, and comprehension did not differ in either. Two small experiments from the TeX community add little. In the first, justified text was read slightly faster and recalled slightly worse after a delay. In the second, run with a small group of post-stroke patients, there was no noticeable difference at all.

Taken together, the experiments say much less than the reputation. In one paper, crude justification slowed reading. In the one study that looked for limits, the cost fell on short lines and weaker readers, while the comprehension measures found little or nothing. No experiment we could find compares paragraph-level line breaking with breaking one line at a time on any reading measure, so the contrast this essay is built on is untested as reading.

The return sweep will not carry it

The physiological story rested on saccades. Reading moves in short jumps with fixations between them, and each line ends in a long return sweep to the start of the next. Tinker's eye-movement records describe that pattern, and later work has not altered it. Later studies find that the sweep tends to undershoot, and that the brief fixation

it leaves short of the line's first word earns its keep, as "Where the Measure Comes From" sets out.

Readers also use the spaces between words to decide where the next fixation lands. The physiological case needs one step more, that the stretched spaces in a justified line upset that targeting, and no source takes it. The first version of this essay also claimed that a reader can mistake a wide word space for a sentence break. Nothing stood behind that, so we have taken it out.

Hyphenation is there, switched off

Browsers and word processors are said to be unable to break words across lines for want of hyphenation algorithms, and a minute with either shows that they can. Chrome, Firefox and Safari all support the CSS hyphens property with bundled language dictionaries, and Word has automatic hyphenation on its Layout tab.

Neither switches hyphenation on for you, so a document left as it came is justified without it. How Word then spreads the slack is another matter. We could get no answer from Microsoft's documentation on whether a line can be tightened as well as stretched, or on where the limits sit. The usual description of word-processor justification as blind stretching is probably right, but it is a guess.

Boxes, glue and penalties

What separates the tools is what they do after a bad break. In 1981 Knuth and Plass published the alternative. Their method treats the paragraph as a whole, models it as boxes, glue and penalties, and uses dynamic programming to find the breakpoints with the lowest total cost, without backtracking. Taking a little more space on the second and third lines can spare the fourth a very loose one, and only a method that weighs the paragraph together can make that trade.

TeX is where the algorithm came from, and it is still the clear case. Typst and InDesign do something in the same family under their own names. In Typst, line breaking is either "simple", first-fit, or

“optimized”, a pass over the whole paragraph, and the optimising mode is the default for justified text. The two are not aliases: one paragraph compiled both ways in Typst 0.13.1 came out with different words on three of its lines. InDesign’s default, the Adobe Paragraph Composer, weighs all the lines of a paragraph together and adjusts earlier ones to prevent a poor break later. Its Single-line Composer settles each line before it looks at the next.

Neither Adobe nor Typst calls what it does Knuth–Plass. The idea is shared but the attribution is not on the record, so TeX is the only program we name as implementing the published algorithm.

The letters stay as they are

Professional engines are credited with adjusting the letters themselves, widening or narrowing them and the spaces between them by fractions of a per cent. InDesign does: it scales glyphs to justify a line, within limits the user sets. Adobe advises keeping them within about 97–103 per cent, and the desired value is 100 per cent, so nothing is scaled until someone changes it.

In the TeX world the equivalents are character protrusion and font expansion, which the microtype package offers through LaTeX. Protrusion needs pdfTeX, LuaTeX or XeTeX, and expansion needs pdfTeX or LuaTeX, so the capability belongs to the engines that came after TeX and not to TeX itself.

Typst 0.13.1 has no font expansion, and its only protrusion is the limited overhang described in “Which Marks Hang”. One word repeated on differently stretched lines of a justified paragraph came out the same width on every line, so justification in that version moves the spaces and leaves the letters alone. Typst 0.14 added character-level justification as an opt-in parameter, and a document that uses it will not compile under 0.13.1.

This edition, set with Typst 0.15.1, opts in, within a hundredth of an em either way: a justified line may space its letters a little closer or wider as well as its words. That moves the letters apart without

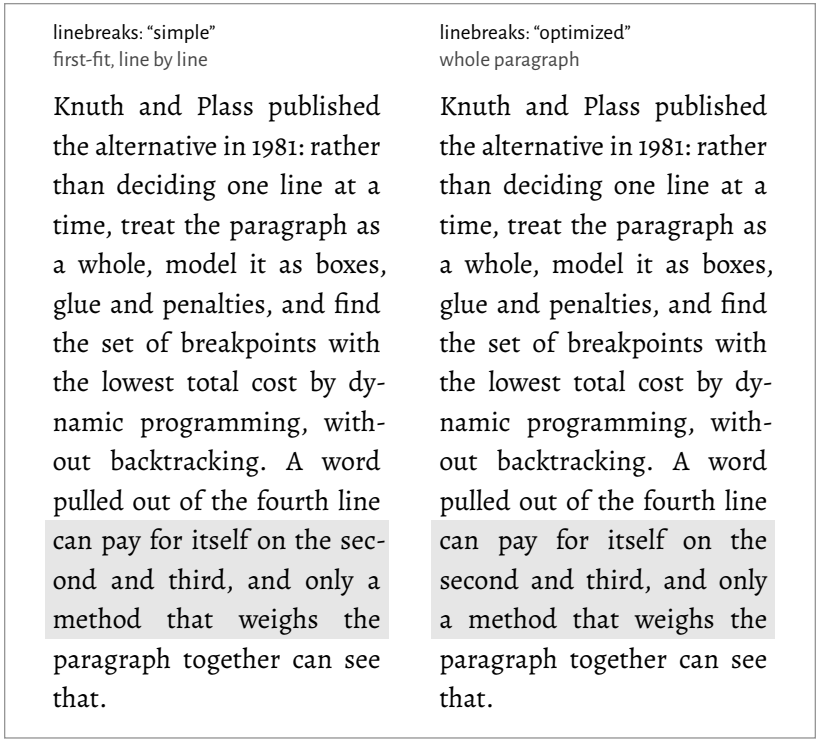


Figure 2: The same paragraph compiled twice in Typst, once with line breaking set to first-fit and once with the whole-paragraph pass, with the three lines whose content differs tinted. The words that move are the paragraph-level decision described in this section.

changing their width, so there is still nothing here like InDesign's glyph scaling. The two specimens in this essay are set without it, so what they show is line breaking alone.

Justify with a composer, or set it ragged

We would make two recommendations, each with its conditions. For continuous text in print, justify only where the tool can hyphenate and weigh the paragraph as a whole. Set the measure long enough

that the slack in any one line stays small: the one study that looked at line length found the cost in seven-word lines and not in lines averaging 12.

On the web and in word processors, and anywhere else the text is set without a paragraph-level composer, a ragged right edge is the safer setting. It gives up the straight margin and avoids the slower reading Trollip and Sales found with crude justification, at no measured cost in comprehension. It will not rescue a reader from fatigue or from abandoning the text, because none of the experiments we could reach reports either.

We would still close the gaps in a badly justified paragraph, for the look of the page and the standard of the trade, and we think that reason is enough without a physiological one.

NOTES

The Rivers Nobody Measured

Essay 1 · pages 11–17

11 justification only in short lines Gregory and Poulton 1970, Abstract: 86 participants; no difference for good readers; justified worse for poorer readers at seven-word lines, p at or below 0.02; no disadvantage at 12-word lines; explanation in terms of spacing irregularities. One study, read in abstract only; the full paper was not obtained. 86 participants in the first experiment and 32 of the poorer readers retested in the second. The bounds matter more than the result: the effect appears for weaker readers at a short measure and not otherwise. Evidence B: one credible study, or evidence with limits.

11 to 133, aiming at 100 Adobe 2026, Adjust word spacing: Minimum, Desired and Maximum, with defaults of 80, 100 and 133 per cent. Adobe's InDesign help, read on 16 September 2026. These are InDesign's defaults for a justified paragraph, not a standard of the trade; other programs set their own limits and most do not publish them. Evidence A: strong or direct evidence.

12 Typographers call them rivers That rivers are the stacking of wide word spaces, and that hyphenation, a longer measure and paragraph-level breaking are the remedies, is our argument from the way justification distributes slack. It is not a finding. No source in this registry measures what a river does to a reader. Evidence E: the journal's argument.

12 good typography tries to do J Simmons 2025, List of typographic goals, including avoiding rivers. WebKit's post of 8 April 2025 introducing the pretty value. It is cited only for the word and for the goal: no browser vendor claims to have measured a reader's response to a river. Evidence A: strong or direct evidence.

13 reach measures rivers at all Gregory and Poulton 1970, Abstract; Trollip and Sales 1986, Abstract (two studies); Akhmadeeva et al. 2016, Design and results; Veytsman and Akhmadeeva 2017, Methods and results. The four experiments we could reach on justified against unjustified setting. All four measure reading speed and comprehension; none measures rivers, eye fatigue or abandonment, and none compares paragraph-level line breaking with line-by-line breaking. Evidence B: one credible study, or evidence with limits.

13 did not differ in either Trollip and Sales 1986, Abstract: two studies; significant increase in reading time for fill-justified text; no differences in comprehension detected. One paper reporting two studies, read in abstract only. Fill justification here means space inserted between words, which is the crude case rather than what a paragraph-level composer produces. Evidence B: one credible study, or evidence with limits.

13 the TeX community add little Akhmadeeva et al. 2016, Design (texts A and B, justified or ragged) and results; Veytsman and Akhmadeeva 2017, Methods (20 post-stroke patients; justified against ragged right, unhyphenated) and results.

Two small studies from the TeX community, read in full. The second tested 20 post-stroke patients with immediate and 60-minute comprehension tests. Samples this size settle nothing on their own; they are reported because they point the same way as the older work. Evidence B: one credible study, or evidence with limits.

13 the start of the next Slattery and Parker 2019, Introduction on saccade targeting and return sweeps; discussion of preview benefit; Tinker 1963, Ch. 2, eye-movement records. Slattery and Parker report that return sweeps influence about 20 per cent of reading fixations and typically undershoot line-initial words, and that the resulting fixations give preview of those words. Neither they nor Tinker set a justified column against a ragged one. Evidence B: one credible study, or evidence with limits.

14 and no source takes it Slattery and Parker 2019, Introduction on saccade targeting. That uneven word spaces interfere with where the eye lands is our argument and an untested one. It is set down here so that no recommendation later in the essay leans on it. Evidence E: the journal's argument.

14 hyphenation on its Layout tab MDN browser-compat-data n.d., __compat.support for chrome, firefox and safari; Microsoft n.d., Hyphenate text automatically: Layout tab, Hyphenation, Automatic; also manual hyphenation. MDN's browser-compat-data, main branch, 16 September 2026, records the property in all three engines, with per-language dictionary differences. Microsoft's page is undated and describes the automatic and manual routes. Neither is on until a person or a stylesheet turns it on. Evidence A: strong or direct evidence.

14 on where the limits sit Microsoft n.d., Microsoft Support (Word): hyphenation controls; nothing on the page describing how a justified line is spaced. A negative result of searching rather than a specification. Microsoft documents the Justify control and hyphenation but publishes nothing we could find on how space is distributed inside a justified line, so the common description of word-processor justification stays a description of practice. A measured test, justifying a paragraph and comparing gaps and glyph widths across lines in the exported file, would settle it. Evidence C: professional practice or tradition.

14 and Plass published the alternative Crossref record for Knuth and Plass 1981, published-print 1981-11; volume 11, issue 11; abstract. Crossref's record for Knuth and Plass, Breaking paragraphs into lines, Software: Practice and Experience 11(11), November 1981. The abstract describes boxes, glue and penalties and the dynamic-programming search for optimum breakpoints. The page range usually given, 1119–1184, was not separately confirmed in the fields read. Evidence A: strong or direct evidence.

15 the default for justified text Typst n.d., Reference: par function, linebreaks parameter; variant table for simple (first-fit) and optimized (whole paragraph); Own test, 2026: Typst line breaking, research/R4b/typst/lb-simple.typ, lb-optimized.typ. Typst's reference, read on 16 September 2026, and a compilation of one paragraph under each setting in Typst 0.13.1: three lines differed in content, so the two modes are not aliases. Typst's documentation nowhere names Knuth and Plass. Evidence A: strong or direct evidence.

15 prevent a poor break later Adobe 2026, Adobe Paragraph Composer and Adobe Single-line Composer subsections. Adobe's InDesign help, read on 16 September 2026. The Paragraph Composer is described as the default and as evaluating all lines in a paragraph together. Adobe does not name an algorithm. Evidence A: strong or direct evidence.

15 within limits the user sets Adobe 2026, Opening description; Minimum, Desired and Maximum list; page updated 2 June 2026. Adobe's InDesign help, updated 2 June 2026. Glyph scaling is applied when a line is composed, and the Desired value of 100 per cent means a default document gets none of it. Evidence A: strong or direct evidence.

15 microtype package offers through LaTeX R Schlicht 2004, Package description: interface to character protrusion and font expansion; engine requirements for each. The documented source of the microtype package, read on 16 September 2026. The engine requirements are the package's own: protrusion in pdfTeX, LuaTeX or XeTeX, expansion in pdfTeX or LuaTeX. Evidence A: strong or direct evidence.

15 limited overhang described in Which Marks Hang Own test, 2026: Typst glyph scaling, research/R4b/typst/ov2-true.typ, jl.typ; Typst n.d., Entry adding opt-in character-level justification. Measured in Typst 0.13.1 in September 2026: one repeated word came out at 39.853 pt on every line of a justified paragraph, however wide the spaces around it. Compiling the 0.14 justification parameter under 0.13.1 fails outright. If the book is re-set on a later version, that parameter is opt-in and has to be switched on deliberately. Evidence A: strong or direct evidence.

15 as well as its words Typst n.d., Entry adding opt-in character-level justification; Typst n.d., Reference: par function, justification-limits parameter, tracking. This edition's template allows letter-spacing of a hundredth of an em either way in justified text and nothing else at the character level: the parameter sets the space between letters, not their width. Measured on the print edition with the book's own typesetting report in October 2026, lines whose word spaces averaged more than 3.64 pt fell from 175 to 24 of about 2,450 when it was switched on. Evidence A: strong or direct evidence.

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