APPLIED RESEARCH

SUMMARY

- Finds that x-height, line length, and line spacing in brochures, scientific journals, and novels do not reflect typographic guidelines
- Demonstrates that the boundaries for these typographic dimensions differ by genre

Typographic Dimensions and Conventional Wisdom: A Discrepancy?

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INTRODUCTION: TYPOGRAPHIC SPECIFICATIONS

When text is presented on paper, we need to consider how it should appear. Two sources can help us make these decisions: published guidelines about typography and trained visual judgment. It takes time and effort to train visual judgment, so it is easier to consult and follow guidelines for the specification of typographic dimensions. Adhering to these guidelines should, according to their authors, lead to legible and attractive documents. However, many document developers who have to make decisions about type specifications struggle to apply these seemingly simple guidelines. And what is worse, following these guidelines may lead to results that are disappointing both functionally and aesthetically.

The guidelines for type specifications seem to be based on a combination of experimental evidence and personal experience. Experimental legibility research goes back for more than a century (Spencer 1969). Reviews of the literature in legibility research have also been published by Foster (1971), Lund (1995), and Schriver (1997). Additionally, important comments about test materials, methods, measurements, participants, information content, context, and application can be found in several articles (for example, Lund 1995; Waller 1991).

As MacDonald Ross and Smith (1977) stated more than 20 years ago,

> *If we take legibility research at face value, . . . then we are bound to conclude that a great deal of useful work has been done, and what we need is more of the same. If, on the other hand, we take a critical look at the details of the experimental design, then maybe . . . much of the effort put into empirical testing has simply been wasted. (p. 42)*

The personal experience of expert typographers provides a second source for guidelines. Paul Rand stated that ". . . in matters of form the typographer must rely on intuition. How else does one select a typeface, decide on its size, linewidth, leading, and format?" (1993, p. 47). As Erik Spiekermann suggests, "The problem with all these measurements is that there aren't any real standards for type designers to follow. . . . What you see is what you get—trust your eyes, not the scientific measurements" (1993, p. 53). Students of graphic design are made aware of the guidelines, but first and foremost, they are taught to trust and follow their own visual judgments.

The development of guidelines seems to go round in circles, then. Typographic guidelines seem useful when decisions about type specifications need to be made. These guidelines try to combine the viewpoints of both empirical researchers and typographic experts. Unfortunately, the researchers and the typographic experts view each other's results with suspicion. The guidelines are therefore frequently an awkward compromise of experience and experimental results. The application of this compromise to a specific document is often difficult, and the subsequent results are frequently not as good as expected.

To achieve the best results, it is necessary to rely on personal visual judgments again. Guidelines based on these personal judgments have been regularly published to make decisions about typographic matters easier for others. The experimental results—which provide "the seal of scientific approval"—are cited again to support these personal judgments. A substantial list of publications cite these experimental results and the experience of practitioners.

There are currently two ways to escape this vicious circle. The first is a *heuristic* approach. This is a systematic, step-by-step process that considers all relevant decisions carefully and methodically. One essential and recurring

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step is the testing of a document through the involvement of people who are likely to read it. Examples of this approach are described by Black (1990); Wright, Lickorish, and Hull (1990); Hartley (1994); and Schriver (1997).

The second way to escape the vicious circle is very pragmatic and is based on the *habit hypothesis*. Several typographers, such as Eric Gill (1931), Dirk Wendt (1970), and Zuzana Licko (1990), have claimed that "we read best what we are used to." From this point of view, the emphasis shifts from the development of documents toward the reading of documents. The question is no longer "How can texts be made legible and attractive?" but "What are readers accustomed to?"

These two approaches might be the best advice that is available at the moment, but they are not very satisfactory. Adopting the heuristic approach would mean that every document development project has to start from scratch and assumes that generalizable knowledge about typography is available only from experts. In practice, only a limited number of projects can afford to involve an expert typographer in the document development process. It would be useful to know what other document developers would do when typographic decisions have to be made and there is no expert available. The results of the decisions of other document developers—who might have had expert advice—are visible in existing documents. Printed documents show the decisions that have been made before.

The pragmatic approach also points toward printed documents. Printed documents provide ample examples of what readers commonly see. For both these reasons, it seems worthwhile to have a look at the typographic specifications of existing documents.

This investigation set out to make an inventory of typographic specifications across three genres: brochures, scientific journals, and novels. Such an inventory shows which typographic dimensions are common and usual, and which dimensions are exceptional. This inventory was used to generalize about whether documents in these genres conform to or violate guidelines for the typographic presentation of continuous text. This inventory could be used in the future as a benchmark for the development of test materials for legibility studies and as comparative material to discuss expert opinions and visual judgments.

SOME PROBLEMS IN MEASURING TYPOGRAPHIC DIMENSIONS OF PRINTED TEXTS

The first issue that I needed to tackle was to choose the typographic dimensions to be measured. The literature about typography states that type size, line length, and line spacing are the three main variables for the specification of continuous text. It is frequently emphasized that the interactions among these three variables are vital. This study looks specifically at these three dimensions and their relations. Other variables that might influence the design of text—such as the information content, language, type design, layout, reproduction technique, reading circumstances, and reader characteristics—were not investigated in this study.

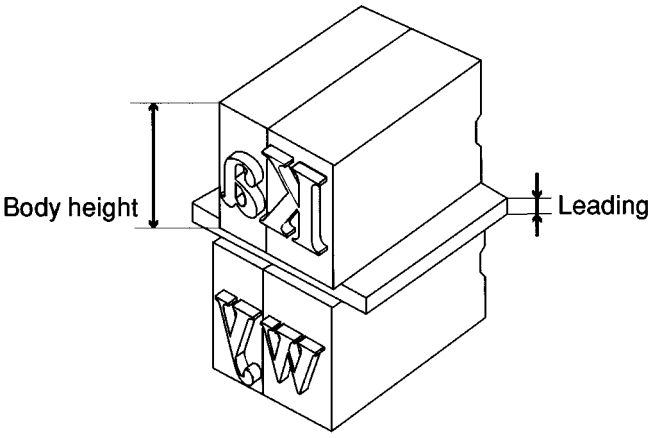

Figure 1. The body height and leading of metal type can be easily measured.

Measuring type is not a straightforward activity. The traditional dimensions (body height and leading) and the measurement unit (typographic points) are not very practical when the actual dimensions of text need to be established. It is necessary to go back to metal type technology to show that these dimensions and units are not suitable for this study (see Black 1990, p. 91).

To create metal type, each character is cast on a bit of lead, and it is easy to measure the height. For example, "eight point type" is a clear instruction for a typesetter about the size to be used (see Figure 1). Furthermore, the distance between two consecutive lines of text set in metal type is determined by the thickness of a strip of lead. "Two point leading" indicates that the typesetter has to put a strip of lead with a thickness of two points between lines. After text is printed, however, it is very difficult to determine the original dimensions: neither the body height nor the leading leaves a visible trace.

Today, type is described digitally, but many of the typographic conventions of metal type have remained:

- The vertical dimensions are still called *body height* and *leading*, although these terms refer to virtual dimensions only. Alternative terms, such as *capital height*, *kp-height*, *linefeed*, *interlinear space*, and *vertical space* are also commonly used to indicate the vertical dimensions of type.
- There are currently four different typographic measurement units: Pica points, Didot points, DTP

Figure 2. The size of characters with identical body heights can vary because type designers do not use a uniform amount of white space above and below characters. There is therefore no general relationship between body height and the dimension of a printed character.

Figure 3. x-height and line spacing can be used to measure typographic dimensions in printed documents.

points (related to inches), and millimeters. Although the differences between these point measurement systems are relatively insignificant, the differences are more substantial when longer texts are measured.

- Designers of typefaces determine the white space around a character. Some type designers prefer to make characters as large as possible by reducing the amount of white space above and below a character. Others prefer ample white space. That is why different typefaces in identical point sizes do not appear to be the same visual size (see Figure 2).

These three issues—inaccurate terminology, different units of measurement, and personal preferences—make measuring type more difficult than it might appear to be.

Two alternative dimensions can be used to measure type (see Figure 3). The first dimension is the height of the lowercase characters: the *x-height*. This dimension determines how large a reader perceives characters to be. The x-height can be used to determine the type size of text in printed documents after the document has been printed.

The second dimension that can be measured after a text is printed is the distance from one baseline to the next. Most software programs use this dimension, but they erroneously and confusingly refer to it as *leading*. I prefer the term *line spacing* because it implies a measurement of the space between lines of text. Line spacing is an appropriate term in the production of digital texts, and it can be applied to presentations on screens as well as to those on paper.

THE CHOICE OF TEST MATERIALS AND MEASURES

After choosing typographic dimensions to measure, I had to select a sample of documents. I had two options:

- Ask typographic experts to choose a number of texts that they consider to be designed in accordance with their professional standards for typography.
- Randomly collect a number of actual documents.

The choice of selection methods could possibly influence the results because there might be a discrepancy between professional opinions and the practical reality. However, because the extent of this difference is unknown, it is therefore possible to start with either selection method. I chose to collect and measure actual documents. My reason was that readers come into contact with documents that are not necessarily designed according to professional standards. In a future study, I plan to compare the results of this inventory of randomly selected documents with the opinions of typographic experts.

I measured the x-height, line spacing, and line length in 114 scientific journals, 110 novels, and 106 A5-size brochures (210 x 148.5 mm; 8.25″ x 5.75″).

- The scientific journals were selected randomly from a collection of about 2,700 journals in a British university library.
- The novels selected represented 43 percent of all first editions of novels published in 1994 in the Dutch language in the Netherlands.
- The brochures were also printed in Dutch and were freely available without cost in public places like post offices, libraries, and waiting rooms.

I took all measures—x-height, line spacing, and line length—in millimeters. I calculated the number of characters in a line by averaging the character count of five consecutive lines of text in a randomly selected single paragraph.

RESULTS

First, I will present the results of the x-height and line spacing measurements. Then I will compare these measurements with the typographic guidelines. Next, I will present the results of the line length measurements and compare these with the guidelines. Finally, I will present the relationships between line length and line spacing, and between x-height and line length.

x-height

The typographic guidelines suggest a range of typesizes that should be used for the specification of continuous texts.

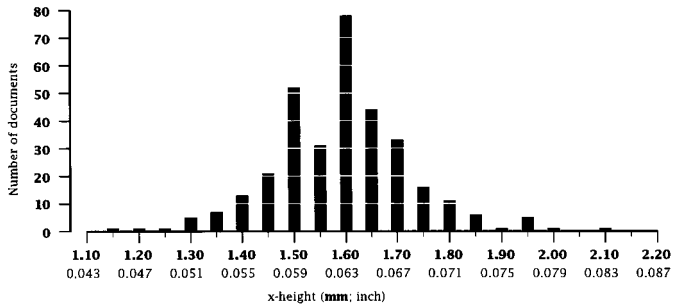

Figure 4. The x-height of 330 documents. There is a clear range of x-heights in continuous texts.

- According to Black, Stiff, and Waller, "Research shows that type sizes between 9 and 11 point are most comfortable for sustained reading" (1992, p. 14).
- Erik Spiekermann states that "Type for extended reading shouldn't be smaller than 9 points, and not larger than 14 points" (1993, p. 135).
- Pedersen and Kidmose say, "For large texts, we suggest a typesize of 8–12 pt" (1993, p. 94).

Figure 4 shows the x-heights of the documents measured in this study. The mean x-height of continuous text in the three types of documents is identical: 1.60 millimeters (0.063 inches) (N = 330; SD = 0.15). Ninety-five percent of all x-heights fell between 1.30 and 1.90 mm (0.05″ and 0.08″). This x-height is independent of the typeface or the typographic point (Didot, pica, or DTP point) the document's creator selected. The variation of the x-height in scientific journals ranges from 1.35 to 1.80 mm (0.05″ and 0.07″), in novels from 1.30 mm to 1.95 mm (0.05″ and 0.08″), and in brochures from 1.15 to 2.10 mm (0.04″ and 0.83″).

These results are very similar to the results of the inventory made by DeMarco and Massof in 1997. They measured the x-height in 100 American newspapers. Although they focused mainly on non-continuous texts—such as the stock exchange listings, obituaries, and cartoon captions—their maximum range of x-heights varied between 1.00 mm (0.04″) and 2.39 mm (0.09″). The dimensions of the x-height of the text used in front page articles, which is comparable to the continuous text studied here, varied between 1.49 mm (0.06″) and 1.90 mm (0.07″).

There seems to be a limited range between which the x-heights of continuous texts in three different genres are set. It also appears that there is a preference to make the x-height of continuous texts 1.60 mm (0.063″) plus or minus 0.30 mm (0.012″). This result indicates the most common vertical dimension of type. Whether this range is optimal or desired can only be investigated through user-tests or interviews with typographic experts.

The discussion of whether these results conform to or violate the published guidelines follows the next section.

Line spacing

The guidelines about the use of line spacing are often related to the typesize. The following guidelines are examples:

- "A leading between 2–4 pt. in reading matter for 10–12 points typesizes will probably lead to an optimum result" (Pedersen and Kidmose 1993, p. 83).
- "If you increase the type size, for example, you might also have to increase the space between lines to maintain legibility" (Black, Stiff, and Waller 1992, p. 13).

The general rule seems to be that it is usually necessary to add space between lines of text and that the larger the type, the greater the line spacing required.

I found a large variation in line spacing in the 330 documents. The line spacing in scientific journals varied between 3.70 and 4.65 mm (0.15″ and 0.18″), in novels between 3.85 and 5.30 mm (0.15″ and 0.21″), and in brochures between 3.00 and 9.90 mm (0.12″ and 0.39″).

A second finding is that the line spacing of the texts is strongly related to the different point systems. Of the 330 documents, 280 (85%) have line spacing that is a multiple of half of a typographic point. Ninety-two documents used DTP-points, 80 documents used pica points, and 78 used Didot points. The line spacing in 30 documents could have been specified in more than one point system. This result provides a strong indication that at least three different point systems are still in use.

However, these results do not mean much if they are not related to the x-heights. The strength of the relationship between x-height and line spacing is indicated by a correlation coefficient. A perfect correlation—that is, an example in which the x-height and line spacing increase at the same rate—would be 1. The correlation coefficient of scientific journals, novels, and brochures is, respectively, 0.42, 0.42, and 0.30. These correlation coefficients indicate that only a weak and insignificant relationship exists between x-height and line spacing in the documents studied.

A second indication that typographic guidelines and practical documents differ is that the line spacing for type with the same x-height varies considerably. In scientific journals, type with an x-height of 1.60 mm (0.06″) has a line spacing between 3.70 and 4.75 mm (0.15″ and 0.19″). In novels, the line spacing for type with an x-height of 1.60 mm (0.06″) varies between 3.95 and 5.10 mm (0.16″ and 0.20″). The variation in brochures is even larger: between 3.55 and 7.10 mm (0.14″ and 0.28″) line spacing for type with an x-height of 1.60 mm (0.06″). These results indicate that a specific x-height is not related to a specific line spacing in actual documents.

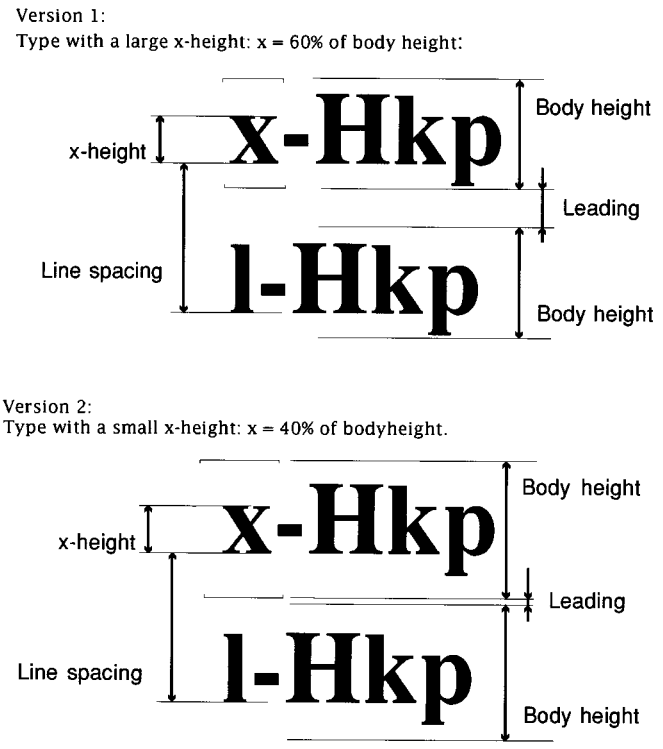

Figure 5. Actual dimensions of x-height and line spacing cannot be related to a specific body height and leading. The x-height and line spacing of version 1 and version 2 are identical, but these can relate to a large difference in body height and leading.

Larger type is not separated by more line spacing in the documents selected for this study.

Unfortunately, it is not possible to relate the actual measures of x-height and line spacing of text to the original point sizes in which a text was specified. The following example illustrates that measured dimensions could have been specified in a wide range of point sizes.

Figure 5 shows two versions of a text with identical x-heights and identical line spacing. To compare the x-height with a body height, it is necessary to guess how much space would have been specified by the type designer above and below the characters (see Figure 2). In version 1, the x-height occupies 60 percent of the body height, and in version 2, 40 percent of the body height. Both percentages are equally likely to occur. The amount of leading that is added is the remaining space between the body heights. The amount of leading in version 1 is substantial, whereas in version 2, it is very small.

This variation can be further illustrated by calculating the possible body heights and leadings for a specific dimension. I took the most frequently appearing x-height in my study, 1.60 mm (0.06″), as an example. The body height of this x-height is 2.67 mm (0.105″) if the x-height is 60 percent of the body height. The body height is 4.00 mm (0.157″) if this x-height is 40 percent of the body height. The most common line spacing is 4.25 mm (0.167″). The remaining leading in version 1 is 1.58 mm (4.25 mm [0.167″] minus 2.67 mm [0.105″]). The resulting leading in version 2 is 0.25 mm (4.25 mm [0.167″] minus 4.00 mm [0.157″]). Table 1 shows the variation when these specific measures are transposed into 3 different typographic points.

Table 1 shows that type with an x-height of 1.60 mm (0.06″) and a line spacing of 4.25 mm (0.167″) could have a body height between 7.1 points (Didot) and 11.4 points (pica). The leading could have been specified between 0.7 points (Didot) and 4.5 points (pica). This variation is clearly very large, especially when all intermediate point sizes can occur as well. This example shows how difficult it is to establish whether the investigated texts follow typographic guidelines.

It might be the case that the range of 1.30 mm to 1.90 mm for the x-height is similar to the range of 8–14 points body height. The line spacing might include a certain amount of leading, but it is not possible to measure and calculate this. The use of body height and leading as typographic measures prevents a comparison between the printed texts and the published guidelines. Whether the investigated documents adhere to the guidelines for typesize and leading therefore remains unknown. However, my study shows that the use of x-height and line spacing as measures makes it possible to establish and compare the vertical dimensions of different texts in different genres.

Line length

The literature frequently states that the optimal length of a line of type is about 10 to 12 words.

- An "ideal line length is about 66 characters, but anything between 45 to 70 characters is satisfactory" (Bringhurst 1996, p. 26).
- "Text set too wide can be difficult to read" (Linotype 1988, p. 10).
- Spiekermann and Ginger provide a motivation: "Lines should be long enough to get a complete thought into them" (1993, p. 119).

The line length is obviously influenced by paper size and number of columns. The scientific journals and brochures I examined use both single-column and double-column layouts. The single-column scientific journals have a line length between 71 characters (110 mm; 4.33″) and 100 characters (155 mm; 6.10″). Most double-column brochures have a line length between 26 characters (39 mm; 1.54″) and 55 characters (65 mm; 2.56″). All novels in the sample use a single column layout. Their line length varies between 46 to 75 characters (85 to 110 mm; 3.35″ to 4.33″).

TABLE 1: VARIATION IN POINT SIZES FOR TYPE WITH AN X-HEIGHT OF 1.60 MM (0.06″) AND A LINE SPACING OF 4.25 MM (0.167″)

		Didot Points 0.376 mm (0.015″)	Pica Points 0.351 mm (0.014″)	DTP Points 0.353 mm (1/72″)
Version 1:				
Body height	2.67 mm	7.1 pt	7.6 pt	7.6 pt
Leading	1.58 mm	4.2 pt	4.5 pt	4.5 pt
Version 2:				
Body height	4.00 mm	10.6 pt	11.4 pt	11.3 pt
Leading	0.25 mm	0.7 pt	0.7 pt	0.7 pt

Only the line length in novels corresponds to the above-mentioned published guidelines. Surprisingly, the optimal line length of 66 characters was found in only 6 out of 330 documents (5 novels, 1 brochure). The results of this study indicate that both single-column scientific journals (too long) and double-column brochures (too short) violate typographic guidelines. Whether this violation has any influence on the legibility or on readers' aesthetic appreciation of these texts remains to be investigated.

The relationship between line length and line spacing

The typographic guidelines state that if the line length increases, the linespace should increase as well. For example, Paul Luna suggests that "In wider columns, line spacing needs to be increased, to help the eye return easily to the start of the following line" (1992, p. 48).

Figure 6 shows a scatter plots of the relationship between line length and line spacing in 114 scientific journals and 110 novels. The single-column and double-column layouts of scientific journals are visible: there are two clusters of dots on the left-hand side of the scatterplot. The top cluster has the longest line lengths and represents the single-column journals. The lower cluster has shorter line lengths and shows the double-column journals. If the line length and the line spacing increased at the same rate, then the points in Figure 6 would be arranged around three diagonal lines: one for single-column journals, one for double-column journals, and one for novels. These lines would indicate that the line spacing and the line length increased simultaneously. The lack of this pattern indicates that the scientific journals and novels I studied do not follow the guidelines.

The correlation coefficient for the single-column journals is 0.34, and 0.36 for the double-column journals. The correlation coefficient for novels is -0.25. The correlation coefficient for brochures is 0.42. Because the perfect correlation would be 1, the results do not indicate a strong relationship between line length and line spacing. In fact, the correlation coefficient in the novels is negative (-0.25), showing that as the line length increases, the line spacing decreases. This finding is in stark contrast to most published guidelines.

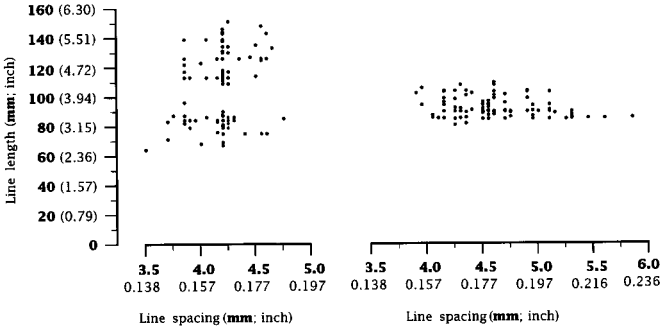

Figure 6. The relationship between line length and line spacing in 114 scientific journals (left) and 110 novels (right). The line spacing does not increase when the line length increases.

The relationship between x-height and line length

Figure 7 shows a scatter plot of the relationship between x-height and line length in 110 novels. The scatterplot should form a diagonal line if the results support the existence of a relationship between x-height and line length. The correlation coefficients of the x-height and line length in these 110 novels is 0.20. The coefficients for scientific journals and brochures are 0.04 and 0.21, respectively. Therefore, the findings do not support the conventional assumption that there is a linear relationship between x-height and line length.

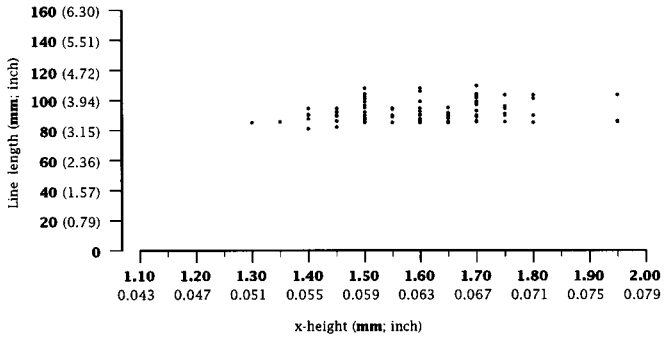

Figure 7. The relationship between x-height and line length in 110 novels. The line length does not consistently increase when the x-height increases.

The variation in line length for type with the same x-height is large. For example, type with an x-height of 1.60 mm (0.06″) was set on a line length ranging from 62.0 to 147.0 mm (2.44″ to 5.79″). Thus, a specific x-height does not correlate to a specific line length.

CONCLUSIONS

This inventory of the typographic dimensions of 330 documents shows that there is no relationship between the following pairs of variables:

- x-height and line spacing
- line spacing and line length
- x-height and line length

The typographic dimensions of the texts in this study do not reflect published typographic guidelines. There is one exception: in general, the line length in novels did conform to the range that is suggested in the guidelines. However, the optimal value of 66 characters per line was found in only five novels.

There seem to be distinct boundaries within which document developers of scientific journals, novels, and brochures specify x-height, linespace, and line length. There are also clear "peaks" in the data that indicate preferences for specific dimensions. They vary according to genre but are fairly consistent within genres. Decisions about typographic dimensions are not based solely on personal judgment, but must be partly related to knowledge about how a text is supposed to look. It is likely that document developers apply, probably unconsciously, some sort of typographic standards related to genres when they design particular types of documents. This variation is not reflected in the published typographic guidelines, however.

DISCUSSION

This inventory shows that documents in three genres do not reflect the typographic guidelines. This result should be interpreted carefully because it might show only a part of the picture. There is a possibility that these findings resulted from a sample of poorly designed documents. If that is the case, then the poor correlations are not surprising. However, the results of this study provide an indication of the variety of typographic dimensions that readers actually see when they read scientific journals, brochures, and novels. The results also provide an overview of the dimensions that document developers find suitable for these three genres.

The next step on the reader's side of the documents might investigate whether these dimensions are optimal for the extraction of information from texts. There is some evidence that readers pay attention to typography and genres (Schriver 1997), and the results of this study could help in the development of test materials that are related to current standards.

The subsequent step on the development side is to find out whether there is such a thing as a professional standard of expert typographers. A comparison of the standards employed in actual documents and the opinions of experienced typographic practitioners might reveal a discrepancy. Further investigations would reveal whether the professional standards fall within or outside the actual ranges used in typical publications.

Another intriguing result of this study was that the peaks and ranges differ from the suggested optimal values and limits that are suggested in the literature. For example, I found that there seem to be limits in the line lengths of double-column layouts in scientific journals and brochures, but most guidelines do not allow for this possibility. It can be argued that according to the guidelines, these double-column layouts are probably not optimally legible and attractive. However, the documents studied here show that layouts that violate guidelines are quite common. Further investigation might reveal that legibility and attractiveness are not the criteria that are most often used in practice. Other criteria—such as cost, standardization, or production deadlines—might be more influential on typographic decisions about x-height, line spacing, and line length.

This investigation shows that existing typographic guidelines should be treated with some skepticism. The ultimate aim of typographic guidelines is to help produce texts that will optimally support readers. It seems unlikely that the range of genres could be covered in a small number of rigid guidelines. It might be possible to make typographic guidelines more reliable by relating them to the different types of reading behaviors, genres, and contexts. T**C**

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REFERENCES

Black, A. 1990. *Typefaces for desktop publishing: A user guide.* London, UK: Architecture, Design and Technology Press.

Black, A., P. Stiff, and R. Waller. 1992. *Designing business documents.* Redhill, Surrey, UK: Monotype Typography Ltd.

Bringhurst, R. 1996. *The elements of typographic style.* 2nd ed. Point Roberts, UK: Hartley & Marks.

DeMarco, L. M., and R. W. Massof. 1997. "Distribution of print sizes in U.S. newspapers." *Journal of visual impairment and blindness* 91, no.1:9–13.

Foster, J., ed. 1971. *Legibility research abstracts.* London, UK: Lund Humphries.

Gill, E. 1931. *An essay on typography.* London: Sheed & Ward.

Hartley, J. 1994. *Designing instructional texts.* 3rd ed. London, UK: Kogan Page.

Licko, Z. 1990. "Typeface designs." *Émigré* 15:8–13.

Linotype, 1988. *The pleasures of design.* Cheltenham, Gloucestershire, UK: Linotype Ltd.

Luna, P. 1992. *Understanding type for desktop publishing.* London, UK: Blueprint.

Lund, O. 1995. "In Black and white: An R&D report on typography and legibility." *Information design journal* 8, no. 1: 91–95.

Macdonald-Ross, M., and E. Smith. 1977. *Graphics in text: A bibliography.* IET monograph no. 6. Milton Keynes, UK: Institute of Educational Technology, the Open University.

Pedersen, K., and A. Kidmose. 1993. *[In black and white].* Copenhagen, Denmark: The Graphic College of Denmark.

Rand, P. 1993. *Design form and chaos.* New Haven, CT: Yale University Press.

Schriver, K. 1997. *Dynamics in document design. Creating texts for readers.* New York, NY: John Wiley & Sons.

Spiekermann, E., and E. M. Ginger. 1993. *Stop stealing sheep and find out how type works.* Indianapolis, IN: Adobe Press.

Spencer, H. 1969. *The visible word: Problems of legibility.* London, UK: Lund Humphries.

Waller, R. 1991. "Typography and discourse." In *Handbook of reading research,* edited by R. Barr, M. L. Kamil, P.B. Mosenthal, and P. D. Pearson. New York, NY: Longman, vol. 2, pp. 341–380.

Wendt, D. 1970. "By what criteria are we to judge legibility?" In *Typographic opportunities in the computer age* (Papers of the 11th Congress of the Association Typographique Internationale, 1969). Prague, Czech Republic: Association Typographique Internationale, pp. 42–46.

Wright, P., A. Lickorish, and A. Hull. 1990. "The importance of iterative procedures in the design of location maps for the built environment." *Information design journal* 6, no. 1:67–78.