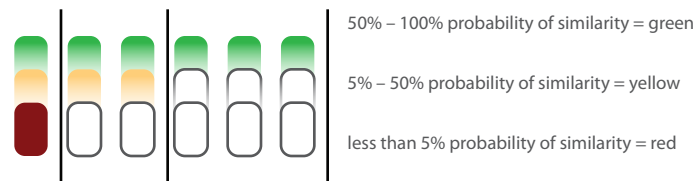


visualization logic



six boxes filled in proportion to show inter-hospital similarities
 six boxes need to show probability over/under 50%
 six boxes can be rapidly enumerated (in about 1 second)

A Statistical Approach for Visualizing the Quality of Multi-Hospital Data

Connolly et. al.

Visible Language

Visible Language

education theory

the journal of visual communication research

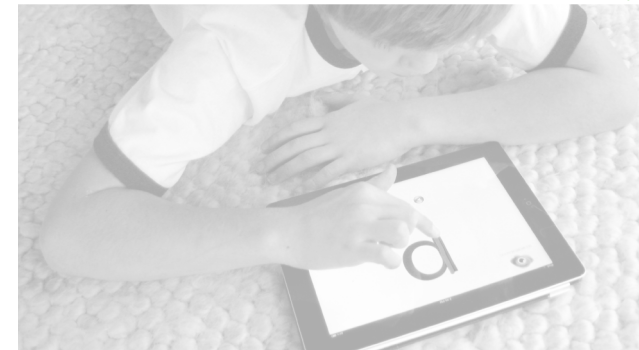
design principle



interaction
usability

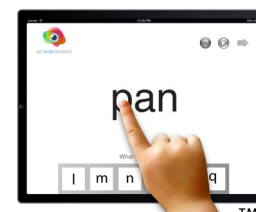
drill
listen to sound
tactile

responsive



universality
visibility

memorability



drag&drop

mnemonics

first-sound

Linking Design Principles with Educational Research Theories to Teach Sound to Symbol Reading Correspondence with Multisensory Typea

Seward et. al.



narrative

individualized
evaluation

Visible Language

the journal of visual communication research

48—3

November 2014

ADVISORY BOARD

Naomi Baron – *The American University, Washington, D.C.*

Michael Bierut – *Pentagram, New York, NY*

Matthew Carter – *Carter & Cone Type, Cambridge, MA*

Keith Crutcher – *Cincinnati, OH*

Mary Dyson – *University of Reading, UK*

Jorge Frascara – *University of Alberta, Canada / Universidad de las Americas Puebla*

Ken Friedman – *Swinburne University of Technology, Melbourne, Australia*

Michael Golec – *School of the Chicago Art Institute, Chicago, IL*

Judith Gregory – *University of California-Irvine, Irvine, CA*

Kevin Larson – *Microsoft Advanced Reading Technologies*

Aaron Marcus – *Aaron Marcus & Associates, Berkeley, CA*

Per Mollerup – *Swinburne University of Technology, Melbourne, Australia*

Tom Ockerse – *Rhode Island School of Design, Providence, RI*

Sharon Poggenpohl – *Estes Park, CO*

Michael Renner – *The Basel School of Design – Visual Communication Institute,
Academy of Art and Design, HGK FHNW*

Stan Ruecker – *IIT, Chicago, IL*

Katie Salen – *DePaul University, Chicago, IL*

Peter Storkerson – *Champaign, IL*

Karl van der Waarde – *Avans University, Breda, The Netherlands*

Mike Zender – *University of Cincinnati, Cincinnati, OH*

Visible Language

1

Visual Improvisation: Cognition, Materiality, and Postlinguistic Visual Poetry

Mike Borkent

04 — 27

2

Typographic Features of Text: Outcomes from Research and Practice

Maria dos Santos Lonsdale

28 — 67

3

A Statistical Approach for Visualizing the Quality of Multi-Hospital Data

Brian Connolly, Robert Faist, Constance West, Katherine D. Holland,
Pawel Matykiewicz, Tracy A. Glauser, and John Pestian¹

68 — 85

4

Linking Design Principles with Educational Research Theories
to Teach Sound to Symbol Reading Correspondence with Multisensory Type

Renee Seward, Beth O'Brien, Allison D. Breit-Smith, Ben Meyer

86 — 108

Book Reviews:

Design for information, an introduction to the histories, theories,
and best practices behind effective information visualizations.

reviewed by Jorge Frascara

Isotype: Design and contexts 1925-1971

reviewed by Per Møllerup

The Case for Mental Imagery

reviewed by Mike Zender

109 — 127

research

Hoplite

The ancient Greek warrior

If one thinks of Classical Greek warfare the image of the hoplite comes instantly to mind. The hoplite was an iconic figure in Greek culture, who dominated in art, literature, political discourse and historical writing. The historical evidence suggests that the hoplite appeared sometime in the seventh-century, and would dominate the Greek world until the Peloponnesian War.

To some extent, the hoplite reflected a distinct socio-political structure in Greece. This development in infantry was based upon a new class of landowning farmers who could afford to arm themselves and defend their land. There is debate concerning the actual social status of the average hoplite. This debate is significant, since the social status, and therefore wealth, of the hoplite has an impact on the equipment he would fight with, and thus how he would fight.

Hans van Wees notes that the traditional perspective on the archaic hoplite as being a middle-class farmer protected by heavy bronze armour does not provide the whole truth (and this is certainly the case for later hoplite forces, who were much lighter). Hans van Wees concludes that, whilst landowning men of leisure did make up some of the hoplite force, many of the soldiers were working-class farmers.

The significance of this is that whilst the wealthy landowner could afford the entire panoply of bronze armour, many of the hoplites would simply wear a cloth cuirass and felt pilos. In fact, in terms of uniform and equipment it appears that a hoplite force would not have presented a homogeneous group. The only exception to this was the shield, which seems to have been the same for every warrior.

Nonetheless, whether they were middle-class or working-class farmers, the fact that hoplites were tied to agricultural land did mean that they tended to have distinct competing seasons. As noted, over time the hoplite became an increasingly lighter form of infantry. For example, J. K. Anderson claims that by 400 BC

practice

Hoplite

The ancient Greek warrior

If one thinks of Classical Greek warfare the image of the hoplite comes instantly to mind. The hoplite was an iconic figure in Greek culture, who dominated in art, literature, political discourse and historical writing. The historical evidence suggests that the hoplite appeared sometime in the seventh-century, and would dominate the Greek world until the Peloponnesian War.

To some extent, the hoplite reflected a distinct socio-political structure in Greece. This development in infantry was based upon a new class of landowning farmers who could afford to arm themselves and defend their land. There is debate concerning the actual social status of the average hoplite. This debate is significant, since the social status, and therefore wealth, of the hoplite has an impact on the equipment he would fight with, and thus how he would fight.

Hans van Wees notes that the traditional perspective on the archaic hoplite as being a middle-class farmer protected by heavy bronze armour does not provide the whole truth (and this is certainly the case for later hoplite forces, who were much lighter). Hans van Wees concludes that, whilst landowning men of leisure did make up some of the hoplite force, many of the soldiers were working-class farmers.

The significance of this is that whilst the wealthy landowner could afford the entire panoply of bronze armour, many of the hoplites would simply wear a cloth cuirass and felt pilos. In fact, in terms of uniform and equipment it appears that a hoplite force would not have presented a homogeneous group. The only exception to this was the shield, which seems to have been the same for every warrior.

Nonetheless, whether they were middle-class or working-class farmers, the fact that hoplites were tied to agricultural land did mean that they tended to have distinct competing seasons. As noted, over time the hoplite became an increasingly lighter form of infantry. For example, J. K. Anderson claims that by 400 BC the hoplite had dispensed with his heavy armour and bronze Corinthian helmet, and subsequently relied for protection on his shield and the 'pile' (a felt cap). Anderson claims that these changes reflected the need for greater mobility, which was to deal

● Paragraphs denoted by one line space (no indent) are significantly superior than paragraphs denoted only by a new line, but not superior than paragraphs denoted by a new line with an indent.

[Hartley et al, 1978]

Readers favour paragraphs denoted by indentation and additional line space.

[Schriver , 1997]

● The first paragraph in an article, chapter, or advertisement should have no indent.

[Simon, 1945; Tschold, 1967; Carter et. al, 1993]

● In books, magazines and newspapers, paragraphs should be denoted with a moderate indentation of one to three ems, or separated by one line space.

[Har tley and Burnhill , 1977a; Rehe, 1979; Bringhurst, 1992; Ca rter et al, 1993;Ha rtley, 1994]

Paragraphs separated by one line space should be avoided when text is composed mainly of short paragraphs.

[Carter et al, 1993]

Typographic Features of Text: Outcomes from Research and Practice



Maria dos Santos Lonsdale

A B S T R A C T :

This paper presents a comprehensive review of literature on the legibility of printed text in order to provide informed guidance on the design and preparation of typographic materials. To this end, experimental findings are taken into account, as well as the perspective of typographers, graphic designers, and authors. First, the typographic features of text are reviewed and illustrated individually to identify all the features that specifically characterise text layouts. It is emphasized, however, that the various typographic features should be selected in relation to each other, and that it is the combination and manipulation of all these typographic features as a group that makes the text legible. Studies are then reviewed and illustrated on the typographic structure of text as a whole. This information will prove useful to anyone involved in the development of typographic materials, including typographic and graphic designers, teachers and students.

.....
KEY WORDS :

typographic features of text, text structure, legibility, typography, reading performance

1. INTRODUCTION

A comprehensive review of studies on the legibility of text is extremely useful to practitioners, researchers, and scholars, particularly when users' reading performance is the primary concern. A literature review of this nature will confirm (or dismiss) many established conventions regarding the typographic design of text. It will also help practitioners to make educated choices and produce user-orientated design outcomes. Moreover, it will give practitioners solid evidence to justify their design decisions.

Therefore, the purpose of the present paper is to draw attention specifically to the legibility of printed text. Legibility is here interpreted as the speed and accuracy with which text on a page can be read. This interpretation is in agreement with Pyke's (1926) own definition, as well as Zachrisson (1965, 36) and Reynolds' (1978, 197) opinions.

It has been argued that many typographic practices impair rather than help legibility. For example, Hartley and Burnhill (1976) have analysed and pointed out several poor typographical practices.

Amongst these are: the centring of headings and other textual components; the practice of changing arbitrarily the internal spacing of the material in order to force the text to fill out a fixed width and depth ("justification"); inconsistency in the sequencing and the grouping of parts; excessive use of indentation in texts which do not consist simply of pages of information arranged in paragraph form; and excessive variety of sizes, styles and weights of typeface chosen to code heading levels. (Hartley and Burnhill, 1976, 100)

They go even further by arguing that these practices could "justifiably be termed "illiterate" for, clearly, parts of a text are not mere objects of varying shapes and sizes to be arranged like ornaments on a mantelshelf or pictures on a wall." (1976, 100). After illustrating these poor typographic practices through examples of *British Psychological Society Publications*, Hartley and Burnhill (1976) propose that fundamental re-thinking is required. This observation, therefore, leads to the hypothesis that the speed and accuracy of reading text may be affected by various typographic features (from the typeface used to the treatment of paragraphs, etc.).

Unfortunately, there are only a few studies on the structure and articulation of information on the page as a whole, i.e. studies that test the effects of combined typographic features on reading. For this reason, this paper starts by reviewing the typographic features of text individually. Referring to each typographic feature individually allows us to identify all of the features that specifically characterise text layouts and which one may have a bigger effect on performance. The few studies on the typographic structure of text as a whole are then reviewed.

This review also takes into account experimental findings as well as the perspective of typographers, graphic designers,

and other authors. Scientific approaches do not always reach the same conclusions as the views of practitioners and other authors. However, for a well-founded review, it makes sense to link scientific research and practice (Lupton, 2004; Hartley et al, 2006; Lonsdale *et al*, 2006; Lonsdale 2006; Beier, 2012; Dyson, 2013; Beier and Dyson, 2014). In the first instance, this allows us to identify the level of agreement between scientific studies and practice. In the second, we can identify how one approach can be used to inform and complement the other. For example, typographic practice can inform the selection and design of the experimental material. Moreover, in those situations where scientific studies are unable to give clear answers, typographic practice can help in deciding how typographic features can be manipulated to produce legible typographic materials.

2. STRUCTURE OF THE PAPER

The present literature review is limited to what is considered relevant and useful to the typographic structure of reading text in common real-life situations. With this aim in mind, this review includes research and opinions considering those design choices that might cause or prevent an unwanted effect on readers. Regarding experimental findings, this review includes studies:

- having adults as participants who regularly read books, articles, technical manuals, etc.;
- testing printed documents with a sufficient number of words to represent standard reading documents such as passages, articles, etc.;
- placing the material to be read at ordinary distances of approximately 300-350mm from the eyes;
- measuring legibility by the speed and/or accuracy of reading, as well as the readers' preference judgements.

Exceptions to this are mentioned throughout the review. However, studies related to people with impaired vision, studies focusing on writing rather than reading, and on-screen legibility studies are excluded as they have no direct relevance to this literature review.

As for the grouping of research findings and opinions according to the typographic features of text, different approaches have been taken thus far (e.g. Zachrisson, 1965; Reynolds, 1978; Wijnholds, 1997; Hartley, 2004). For the purpose of this paper, Twyman's model of verbal graphic language (Twyman, 1982, 11-6) will be followed. Twyman presents a clearly structured model with a theoretical explanation, where a distinction is made between intrinsic and extrinsic features. Intrinsic features are described as those that reside in the characters themselves and, more particularly, in the system that produces those characters (for example, manuscript as opposed to typeset). Examples of intrinsic features are size and style of letterforms, including the use of italic, bold, and small capitals

(i.e. capital letters of a typeface in smaller size that are redrawn to match the x-height and weight of lowercase letters). Extrinsic features relate to what can be done to those characters or sets of characters by changing their colour, controlling the space between them, or changing their configuration. Tyman further distinguishes spatial features at the micro level – in relation to intercharacter space, interword space or the position of subscripts and superscripts – and also at the macro level – in relation to the spacing of larger units of text.

This approach is used to group and discuss the literature on the typographic features of text in Sections 3 and 4. The combination and manipulation of the various typographic features that can make clear (or unclear) the structure of text is then addressed in Section 5.

At the end of almost every section a summary table presents the main advice that has emerged from research and practice. An example is also provided in parallel to illustrate and sometimes compare approaches. Section 6 presents a comprehensive summary table, which lists all of the empirical studies referred to in this paper, and grades their validity taking into account the parameters described below.

3. INTRINSIC FEATURES

3.1. TYPEFACE CHOICE

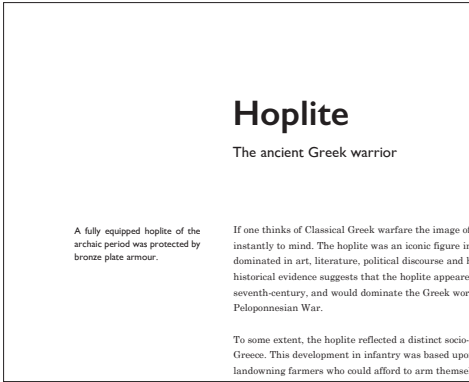


FIGURE 1.

Main text in serif, heading and caption in sans serif.

Choosing a typeface according to its legibility has been a primary concern of many designers (both typographic and graphic) when the main purpose of the text with which they are working is continuous reading. This choice has also formed the basis for experimental studies and has been widely discussed.

Three experiments measuring speed of reading have reported findings of no significant differences between typefaces in common use. One example of no significant differences between typefaces is Paterson and Tinker's (1932) test to identify which typefaces could be read most rapidly. The speed of reading for each of the six typefaces in common use at that time (Garamont, Antique, Bodoni, Old Style, Caslon Old Style, and Cheltenham) was compared with Scotch Roman (another commonly used typeface). The choice was based mainly on the opinions of a large number of editors and publishers. All typefaces were set in 10-point size, 19-pica line length (about 52 characters – Scotch Roman), and set solid (in text that is set solid, the interlinear space is equal to the point size of the type). The results showed that the six typefaces did not differ significantly from Scotch Roman. The study further included three radically different typefaces from the ones

in common use. In this case, however, two of these typefaces (American Typewriter and Cloister Black – Old English) were read more slowly than Scotch Roman. The modern typeface Kabel Lite was practically as legible as Scotch Roman. (A description of this test can also be found in Tinker’s book *Legibility of Print*, 1963.)

Another example is Pyke’s (1926) study testing the legibility of eight typefaces (referred to by, for example, Tinker, 1963a, 51; Cornog and Rose, 1967, 302-4; Lund, 1999, 102-5). Although Old Style No. 2 seemed the most legible and Modern Condensed No. 39 the least legible typefaces, Pyke considered the differences to be small. He concluded that typefaces used in everyday reading situations, if well printed, do not produce significant differences in legibility. Burt (1959) also conducted an investigation to determine the relative legibility of ten different book faces that were in common use at that time. However, Burt’s practices and contributions are considered dubious. (see Lund, 1995 and 1999, and Hartley and Room, 1983, for further discussion), mainly due to concerns about whether the data were used to support a predetermined position.

Readers’ preference judgement is another measure that has also been considered when researching the legibility of typefaces. Tinker (1963a, 49-50) concluded from the combined judgements of participants on the typefaces used in Paterson and Tinker’s study in 1932 that readers do have preferences for typefaces, but that preferences do not always coincide with readers’ performance when reading their preferred typeface.

Recommendations supported by practice have been made for how to choose an effective typeface. Simon (1945, 11) and later Hartley (1994, 32; 2004, 920), suggest that the purpose of the text should be taken into account. In agreement with Black (1990, 12-3), Hartley (1994, 32; 2004, 920) further recommends the avoidance of those typefaces with unusual features which may create irregularities in the text and confuse readers. Furthermore, typefaces which may lose their identity when printed or copied should also be avoided: typefaces with fine lines which may break down; typefaces with small internal spaces which may fill in; typefaces with a strong contrast between thick and thin strokes which may cause a dazzle effect; and typefaces in which the letters appear to touch one another. (See also Simon, 1945, 11-21, and Bringhurst, 1992.) Luna (1992, 74-6) adds to this the opinion that a typeface that calls attention to itself rather than to the text should not be chosen; nor a typeface that is based on tradition without its appropriateness having been tested more objectively.

The comparative legibility of serif and sans serif type should also be considered when choosing a typeface. Luna (1992, 74) argues that “traditional seriffed typefaces are rarely unsuitable for continuous reading, and that few sans serif are appropriate for this purpose.” From studies that have compared the legibility of these two distinctive categories, no definitive conclusion has been reached. (See extensive research and conclusions of Lund, 1999.) Serif and sans serif typefaces are likely to be read equally quickly and accurately.

Examples of experiments measuring speed of reading and comprehension that have not shown a significant difference in legibility between serif and sans serif typefaces are Paterson and Tinker's study (1932) mentioned above and Moriarty and Scheiner's (1984) experiment measuring how many words were read in a given time period (the serif typeface Times New Roman and the sans serif typeface Helvetica were tested).

However, suggestions are also made that sans serif typefaces whose rhythms and spacing relate closely to those of serif typeface seem most satisfactory for continuous text (Lund, 1992, 74). In fact, it is interesting to note that some studies have found a significant difference between sans serif typefaces, despite there being no significant difference between serif and sans serif typefaces. In a study measuring rate of comprehension, Poulton (1965) found that the sans serif typeface Gill medium produced a reliably greater rate of comprehension than all the other sans serif typefaces tested (although it was not reliably better than any of the serif typefaces). Poulton attributed this result to the fact that Gill, with its geometrical approach allied to humanistic letterforms, has a stronger character differentiation than the other sans serif typefaces.

Readers' preferences have also failed to clearly distinguish between serif and sans serif typefaces. For example, Schriver and colleagues (Schriver, 1997, 288-303) conducted a study on typeface preferences using complete texts that reflected the sorts of documents people read in everyday contexts. Four different materials were assessed: a microwave manual, a credit letter, a tax form, and a short story. Each document was designed using four different serif typefaces and four different sans serif typefaces. To avoid confounding typeface legibility with differences in x-heights, Schriver and colleagues employed a larger type size in the serif versions of the documents. Although the results suggested that serif or sans serif typefaces are equally likely to be preferred, they also suggested that serif type might be better when reading continuous prose and sans serif type when reading instruction manuals. Schriver and colleagues then concluded that the situation in which reading is taking place might well influence readers' preferences.

In the 1930s, Tschichold (1967) strongly defended the use of sans serif, claiming that it "is so simple and clear that it is by far the best all-purpose type for today and will remain so for a long time to come..." (1967, 28). However, for the purpose of continuous reading, Tschichold accepted the use of serif to be appropriate. More recent opinions have favoured the use of both serif and sans serif in the same document. Serif type could be used for the body of the text (e.g. McLean, 1980; Schriver, 1997), which is in agreement with Luna's opinion referred to above, and sans serif could be used for headings, captions and marginalia (e.g. Simmonds and Reynolds, 1994, 46; Schriver, 1997).

The lack of clarity in these findings and the assumptions made suggest that Carter *et al* (1993, 88) may well be right when

TABLE 1.

Typeface

| Research | Practice |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none">• Typefaces used in everyday reading situations, if well printed, do not produce significant differences in legibility [e.g. Pyke, 1926 (described in Tinker, 1963a); Paterson and Tinker, 1932]• No distinctive difference between serif and sans serif type in speed of reading and comprehension. [e.g. Paterson and Tinker, 1932; Poulton, 1965; Moriarty and Scheiner, 1984]• No clear preference for either serif or sans serif type. [e.g. Schriver, 1997] | <ul style="list-style-type: none">• Avoid typefaces: with unusual features; which may lose their identity when printed or copied; which call attention to themselves rather than to the text; which have not been tested objectively. [Simon, 1945; Hartley, 1994 and 2004; Black, 1990; Luna, 1992]• Use serif for continuous prose and for the body of the text. [e.g. McLean, 1980; Schriver, 1997]• Use sans serif for instruction manuals, headings, captions, and marginalia. [e.g. Simmonds and Reynolds, 1994; Schriver, 1997] |

claiming that other typographic features seem to be far more important in the reading process than the selection of either a serif or a sans serif typeface.

3.2. TYPE VARIANTS

3.2.1. Italic

Studies have been carried out exploring the use of italic in continuous prose instead of roman lowercase characters, and have shown that the use of italics retards reading. One example is Tinker's (1955) experiment using prolonged reading tasks. Tinker's study showed that reading speed was substantially reduced when reading italic (a retardation of 15.5 words per minute). The material used included two forms set in 10-point type in a 20-pica line length (about 55 characters per line) with 12-point interlinear space. The only difference was that one form was set in Excelsior roman and the other in Excelsior italic type. Another example is Tinker and Paterson's (1928) study where italic text was read 2.8 per cent slower than lowercase text. As for preferences, in another study carried out by Paterson and Tinker (1940, described in Tinker, 1963a, 54-6), 96 per cent of the participants judged that roman lowercase could be read more easily and faster than italic.

In addition, when we analyse documents in current use, we can see how italic is frequently applied to distinguish elements in a text: for example, titles of books in bibliographies, foreign words, abstracts in journal articles, etc. (as referred to by Simon, 1945, 5; Glynn *et al*, 1985; Carter *et al*, 1993, 91; Gilreath, 1993; Hartley, 1994, 30, and 2004, 921; Simmonds and Reynolds, 1994, 65-6; Schriver, 1997, 266). Thus, despite some authors' claims that bold should be used instead of italic for differen-

tiation in text matter (e.g. Rehe, 1979, 31), the common practice of using italic for differentiation is likely to be more appropriate. At least in certain situations, readers may well prefer italic over bold because of its conventional use.

3.2.2. Bold

Hoplite

The ancient Greek warrior

The concave shield was typically just over three feet in diameter. Because it was so large, to keep the weight of the shield down the *hoplon* could not be particularly thick. Even so, the *hoplon* still weighed approximately 16-20 pounds. It was primarily constructed of wood, with a bronze facia. The shield was carried with a handgrip and arm support, although in the push of battle the hoplite could fix his shoulder under the rim.

Hoplite

The ancient Greek warrior

The concave shield was typically just over three feet in diameter. Because it was so large, to keep the weight of the shield down the *hoplon* could not be particularly thick. Even so, the *hoplon* still weighed approximately 16-20 pounds. It was primarily constructed of wood, with a bronze facia. The shield was carried with a handgrip and arm support, although in the push of battle the hoplite could fix his shoulder under the rim.

FIGURE 2.

Italic or bold to distinguish elements [top]. Bold for black background [bottom].

Some researchers have explored the weight of a typeface in an attempt to define the optimum degree of boldness for reading. Luckiesh and Moss (1940) examined the speed of reading Memphis typeface in four weights: light, medium (20 per cent greater boldness than light), bold (35 per cent greater boldness than light) and extra bold (69 per cent greater boldness than light). Text was set in 10-point type Memphis with 2 points of leading and a line length of 21-pica (about 53 characters for Memphis medium). There was no significant difference in speed of reading, measured by the number of lines of text read during a period of five minutes of continuous normal reading. However, the medium and bold settings produced the highest reading speeds (an improvement of only three per cent).

Tinker and Paterson's (1942) study also failed to find any difference when participants read continuous text at a normal distance. Both

weights, i.e. standard and bold, were read at the same rate. The text was printed in 10-point Scotch Roman type, 19-pica (about 52 characters) line length and set solid. As for judgements, a different group of 224 participants thought that standard type was more legible and pleasing than bold face.

Readers' judgements, therefore, seem to correspond to the opinions of authors who suggest that for continuous text a typeface of medium weight, not too heavy or too light, should be employed (e.g. Rehe, 1979, 31). Nonetheless, bold can be very effective to emphasise one piece of information over another (e.g. Reynolds, 1978, 199; Rehe, 1979, 31; Bringhurst, 1992, 52; Carter *et al*, 1993, 91; Schriver, 1997, 267-8; Wijnholds, 1997; Strizver, 2014), or as a technique to thicken the lines of characters that will be printed in pale ink, or on a black or coloured background (Bringhurst, 1992, 52). Because bold type draws attention, this variant is best used for specific situations that require emphasis. So, for example, it can be used to distinguish words (e.g. 'not', 'NB') or headlines, rather than whole sentences. But because bold has different weights (bold, semi-or demi-bold, black or ultra) from which we can choose, care should be taken when using bold for emphasis where the aim is to create enough contrast. A slight difference in weight will be ineffective and can actually look like a print error.

TABLE 2.

Type variants: italic and bold

| Research | Practice |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none">• When compared to roman lowercase text, italic retards reading. [e.g. Tinker and Paterson, 1928; Paterson and Tinker, 1940 (described in Tinker, 1963a); Tinker, 1955]• Both medium and bold text are read at the same rate. [Luckiesh and Moss, 1940; Tinker and Paterson, 1942]• Readers consider medium type more legible and pleasing than bold type. [Tinker and Paterson, 1942] | <ul style="list-style-type: none">• Use italic to distinguish elements in a text. For example: titles of books (in bibliographies), foreign words, abstracts in journal articles. [e.g. Simon, 1945; Glynn <i>et al</i>, 1985; Carter <i>et al</i>, 1993; Gilreath, 1993; Hartley, 1994 and 2004; Simmonds and Reynolds, 1994; Schriver, 1997]• Bold can be very effective to emphasise one piece of information over another. [e.g. Reynolds, 1978; Rehe, 1979; Bringhamst, 1992; Carter <i>et al</i>, 1993; Schriver, 1997; Wijnholds, 1997]• Bold can be used as a technique to thicken the lines of characters that will be printed in pale ink, or on a black or coloured background. [Bringhamst, 1992] |

3.3. ALL-CAPITALS VERSUS LOWERCASE

Hoplite

The ancient Greek warrior

If one thinks of Classical Greek warfare the image of the hoplite comes instantly to mind. The hoplite was an iconic figure in Greek culture, who dominated in art, literature, political discourse and historical writing. The historical evidence suggests that the hoplite appeared sometime in the seventh-century, and would dominate the Greek world until the Peloponnesian War.

To some extent, the hoplite reflected a distinct socio-political structure in Greece. This development in infantry was based upon a new class of landowning farmers who could afford to arm themselves and defend

HOPLITE

THE ANCIENT GREEK WARRIOR

IF ONE THINKS OF CLASSICAL GREEK WARFARE THE IMAGE OF THE HOPLITE COMES INSTANTLY TO MIND. THE HOPLITE WAS AN ICONIC FIGURE IN GREEK CULTURE, WHO DOMINATED IN ART, LITERATURE, POLITICAL DISCOURSE AND HISTORICAL WRITING. THE HISTORICAL EVIDENCE SUGGESTS THAT THE HOPLITE APPEARED SOMETIME IN THE SEVENTH CENTURY, AND WOULD DOMINATE THE GREEK WORLD UNTIL THE PELOPONNESIAN WAR.

TO SOME EXTENT, THE HOPLITE REFLECTED A DISTINCT

It has been argued that lowercase is easier to distinguish and recognise than all capitals (e.g. Rehe, 1979, 35-6; Humphreys and Bruce, 1989, 329). In fact, studies have shown that lowercase is read more rapidly than all-capitals: in Tinker and Paterson's (1928) study lowercase was read 13.4 per cent faster; in Tinker and Paterson's (1942) study lowercase was read 11.8 per cent faster; and in Tinker's (1955) study lowercase was read 10.2 to 14.2 per cent faster.

Another study, carried out by Poulton (1967), showed that readers located newspaper headlines printed in bold lowercase more quickly than headlines in all-capitals. The x-heights of the bold lowercase letters were approximately the same as the heights of the capital letters. In addition to the finding that lowercase is read more rapidly than all-capitals, Tinker and Paterson (1942) further found that readers judged lowercase as more legible and pleasing. As all continuous

FIGURE 3.
Main text in lowercase [top]
and all-capitals [bottom].

reading involves more lowercase (Tinker and Paterson, 1928, 366-7 and Tinker ,1963a, 61), lowercase might be more familiar to readers, i.e. readers had more practice with it.

This evidence for the superiority of lowercase led to the conclusion that all-capital printing should be avoided whenever rapid reading is required or when readers’ preferences are the main concern (Tinker, 1963a, 61; Rehe, 1979, 36). Instead it is proposed that both capitals and lowercase letters should be used, reserving the capitals for the initial letter of nouns, sentences, and headings (Poulton, 1967; Hartley and Burnhill, 1977a, 71). The use of all-capitals for main headings, or small capitals for secondary headings, may be satisfactory because such headings are normally surrounded by space, which helps in their visual distinction (Hartley, 2004, 921). Opinions expressed by Tschichold (1967, 34 and 38), Black (1990, 16 and 30), Carter *et al* (1993, 89), Simmonds and Reynolds (1994, 66), Schriver (1997, 274), Hartley (2004, 921) agree with the research findings described above.

Another interesting argument is the fact that lowercase occupies less space than all-capitals of the same body size (Hartley and Burnhill, 1977a, 71; Black, 1990, 16), about 35 per cent less (Tinker 1963a, 60; Carter *et al*, 1993, 89). This results in economy of space.

TABLE 3.

| All-capitals versus lowercase | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Research | Practice |
| <ul style="list-style-type: none">Lowercase is read more rapidly than all-capitals. [e.g. Tinker and Paterson, 1928; Tinker and Paterson, 1942; Tinker, 1955; Poulton, 1967]Readers prefer lowercase. [Tinker and Paterson, 1942] | <ul style="list-style-type: none">Both capitals and lowercase letters should be used, reserving the capitals for the initial letter of nouns, sentences and headings. [Poulton, 1967; Hartley and Burnhill, 1977]Lowercase occupies less space than all-capitals of the same body size, about 35 per cent less. [e.g. Tinker, 1963a; Hartley and Burnhil, 1977a; Black, 1990; Carter <i>et al</i>, 1993] |

3.4. TYPE SIZE

In metal type the size of type is conventionally expressed in points, i.e. the measure of the whole body of the metal block for the letterform including ascenders, descenders, and the extra space at the top and bottom that is required to create space between successive lines of type. However, different typefaces with the same type size vary in their x-heights (the top-to-bottom dimension of a lowercase “x”). Several researchers have argued that point size terminology is an unsatisfactory measure for research since it does not specify the actual size of the printed typeface (Poulton, 1965, 350-60; Poulton, 1969, 58; Hartley *et al*, 1975, 115-6; Hartley, 2004, 919-20).

This is clearly illustrated by the results of Poulton's study (1972) comparing the legibility of three typefaces, i.e. number of target words found in a list of food ingredients. When all typefaces were printed in the same point size, differences of legibility were found, but when the x-height of all three was equated to approximately the same size, no difference was found. Typographers (e.g. Simon, 1945, 13), designers (e.g. Carter *et al.*, 1993, 90), and other authors (e.g. Rehe, 1979, 27-9) seem to agree with these results. Some go even further by claiming that typefaces with greater x-heights can be set at a smaller size than typefaces with smaller x-heights without losing legibility (e.g. Schriver, 1997, 258-9). (See also Legge and Bigelow, 2011, for a discussion of x-height and a thorough review of findings from vision science and typography regarding type size.)

Sizes of type, however, have also been frequently defined by measuring the body size of the type and not the x-height (as reported below). Therefore, it is important to keep in mind that when choosing a typeface according to its body size, the same designated type sizes will not, in fact, look the same size.

The most regularly used type sizes, between 9-and 12-point, are regarded as being the most legible for text intended to be read at normal reading distances of 12-to 14-inches, i.e. about 300 to 350 millimetres (e.g. Tinker, 1963a, 69-73; Spencer, 1969, 35; Rehe, 1979, 29; Carter *et al.*, 1993, 90). Furthermore, 10-or 11-point are suggested as the optimum sizes with the caveat that it depends on the typeface (e.g. Tinker 1963a, 71; Reynolds, 1978, 200). These suggestions and results concern both speed of reading and preference judgements. It is also noted that smaller sizes such as 6-or 8-point type are often used in legal documents, but these can be too small to read easily. Larger sizes of 14, 18-and 24-points are often used for headings and display purposes (Hartley, 2004, 919).

Although type size may have a strong influence on legibility, it has been argued that it is best not to consider type size separately. For example, after describing one of his extensive studies with Paterson (Paterson and Tinker, 1929) on the influence of type size on legibility of print in a chapter devoted to *Size of type*, Tinker (1963a, 69-72) discarded the data as inconclusive. In the study, speed of reading was measured comparing 6-, 8-, 12-, and 14-point type to the standard 10-point type (an illustration can be found in Tinker, 1963a, 70). The results do not seem unreasonable: texts in 6, 8, 12 and 14-point type were read significantly more slowly than 10-point type. The difference ranged from 5.2 to 6.9 per cent. However, line length and interlinear space were kept constant while type size varied. Tinker, therefore, concluded that:

... line width, leading, and type size must be coordinated in any final judgement concerning the legibility of type size. All three factors should be studied under conditions where simultaneous and systematic variations of all three are made. (Tinker, 1963a, 73)

Others that agree with Tinker's view include Zachrisson (1965, 39), Reynolds (1978, 200), Rehe (1979, 29-30), Schriver (1997, 263), and Wijnholds (1997). Scientific evidence (Skottun and Freeman, 1983) has further shown, however, that the space between letters also affects how size of type is perceived. Therefore, interletter space should also be coordinated with type size before any conclusion can be reached on legibility.

4. EXTRINSIC FEATURES

4.1. COLOUR

4.1.1. Type and background colour

It is acknowledged that the relationship between type and background colour is another important factor for legibility. Michael and Jones (1955) conducted a meticulous study to determine the extent of differences in the average scores of students when presented with examination papers on different colours of paper. Different colours of paper were selected and randomly presented to participants. This selection took into account, for example, the complaints of faculty members and students on the unpleasant aesthetic qualities of yellow-orange paper. Results were straightforward in showing that colour of paper did not significantly affect the average number of correct answers.

Aside from the legibility of type on coloured backgrounds for examination papers, other studies have been carried out which are reviewed, described, and discussed by Tinker (1963a, 137-51) in his book *Legibility of Print* (e.g. Tinker and Paterson, 1931 and Luckiesh and Moss, 1938). The studies tested the speed of reading: black text on coloured paper, black on white versus white on black arrangements, and coloured type on coloured paper. In summary, the results from all the studies indicate that black print on a white background is much more legible than white print on a black background for materials to be read in an ordinary situation. On this basis, Tinker concludes that if white type on black is employed to attract attention, the amount of text should be small, and a sans serif type in 10 to 14-point size should be used to minimise the loss of legibility. Readers also prefer to read black on white, rather than white on black. It is further concluded that it is possible to coordinate coloured print with coloured paper so that legibility and 'pleasingness' are maintained at a satisfactory level.

Supported by references to empirical research, Hartley (2004, 921) notes that black ink on white or yellow paper is generally preferable to red ink on these colours, and that black ink on dark red or purple paper is generally to be avoided.

4.2. MICRO SPACING

4.2.1. Interletter and interword space

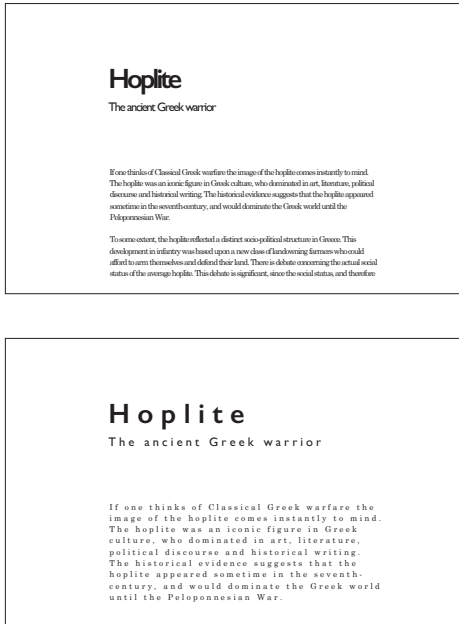


FIGURE 4.1

Interletter space: too narrow [top]; too wide [bottom].

Although interletter and interword space also seem to affect legibility, limited experimental evidence is available on this matter. One of the few examples is the investigation carried out by Spencer and Shaw in 1971. The aim of the study was to find out whether variation in interletter space (close, average and wide spacing) for the sans serif type Gill Sans affected the legibility of continuous printed text. The results showed that reading speed and comprehension were the same for all the kinds of spacing tested. However, from the illustrations provided it is clear that the narrowest setting is too close to the point of making the letters collide with each other and, consequently, causes a significant decrease in legibility. We should also be aware that the same percentage of space reduction might have different effects on the legibility of other type sizes and other typeface designs. This may be the case, for instance, with a serif typeface where serifs might touch with the same interletter space for a sanserif typeface that does not touch.

A more recent study conducted by Chung (2002) has shown that reading speed is at its peak with standard letter spacing, and decreases for both smaller and larger letter spacing. As later found and explained by Yu *et al* (2007), with extra wide spacing, reading becomes slower because the size of the visual span (the number of letters recognized with high accuracy without moving the eyes) becomes smaller. However, in these studies the text was presented on a computer monitor. Therefore, these results are only used in this paper for theoretical reflection.

Opinions expressed by authors and practitioners indicate interletter space that is too wide disrupts the reading process since the readers are forced to read the letters individually. Moreover, extreme interword space also creates vertical white spaces that look like rivers running down the page, which destroys the normal page texture. This is especially apparent in newspapers where text is fully justified, resulting in inconsistent interword and interletter spacing. On the other hand, with space that is too narrow, the letters and words join together and readers have more difficulty in recognising adequately each individual letter and word. All these issues should be considered (Simon, 1945, 30; Tschichold, 1967, 37-8; Black, 1990, 17-8 and 39-41; Carter *et al*, 1993, 89-90), especially when the information has to be taken in at a quick glance (Hartley and Burnhill, 1977a, 69).

Therefore, where quick reading seems to be the first concern, it is definitely wiser to avoid setting the type too wide or too

close. However, research and practice are yet to give us quantifiable definitions for ‘too wide’ and ‘too close’. Based on the studies reported above, it seems that for a 10 to 12-point type size, ‘too wide’ letter spacing would correspond to an overall space character above a “thick” space (1/3 the width of an em). An ‘em’ is defined by Simmonds and Reynolds (1994, 173) as the width of a lowercase letter ‘m’. ‘Too close’ letter spacing would correspond to an overall space character below a “thin” space (about 1/5 to 1/8 of an em). In fact, type in smaller sizes, lighter weights, and expanded style can actually benefit from wider letter spacing. Type in larger sizes, heavier weights, and condensed style can also benefit from closer letter spacing.

TABLE 4.

Interletter and interword space

| Research | Practice |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none">• Reading speed is not affected when interletter space is changed slightly. [Spencer and Shaw, 1971] | <ul style="list-style-type: none">• Interletter space that is too wide or too narrow disrupts the reading process. [e.g. Simon, 1945; Tschichold, 1967; Black, 1990; Carter <i>et al</i>, 1993]• Extreme interword space creates vertical white spaces that look like rivers running down the page, which destroys the normal page texture. [e.g. Simon, 1945; Tschichold, 1967; Black, 1990; Carter <i>et al</i>, 1993] |

4.3. MACRO SPACING

4.3.1. Alignment

Type set fully justified seems to represent a more traditional approach (Luna, 1992, 640). In fully justified setting the space between words is inconsistent in order to fill the width of the column (as mentioned above, newspapers are a good example of justified setting with clearly inconsistent word spacing). Conversely, text aligned on the left and ragged right creates consistent word spacing and has become an increasingly popular practice (Gregory and Poulton 1970, 427; Reynolds, 1978, 203, Luna, 1992, 64).

Unlike right alignment and centred text, the effect of full justification and left alignment on the legibility of text has been the subject of a number of studies (e.g. Zachrisson, 1965; Fabrizio *et al*, 1967; Becker *et al*, 1970; Gregory and Poulton, 1970; Hartley and Burnhill, 1971; Hartley and Mills, 1973; Wiggins, 1977). When comparison was made between the two type settings, no differences in reading times were found when a medium line length was used.

Of the studies comparing full justified and left aligned text, Gregory and Poulton’s study (1970) is the most clearly

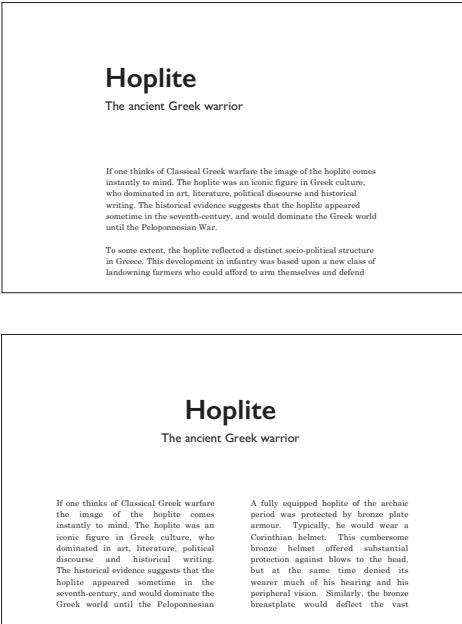


FIGURE 5.

Left aligned text [top].
Justified text with rivers
[bottom].

(1965, 145-55), in an earlier study, had also cited evidence that left aligned text is read more quickly by less proficient readers when the lines are, on average, 9 words (about 52 characters).

A study carried out on readers' preferences for typeface, alignment and interlinear space by Becker *et al* (1970) showed no differences in preferences for fully justified or left aligned text. The researchers concluded, however, by saying that definitive conclusions could not be drawn since the number of participants was small (ten), and that it was hard to say how far the findings could be generalised for other typefaces or situations.

As no definitive conclusions have been reached with these studies concerning the alignment of text, it seems that the real issue here has more to do with interletter and interword space than with the alignment of text. As Schriver (1997) concluded, "Justifying the text or not is probably the wrong concern. The right concern is how to achieve a text without rivers and excessive hyphenation." (1997, 270). Rivers can be prevented by aligning text to the left or by avoiding short line lengths. However, if justification has to be used, then a consistent texture can be achieved by hyphenating at the ends of lines whenever possible (Carter *et al*, 1993, 93). Further practical considerations of hyphenation on the legibility of text are given by Bringhurst (1992, 40-1) and Luna (1992, 58-66).

Hartley and Burnhill (1971) compared various settings of standard left aligned text (i.e. with no hyphenated words at the end of the text lines) and left aligned text with a moderate hyphenation (i.e.

articulated. It also contains a clear attempt by the researchers to maximise the sensitivity of the study (Gregory and Poulton, 1970, 428). A comparison was made between the rate of comprehension when reading passages presented in three different styles – fully justified, left aligned with hyphenated words (i.e. broken words), and left aligned with no hyphenated words. All passages were printed in one style only and set in 9-point type with 10-point interlinear space and in a line with a maximum length of seven words per line, about 42 characters (a single narrow column). To confirm some of the findings of this first experiment, Gregory and Poulton conducted two additional experiments with some adjustments, including an increase in the line length from an average of seven words per line to twelve words per line (about 70 characters). Over the whole study, the alignment of text made no difference for good readers, but for poor readers the fully justified style resulted in significantly worse performance when reading the shorter lines of seven words. Zachrisson

where 33 per cent of the text lines end with hyphenated words). No differences were found between them in the number of words read. However, after showing the differences between the typographic layouts to the subjects, 24 preferred the standard left aligned version against 10 that preferred the hyphenated version, while 8 subjects had no preference. This suggests that, if readers' preferences are to be taken into account, hyphenation should be used sparingly, or not used at all.

TABLE 5.

| Alignment | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Research | Practice |
| <ul style="list-style-type: none">• No difference in performance between fully justified or left aligned text with a medium line length. [e.g. Zachrisson, 1965; Fabrizio <i>et al</i>, 1967; Becker <i>et al</i>, 1970; Gregory and Poulton, 1970; Wiggins, 1977]• No difference in preferences for fully justified or left aligned text. [Becker <i>et al</i>, 1970] | <ul style="list-style-type: none">• Reading is disrupted when text is fully justified, with rivers and excessive hyphenation that disrupts reading. [Carter <i>et al</i>, 1993; Schriver, 1997] |

4.3.2. Line length

Driven by technology, different measures have been used for line length (sometimes called line width). These include ems, picas, points, millimetres, and inches. To avoid confusion, some authors have described line length in terms of the average number of characters per line (e.g. Spencer, 1969, 35). Other authors have explicitly recommended checking the number of characters and spaces as a practical expedient, rather than using a linear measurement (e.g. Reynolds, 1978, 201;and Wijnholds, 1997). Each letter, numeral, punctuation mark, and space is considered a 'character' (Simmonds and Reynolds, 1994, 48). However, studies rarely describe line length as the average number of characters and spaces per line. Since characters-per-line is a more precise unit of measure, in this paper all line length measures were converted into an approximate number of characters per line.

As previously discussed, it is generally accepted that an optimal typographic arrangement is dependent upon the simultaneous variation of type size, line length, and interlinear space for any final judgement concerning the legibility of type. However, the few available studies conducted to test the effects of line length on legibility did not consider the three variables together (except for some studies carried out by Tinker and Paterson which are discussed in the next section).

For example, Wiggins (1977) tested only one or two variables at the same time. In one experiment, line lengths of 10-, 11-

and 12-picas (about 26, 29 and 33 characters respectively) were tested in combination with three different typefaces and a 10-point type size (the x-height varied). In a second experiment, line lengths of 10-, 14-, 19-, 24-, and 29-picas (about 26, 39, 52, 65 and 78 characters respectively) were tested using constant and variable space between words for 10-point size in order to produce uneven and even right margins, accordingly. Wiggins (1977) found that lines of medium length were read faster than the shorter and longer lines. The 12-pica line was read faster than 10- and 11-pica lines when averaged over three different typefaces; the 14-pica line was the optimum for constant interword space; and the 19-pica line was the optimum for variable space. Thus, it seems that in all cases moderate line lengths were read faster than shorter or longer line lengths.

Tinker (1963a, 86) also reports that readers favour moderate line lengths. This advantage of moderate line length over short or long line length, for both reading speed and preference, seems to be for two distinct reasons. First, more fixation pauses of greater duration seem to be employed when reading very short line lengths than when reading moderate line lengths (e.g. Tinker, 1963a, 86). Moreover, with very short line lengths the readers have to change lines too frequently, thus making inefficient use of their peripheral vision when reading (e.g. Simmonds and Reynolds, 1994, 48). The number of hyphenations is also greater with very short line lengths than with moderate line lengths. Second, with very long line lengths it is more difficult for the eyes to make an accurate return sweep, i.e. a long movement to the left from the end of a given line to the beginning of the next line (e.g. Luna, 1992, 54; Carter *et al*, 1993, 90; Simmonds and Reynolds, 1994, 48; Schriver, 1997, 263; Wijnholds, 1997). Consequently, several fixations may be required before the correct line is found (e.g. Simmonds and Reynolds, 1994, 48) and the number of regressions after the return sweep of the eyes may be greatly increased, which leads to less efficient reading (e.g. Tinker, 1963a, 86).

According to Spencer's (1969, 35) review of scientific studies, the optimal line length seems to be between ten to twelve words, or 60 to 70 characters per line. Opinions of both authors and practitioners concur with this recommendation (Simon, 1945, 7; Tschichold, 1967, 40; Lewis, 1963, 57; Rehe, 1979, 30; Black, 1990, 43; Bringham, 1992, 26-7; Carter *et al*, 1993, 91; Simmonds and Reynolds, 1994, 48; Schriver, 1997, 263; Wijnholds, 1997).

4.3.3. Interlinear space and relationship with type size and line length

Interlinear space is used in this paper as a term to describe 'baseline to baseline measurement', i.e. the amount of vertical space placed between the baseline of one text line and the baseline of the next, and is expressed in points. (As mentioned above, in text that is set solid the interlinear space is equal to the point size of the type.) Interlinear space has also been described

Hoplite

The ancient Greek warrior

If one thinks of Classical Greek warfare the image of the hoplite comes instantly to mind. The hoplite was an iconic figure in Greek culture, who dominated in art, literature, political discourse and historical writing. The historical evidence suggests that the hoplite appeared sometime in the seventh-century, and would dominate the Greek world until the Peloponnesian War.

To some extent, the hoplite reflected a distinct socio-political structure in Greece. This development in infantry was based upon a new class of landowning farmers who could afford to arm themselves and defend

Hoplite

The ancient Greek warrior

If one thinks of Classical Greek warfare the image of the hoplite comes instantly to mind. The hoplite was an iconic figure in Greek culture, who dominated in art, literature, political discourse and historical writing. The historical evidence suggests that the hoplite appeared sometime in the seventh-century, and would dominate the Greek world until the Peloponnesian War.

To some extent, the hoplite reflected a distinct socio-political structure in Greece. This development in infantry was based upon a new class of landowning farmers who could afford to arm themselves and defend their land. There is debate concerning the actual social status of the average hoplite. This debate is significant, since the social status, and therefore wealth, of the hoplite has an impact on the equipment he would fight with, and thus how he would fight.

Hans van Wees notes that the traditional perspective on the archaic hoplite as being a middle-class farmer protected by heavy bronze armour does not provide the whole truth (and this is certainly the case for later hoplite forces, who were much lighter). Hans van Wees concludes that, whilst landowning men of leisure did make up some of the hoplite force, many of the soldiers were working-class farmers.

FIGURE 6.

Moderate line length and an additional interlinear space of 4 points [top]. Long line length and type set solid [bottom].

as ‘leading’, relating to the strips of lead of varying thickness that were placed between lines of type to increase the space.

As already highlighted, researchers, authors, and practitioners agree that line length must be coordinated with type size and interlinear space for any final judgement concerning the legibility of type (Tinker, 1963a, 73; Zachrisson, 1965, 39; Reynolds, 1978, 200; Rehe, 1979, 29; Carter *et al*, 1993, 91; Wijnholds, 1997). An inadequate ratio of type size to line length results in the text appearing unbalanced. For instance, when text is set fully justified, a badly chosen ratio can result in stretched words separated by large gaps (Wijnholds, 1997). These observations offer a clear suggestion that line length cannot be determined without considering type size. The same association has been made between line length and interlinear space. When it is really necessary to use long line lengths, legibility can be preserved if interlinear space is increased (Schriver, 1997, 263)

in order to help the eye find the following line accurately.

Paterson and Tinker (described by Tinker, 1963a, 94-102) completed a series of experiments between 1932 and 1949, which varied line length (from 7 picas, about 18 characters, to 43 picas, about 124 characters) and interlinear space (from solid to an increase of 4 points) for each of the commonly used type sizes (from 6-to 12-point type). Speed of reading for material set in each of the variations in line length and interlinear space was compared for each size of type. This extensive and detailed investigation made it possible to list ‘safety zones’ for each type size. (See Tinker, 1963a, 106.) According to Tinker, the safety zone refers to the limits of variation in line length and interlinear space that may be used for a given type size without appreciable loss of legibility. On the basis of Tinker’s (1963a) safety zones, it seems that for the sizes of type suggested above as the most legible (9-, 10-, 11-, and 12-point), one to four points can be added to the interlinear space in order to increase legibility. However, this surely depends on the typeface used. Extreme line lengths were omitted from the list. For example, for 10-point type, line lengths below 14 picas (about 38 characters) and above 31 picas (about 83 characters) were omitted. An examination of the results in Tinker’s tables shows that, independent of the interlinear space used, those extreme line lengths always fell in the region of poor legibility.

Tinker (1963b) then carried out another experiment, which confirmed Paterson and Tinker’s findings. Moderate arrangements (in this case of 8-point type with a line length of 12 picas – about 41 characters, or 9-point type with a line length of 18 picas – about 55

characters, both with an additional interlinear space of 2 points) were read more rapidly than text in relatively long or short lines, smaller type sizes, and with little or no interlinear space. Readers' choices were consistent with their performance and they definitely disliked text in relatively short or long lines, small type, as well as material set solid.

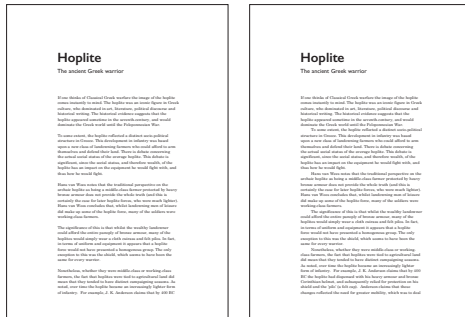
Becker *et al* (1970) also found that according to readers' judgements, different typefaces need a different amount of interlinear space. For instance, sans serif and italic may need an additional interlinear space of 1 point more than serif roman types. Schriver (1997, 263) also suggests that it is a good idea to insert more interlinear space between the lines of sans serif type because the uniform line weight and similarity of letterforms may make it harder to read the text smoothly.

Authors and practitioners (e.g. Simon, 1945; Tschichold, 1967; Spencer, 1969; Rehe, 1979; Black, 1990; Bringhurst, 1992; Carter *et al*, 1993; Schriver, 1997; Wijnholds, 1997) seem to agree with these findings and indeed go further by adding other considerations concerning interlinear space that should be taken into account when arranging text. For example, body text usually needs an interlinear space in a point size bigger than the size of the type. Even though the type is designed to maintain a legible appearance when set solid, the space between lines can still look insufficient. If so, the eyes take in other lines as well. However, too much interlinear space is also bad because when lines are too separated it will take longer to get to the following line (Tschichold, 1967, 44; Rehe, 1979, 31; Bringhurst, 1992, 34-5; Carter *et al*, 1993, 91; Schriver, 1997, 260-1). That is to say, it is more difficult for the eyes to make an accurate return sweep to the beginning of each new line of text (Simmonds and Reynolds, 1994, 35 and 52). Furthermore, it is also more expensive because of the additional paper used (Wijnholds, 1997). As discussed above, longer line lengths always need more interlinear space than shorter ones (Schriver, 1997, 262-3).

TABLE 6.

Type size, line length and interlinear space

| Research | Practice |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none">• For sizes of type 9-, 10-, 11-, and 12-point (suggested as the most legible) an interlinear space of one to four points can be added to increase legibility [Tinker, 1963a]• Moderate arrangements are read more quickly than text in relatively long or short lines, smaller type sizes and with little or no interlinear space. [Tinker, 1963b]• Readers definitely dislike very short and very long lines, small type, as well as material set solid. [Tinker, 1963b] | <ul style="list-style-type: none">• Arrangements of 10- and 11- point size, with a line length of 60 to 70 characters per line, and additional interlinear space of one to four points, are considered most legible. [e.g. Simon, 1945; Tschichold, 1967; Hartley and Burnhill, 1977; Spencer, 1969; Black, 1990; Bringhurst, 1992; Carter <i>et al</i>, 1993; Schriver, 1997; Wijnholds, 1997]• Italic, body text and sans serif type, may need an additional interlinear space of one point more than serif roman types. [Becker <i>et al</i>, 1970; Schriver, 1997] |



Paragraphs denoted by
one line space [left] or by a
new line with a moderate
indentation of 3 ems [right].

Paterson and Tinker (1940; described in Tinker, 1963a, 122) examined the effects of paragraph denotation on speed of reading. Results showed that indentation at the beginning of a paragraph improved, or at least did not decrease, the legibility of printed matter. Hartley *et al* (1978), with a later experiment, investigated the effects of paragraph denotation on legibility of text by

Schrir (1997, 356-7) added to Tinker and Hartley's findings. For continuous text, thirteen participants preferred the double-signalled layout using both indentation and additional line space; three chose the layout with additional line space between paragraphs; and two favoured the layout that employed indented paragraphs without extra line space. The comments made by the thirteen readers who chose the same style suggested that they thought this style made the text appear easier and shorter than the others.

As for the first paragraph in an article, chapter or advertisement, it should have no indent (Simon, 1945, 9; Tschichold, 1967, 49; Carter *et al*, 1993, 93). This is a way of maintaining the square corner of the first column for aesthetic reasons. The use of paragraphs separated by one line space is also advocated (Hartley and Burnhill, 1977a, 71; Rehe, 1979, 51; Hartley, 1994, 35). However, Carter *et al* (1993, 93) suggest that this system should be avoided when the text is composed mainly of short paragraphs, not only because it creates a disturbing texture but also because it occupies too much space.

48.3

paragraphs makes it easier for readers to return to the paragraphs and find their points of interest.

TABLE 7.

| Paragraphs | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Research | Practice |
| <ul style="list-style-type: none">• Paragraphs denoted by one line space (no indent) are significantly superior to paragraphs denoted only by a new line, but not superior than paragraphs denoted by a new line with an indent. [Hartley <i>et al</i>, 1978]• Readers favour paragraphs denoted by indentation and additional line space. [Schriver, 1997] | <ul style="list-style-type: none">• In books, magazines and newspapers, paragraphs should be denoted with a moderate indentation of one to three ems, or separated by one line space. [Hartley and Burnhill, 1977a; Rehe, 1979; Bringhamurst, 1992; Carter <i>et al</i>, 1993; Hartley, 1994]• The first paragraph in an article, chapter or advertisement, should have no indent. [Simon, 1945; Tschichold, 1967; Carter <i>et al</i>, 1993]• Paragraphs separated by one line space should be avoided when the text is composed mainly of short paragraphs. [Carter <i>et al</i>, 1993] |

4.3.5. Margins

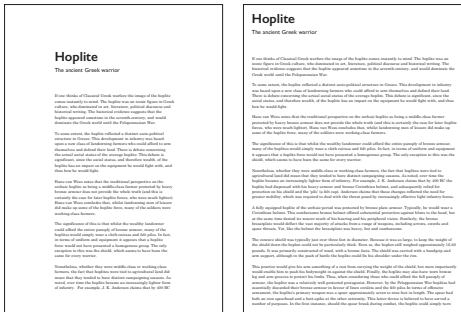


FIGURE 8.

Wide margins [left] and narrow margins [right].

Unfortunately, the amount of research with regard to margins is very limited. Of the very few studies on the effects of margins on legibility, a study by Paterson and Tinker (1940; summarised in Tinker, 1963a, 114) investigated the effects of margins on reading speed. Material with ⁷/₈ inch margins on the right and on the left of the column of print was compared with material without margins at either end of the lines. (It is likely that there was a very small margin, but no illustration is given to confirm this.) The results showed no significant speed difference when reading material printed on a flat

page with or without margins. The final conclusion was that margins do not increase legibility measurably, so the use of margins on a flat page can be justified only for aesthetic reasons.

Spencer (1969, 48) criticised Paterson and Tinker's conclusion for ignoring practical factors. As Spencer stressed, margins have the important function of allowing the readers to make notes and hold the book without covering any part of the printed text or image. Hartley (2004, 918) also mentions the fact that the printed page may be copied at some time, and the copies punched or clipped for filing with

other material. These issues have been discussed by several authors and practitioners such as Simon (1945), Tschichold (1967), Bringhurst (1992), and Carter *et al* (1993). As McLean (1980, 126) further emphasises, the smaller the margins, the less they can fulfill these practical functions.

TABLE 8.

| Margins | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Research | Practice |
| <ul style="list-style-type: none">• Margins do not seem to increase reading speed. [e.g. Paterson and Tinker, 1940 (described in Tinker, 1963a, and cited in Spencer, 1969)] | <ul style="list-style-type: none">• Margins are functional as they allow the readers to: make notes; hold the book without covering any part of the printed text or image; punch or clip copies for filing without damaging the text. [e.g. Simon, 1945; Spencer, 1969; Tschichold, 1967; McLean, 1980; Bringhurst, 1992; Carter <i>et al</i>, 1993; Hartley, 2004] |

4.4. CONFIGURATION

4.4.1. Headings

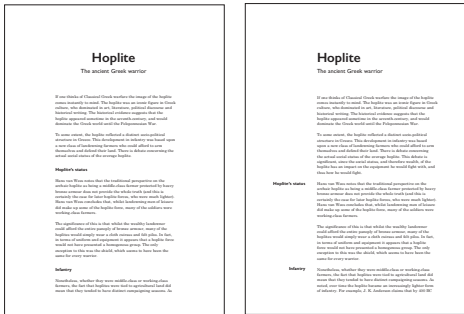


FIGURE 9.

Embedded headings [left] and marginal headings [right].

Headings are claimed to be a significant help for readers in decoding the main topic of the subsequent text they are planning to read (Schwarz and Flammer, 1981, 61 and 65; 1985; Lorch, 1989, 210), as well as the hierarchical structure of the text (Glynn *et al*, 1985, 197). Due to the importance of headings, it has been suggested that when discussing the treatment of headings three factors should be considered for good legibility: type size, type weight (Glynn *et al*, 1985, 197) and spatial location on the page (Lorch, 1989, 214). These are the most frequently used ways of emphasising and

distinguishing headings from the main text or distinguishing between headings at different levels.

Type variation has been addressed by Williams and Spyridakis (1992) in a detailed study that looked at the visual distinction of headings in text. Participants were presented with 16 cards with the same meaningless text, but each one had different heading treatments. The results indicated that participants could discriminate between different hierarchical levels of headings more quickly when fewer typographical variations were used. Size (when used alone) was chosen by readers as the most powerful visual feature of a group of four (type size, underlining, case, and position) to distinguish the hierarchy of headings. The experiment showed that relative, not absolute, differences in heading sizes provided the most distinguishable cues to hierarchical level. Size differences of 3 points

between headings were discriminated more rapidly with headings ranging between 12 and 21 points in size than with headings in larger sizes.

In relation to the spatial location of headings, Hartley and Trueman (1983) conducted a series of experiments to examine the effects of headings in text on recall, search, and retrieval. The results revealed no difference in accuracy between marginal and embedded headings for recall, search, or retrieval. Williams and Spyridakis (1992), however, showed that participants consistently judged centred headings as most important and embedded headings as least important. Left aligned and indented headings were ranked second and third in importance.

Some considerations to take into account when setting text headings have been pointed out by the typographer Tschichold (1967):

- When the heading spans over more than one line, the first line of the heading must be either longer or shorter than the second one. If necessary, interword space can be slightly changed, but word breaks should be avoided (1967, 44).
- When the text is set in sans serif type, only sans serif type should be used for headings, either in the same weight or bolder. With serif text, either the same type may be used for headings, or the semi-bold or bold, or a suitably and pleasing contrast type (1967, 89).
- Normal paragraph headings, if set heavier than the body face, do not need to be in a larger size. A blank line is preferable between them and the text (1967, 89).

Simmonds and Reynolds (1994, 67) add to this the recommendation that headings should be aligned left because the eye automatically returns to the left-hand margin of the text. Moreover, a heading with more space around it has more emphasis, but it is important to define a system of spacing for headings and use it consistently.

Hartley (2004, 921) also suggests that the use of all-capitals for main headings, or small capitals for secondary headings, may be satisfactory because such headings are normally surrounded by space, which helps in their perception (as already remarked above regarding capitals versus lowercase). He also regards large sizes of 14-, 18- and 24-points as suitable for headings (Hartley, 2004, 919).

There has also been research on newspaper headlines. In terms of the typeface, scientific evidence reveals that headlines in newspapers are more difficult to locate (measured by speed of search) when printed in all-capitals (whose height is about the same as the x-height of the lowercase letters) than when printed in bold lowercase letters (Poulton, 1967, 424). In his review, Rehe (1979, 52) recommends the best type sizes for newspaper headlines as between 14- and 30-point.

Wright and Barnard (1975) warn that, although there are several options for distinguishing headings from the subsequent

text, departures from the horizontal arrangement of words are less easily read. This means, “a heading printed sideways, to bracket several rows of questions all relating to the same topic, will be less effective than a heading written horizontally.” (Wright and Barnard, 1975, 216).

TABLE 9.

| Headings | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Research | Practice |
| <ul style="list-style-type: none">Relative differences in sizes provide the best cue to distinguish the hierarchy of headings. [Williams and Spyridakis, 1992]Readers consider size (when used alone) to be the most powerful visual feature to distinguish headings. [Williams and Spyridakis, 1992]No difference in accuracy between marginal and embedded headings. [Hartley and Trueman, 1983]Centred headings are judged as most important, then left aligned and indented headings, and embedded headings as least important. [Williams and Spyridakis, 1992] | <ul style="list-style-type: none">When serif type is used for the main text, set the heading in semi-bold or bold, or in a suitable and pleasing contrast type. [Tschichold, 1967]When sans serif type is used for the main text, only sans serif type should be used for headings, either in the same weight or bolder. [Tschichold, 1967]Normal paragraph headings, if set heavier than the body type, do not need to be in a larger size. A blank line is preferable between them and the text. [Tschichold, 1967]The first line of the heading must be either longer or shorter than the second one (word breaks should be avoided). [Tschichold, 1967]Headings should be aligned left. [Simmonds and Reynolds, 1994] |

4.4.2. Columns

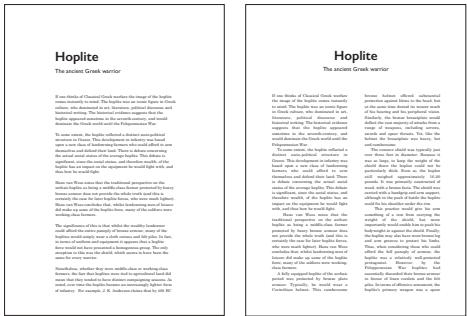


FIGURE 10.

Single column [left] and double columns [right].

Little attention appears to have been paid to how text is set in columns. However, the evidence available on single or multiple columns suggests that neither of these layouts is superior to the other. In fact, it seems that any advantage in terms of legibility, i.e. speed of reading, for either of these layouts largely depends on the column width, on the nature of the text, and on the circumstances of use.

In situations where participants are required to scan the text and search for key words, the double column layout seems to have an

advantage over the single column layout. An example of this is the study carried out by Foster (1970) on the legibility of single and double column layouts. Participants had to scan a one-column text and a two-columns text for target words. Page size, typeface and type size used were identical in both texts. Foster (1970) concluded that for this particular arrangement, the single column layout significantly diminished legibility, i.e. the number of target words located.

Hartley *et al* (1978) used texts arranged in either single or double column to test the effects of line length and paragraph denotation on the retrieval of information from prose text. Performance was measured by the number of items scanned. Again, results were in favour of the double column layout in terms of the average number of items scanned. It is concluded that the double column layout is probably preferred to a single column for the setting of straightforward prose, at least in terms of cost-effectiveness, as it is possible to get more words in the page.

In relation to textbooks for secondary schools, in Wendt's (1979) study, participants were asked to read the texts completely and carefully. They took, on average, a little less reading time and had slightly higher achievement with the single column version compared to the double column version. However, these results were not significant. The students slightly preferred the double column version, though.

A similar preference was reported in a study conducted by Paterson and Tinker (1940; cited in Tinker, 1963a, 117-8), where samples of single and double column layouts were submitted for preference. It was reported that a large percentage of participants preferred the double column layout over the single column layout. But preferences may have been influenced by the fact that a double column is more familiar, since printing practice has favoured double column layouts.

For scientific journals, Poulton (1959) reported an advantage in favour of single columns, which were read more rapidly than the double column. Passages were printed in a layout of a scientific paper (but without title, subheadings, summary, tables, etc.). However, the two single column layouts had a larger serif type and a longer line length. Therefore, it is possible that the significant advantage of the single column layout over the double column layout in terms of speed of reading and comprehension might have also been related to the change in type size, and not just to the number of columns.

For reading examination materials using academic texts from scientific journals and magazines, Lonsdale *et al* (2006) and Lonsdale (2007) reported an advantage in favour of the single column layout. Participants took less time to read and answer questions with the single column layout. The number of correct answers was also higher with this layout. In terms of judgement, participants also considered that the answers were easier to locate with the single column layout. However, as in Poulton's (1959) study, other typographic features were manipulated. Both layouts

had the same Time News Roman typeface and the same type size of 10.5 points. Logically, as the page size was the same, the single column layout had a longer line length (70 characters) than the double column layout (42 characters). In addition, the single column layout had an interlinear space of 14 points (as opposed to 11 points), and the paragraphs were distinguished by a line space (as opposed to an indent of 35mm at the beginning of the paragraphs with no line space). Therefore, the advantage of the single column layout over the double column layout seems to be related to a combination of typographic features that work together in order to produce a more legible layout.

Authors have also made some recommendations concerning the structural nature of the text, page size, margin width, as well as circumstances of use. It has been proposed that for straightforward prose to be set on an A4 page, a double column arrangement with a medium line length is probably better than a single column arrangement with long lines (Rehe, 1979, 50), unless wide margins are used with the single column (Simmonds and Reynolds, 1994, 54). Moreover, if the text requires headings or integrates non-textual elements that could occupy the space of two columns (e.g. large tables, diagrams, or figures), then a single column layout is advisable (e.g. Hartley and Burnhill, 1977a, 69; Southall, 1984, 87). However, if the non-textual elements have different sizes, two columns give more flexibility (Simmonds and Reynolds, 1994, 54). If the two columns are asymmetric, for example, a wider column and a narrow column, even more flexibility is possible. As explained by Simmonds and Reynolds (1994, 54), with a wider and a narrower column the non-textual elements can occupy the wider column, the narrower column, or both. According to the authors, the narrower column can also be used for headings, captions, and notes, as well as small illustrations. However, Simmonds and Reynolds emphasise the importance of avoiding having too many different elements competing for attention in the narrower column.

In conclusion, decisions regarding columns cannot be taken by considering line length alone. Instead, all the structural requirements of the text and circumstances of use have to be taken into account (Hartley *et al*, 1978, 193-4). Carter *et al* (1993, 91) add that, as column measure increases, the interlinear space should also increase to maintain a proper ratio of column width to interlinear space (as discussed above).

TABLE 10.

Columns

| Research | Practice |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none">• When scanning for target words, the double column layout seems to have an advantage. [Foster, 1970; Hartley <i>et al.</i>, 1978]• For scientific journals and exams, a single column layout is read quicker. [Poulton, 1959; Lonsdale <i>et al.</i>, 2006; Lonsdale, 2007] | <ul style="list-style-type: none">• For straightforward prose a double column layout with a medium line length is better than a single column layout with long lines. Unless wide margins are used with the single column. [Rehe, 1979; Simmonds and Reynolds, 1994]• If the text requires headings or integrates non-textual elements that could occupy the space of two columns, a single column layout is advisable. [Hartley and Burnhill, 1977a; Southall, 1984]• If the two columns are asymmetric the narrower column can be used for headings, captions, and notes, as well as small illustrations [Simmonds and Reynolds, 1994]• As column measure increases, the interlinear space should also increase. [Carter <i>et al.</i>, 1993] |

FIGURE 11. BELOW

Layouts intended to be: more legible [top left], of medium legibility [top right], less legible [bottom left] – based on Lonsdale *et al.*'s study (2006).

5. TYPOGRAPHIC STRUCTURE

5.1. TEXT STRUCTURE



Jonassen (1985, 187) notes that text structure should be clear to readers, as it can give clues about the location of information in the text. Hartley and Burnhill (1976, 100) also argue that a clear structure of text is important, as readers cannot focus on the content if at the same time they have to sort out the arrangement of the material (see also Hartley, 1980a, 1980b, 1994, 2004; and Hartley and Burnhill, 1977b). With this view as a basis, some experimental comparisons have been conducted to assess legibility of original versus revised layouts, using speed of reading and accuracy as measures.

Hartley and Burnhill (1976), for example, revised and compared a printed document circulated by the British Psychological Society (BPS) with the original version. The revision consisted of manipulating a combination of typographic features, mainly the rational use of vertical (additional space between line and sections) and horizontal space (wider margins and inclusion



of some marginal headings) to clarify the hierarchical structure of the document. Participants were asked to find and circle information in one or other of the two documents. The results demonstrated that participants with the original document took longer to find the main items on the page, and a considerable percentage (50 per cent) did not find any item at all. Hartley and Burnhill's (1976) concluding comment was that function and form must work in parallel, and if writers, editors, and printers think more about the spatial arrangement of text, then the way the content is logically structured will be improved.

Two other studies (Lonsdale *et al*, 2006 and Lonsdale, 2007), already mentioned in the previous section, tested the effect of text layout on performance in the particular context of examination-type situations. The three layouts tested were chosen from existing examinations and were intended to represent three levels of legibility: layout 1 was intended to be more legible than the other two; layout 2 was intended to have medium legibility, and layout 3 was intended to be the least legible of the three. Results showed that layout 1, the one conforming to legibility guidelines (serif type for the text, sans serif type for the headings, type size of 10.5 points, interlinear space of 14 points, line length of 70 characters, text left aligned, single column, wide margins and paragraphs distinguished by one line space with no indent) resulted in a shorter task time, better accuracy, and more correct answers per second. This layout was also perceived as making it easier to locate answers.

Preferences for different typographic layouts have been further examined. Hartley and Trueman (1981) developed an experimental comparison to see the contributions that changes in layout could

TABLE 11.

| Text structure | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Research | Practice |
| <ul style="list-style-type: none">• The rational use of horizontal and vertical space clarifies the hierarchical structure of the document. Readers favour these structures. [Hartley and Burnhill, 1976; Hartley and Trueman, 1981]• Layouts conforming to legibility guidelines (serif type for the text, sans serif type for the headings, type size between 10- and 11-points, interlinear space of 14 points, line length of 70 characters, left aligned text, single column, wide margins), result in better performance and are perceived as easier to read. [Lonsdale <i>et al</i>, 2006; Lonsdale, 2007] | <ul style="list-style-type: none">• Text structure should be clear and give clues about the location of information in the text. [Jonassen,1985; Hartley and Burnhill, 1976; Hartley, 1980a, 1980b, 1994 and 2004; Hartley and Burnhill, 1977b] |

make to the effectiveness of a particular text. A large number of students were asked for their preferences for text versions that varied in terms of their layout (features such as typeface, space, and configuration). Results showed a significantly greater preference for the layout in which the typographic features had been manipulated in order to increase the effectiveness of a particular text.

In all these experiments, great importance was given to the manipulation of space as a simple way to help readers see clearly the structure of the printed information when looking at the whole page.

6. SUMMARY AND RATING OF STUDIES

All of the studies mentioned in this paper are listed in Table 12 to give further information on the different approaches followed by each researcher, as well as the results obtained. The studies have been rated taking into account sensitivity and detail, i.e. whether

- _ more than one measure was used,
- _ there was an adequate check of accuracy when testing only reading speed,
- _ there was a sufficient number of participants,
- _ the reading materials tested were real-life materials, as opposed to unrealistic simulations,
- _ the reading materials had the same level of difficulty,
- _ an example/illustration of the reading materials was presented,
- _ the reading task tested was a task performed in real-life reading situations,
- _ the reading materials were long enough to produce reliable results,
- _ the x-height was considered when testing different fonts,
- _ different typographic variables were considered in relation to each other.

After reviewing the literature, it seems that speed of reading continuous text is one of the most satisfactory methods available for investigating typographic legibility and, therefore, the most widely used. Preferences are not as sensitive as speed of reading and users' judgements do not always agree with their performance. For these reasons, studies testing only preferences do not score high on the table. It should be also noted that secondary sources (indicated with SS on the table) are not rated because there is not sufficient information to make a fair judgment.

TABLE 12.

| | RESEARCHERS | MEASURE | SUBJECTS | MATERIAL | FINDING | RATING |
|------------------------------|----------------------------------------------------------|---------------------------------------------------|--------------------|-----------------------------------|----------|--------|
| Typeface | Pyke (1926) | Reading speed Accuracy Preferences | — | 48 lines of text per page | NS | SS |
| | Paterson and Tinker (1932) | Reading speed w/ accuracy check | 900 (10gp X 90) | 30 paragraphs of 30 words each | NS | *** |
| | Burt (1959) | Reading speed Accuracy Preferences | — | One page long passage | NS | SS |
| | Tinker (1963a) | Preferences | 210 | — | S | SS |
| Serif vs sans serif | Poulton (1965) | Reading speed w/ accuracy check | 375 (6 groups) | 450 words long passages | NS | **** |
| | Moriarty and Scheiner (1984) | Reading speed | 260 | Sales brochure | NS | *** |
| | Schriver (1997) | Preferences | 67 | Documents typically used | NS | *** |
| Italic | Tinker and Paterson (1928) | Reading speed w/ accuracy check | 320 (4gp X 80) | 30 paragraphs of 30 words each | S | *** |
| | Paterson and Tinker (1940; described in Tinker 1963a) | Preferences | 224 | — | S | SS |
| | Tinker (1955) | Reading speed w/ accuracy check | 192 (6gp X 32) | 450 items of 30 words each | S | *** |
| Bold | Luckiesh and Moss (1940) | Reading speed Rate of blinking | 40 | Continuous text | NS NS | *** |
| | Tinker and Paterson (1942) | Reading speed w/ accuracy check Preferences | 100 224 | 5 paragraphs of 30 words each | NS S | *** |
| All-capitals vs lowercase | Tinker and Paterson (1928) | Reading speed w/ accuracy check | 320 (4gp X 80) | 30 paragraphs of 30 words each | S | *** |
| | Tinker and Paterson (1942) | Reading speed w/ accuracy check Preferences | 320 224 | 5 paragraphs of 30 words each | S S | *** |
| | Tinker (1955) | Reading speed w/ accuracy check | 254 (2gp X 127) | 450 items of 30 words each | S | *** |
| | Poulton (1967) | Searching speed w/ accuracy check | 264 | Newspaper (2 sheets) | S | ***** |
| Type size | Paterson and Tinker (1929) | Reading speed w/ accuracy check | 320 (4gp X 80) | 30 sentences of 30 words each | S | ** |
| | Tinker (1963a) | Preferences | 224 | — | S | SS |
| | Poulton (1972) | Searching speed w/ accuracy check | 262 | List of food ingredients | S | **** |

| | RESEARCHERS | MEASURE | SUBJECTS | MATERIAL | FINDING | RATING |
|--------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------|---------------------------|------------------------------------------------------------|----------|--------|
| Colour | Tinker and Paterson (1931) | Reading speed w/ accuracy check | 850 (10gp X 85) | 30 paragraphs of 30 words each | S | *** |
| | Luckiesh and Moss (1938, described in Tinker 1963a) | Reading Speed Rate of blinking Preferences | 20 | Continuous text | NS S | SS |
| | Michael and Jones (1955) | Accuracy | 688 (4 groups) | Examinations | NS | *** |
| | Tinker (1963a) | Preferences | 210 | 30 paragraphs of 30 words each | S | SS |
| Interletter/ interword spacing | Spencer and Shaw (1971) | Reading speed Accuracy Searching speed | 100 (5 groups) | 500 words long texts | NS | ***** |
| Alignment | Zachrisson (1965) | Reading speed (eye-movements) | 48 | 20 lines of text | NS | ** |
| | Fabrizio et al (1967) | Accuracy speed and level | 216 | Davis Reading Test = 4 test forms with 80 items each | NS | *** |
| | | Reading speed (eye-movements) | 18 | | | |
| | Becker et al (1970) | Preferences | 80 | 6 pages long text | NS | ** |
| | Gregory & Poulton (1970) | Reading speed Accuracy | 72 | 450 words passages | NS | ***** |
| | Hartley and Burnhill (1971) | Reading speed Accuracy Preferences | 49 | 2500 words long passages | NS | ***** |
| | Hartley and Mills (1973) | Reading speed Accuracy Preferences | 156 (2 groups) 61 | 700 words long passages | NS NS | ***** |
| | | | | | | |
| | Wiggins (1977) | Reading speed w/ accuracy check | 324 | 30 paragraphs of 30 words each | NS | *** |
| Line length | Wiggins (1977) | Reading speed w/ accuracy check | 300 | 30 paragraphs of 30 words each | S | *** |
| Interlinear space Type size Line length | Paterson and Tinker (1932 to 1949; described in Tinker 1963a) | Reading speed w/ accuracy check | 11420 | 30 paragraphs of 30 words each | S | SS |
| | Tinker (1963b) | Reading speed w/ accuracy check Preferences | 820 (10gp X 82) 180 | 30 paragraphs of 30 words each | S S | **** |
| Paragraphs | Paterson and Tinker (1940; described in Tinker 1963a) | Reading speed w/ accuracy check | 180 | 6 paragraphs with 15 words each | S | SS |
| | Hartley et al (1978) | Scanning speed w/ accuracy check | 500 (8 groups) | 4 pages long text | S | **** |
| | Schrivver (1997) | Preferences | 18 | 2 page spreads | S | ** |

TABLE 12. CONTINUED

| | RESEARCHERS | MEASURE | SUBJECTS | MATERIAL | FINDING | RATING |
|----------------|-------------------------------------------------------|-----------------------------------------------------|-----------------|--------------------------------|------------|--------|
| Margins | Paterson and Tinker (1940; described in Tinker 1963a) | Reading speed w/ accuracy check | 190 | 30 paragraphs of 30 words each | NS | SS |
| Headings | Poulton (1967) | Searching speed w/ accuracy check | 264 | Newspaper (2 sheets) | S | ***** |
| | Hartley and Trueman (1983) | Recall + Search + Retrieval (all w/ accuracy check) | 1270 (9 groups) | 3½ pages long passages | NS | **** |
| | Williams and Spyridakis (1992) | Discriminability Preferences | 30 | 16 cards with meaningless text | S S | **** |
| Columns | Paterson and Tinker (1940; described in Tinker 1963a) | Preferences | 241 | Article | S | SS |
| | Poulton (1959) | Reading speed w/ accuracy check | 275 | 2 passages of 1,150 words | S | **** |
| | Foster (1970) | Reading speed w/ accuracy check | 40 | One page article | S | *** |
| | Hartley et al (1978) | Scanning speed w/ accuracy check | 500 (8 groups) | 4 pages long text | S | **** |
| | Wendt (1979) | Reading speed Achievement Preferences | 600 (4gp X 150) | 2 page spread – textbook | NS – | ***** |
| | Lonsdale (2006) | Reading speed Accuracy Efficiency Preferences | 30 | Passages of 800 words | S S | ***** |
| | Lonsdale (2007) | Reading speed Accuracy Efficiency Preferences | 90 (3gp X 30) | Passages of 800 words | S S | ***** |
| | | | | | | |
| Text structure | Hartley and Burnhill (1976) | Reading speed w/ accuracy check | 20 | Pamphlet pages of 300 words | S | **** |
| | Hartley and Trueman (1981) | Preferences | 315 (5 studies) | Pages of instructional text | S | *** |
| | Lonsdale (2006) | Reading speed Accuracy Efficiency Preferences | 30 | Passages of 800 words | S S | ***** |
| | Lonsdale (2007) | Reading speed Accuracy Efficiency Preferences | 90 (3gp X 30) | Passages of 800 words | S S | ***** |

7. CONCLUSION

This literature review started by discussing evidence on how each typographic feature may affect legibility, i.e. the speed and accuracy of reading text. Legibility can be affected by the way features are treated that reside in the characters themselves, the horizontal and vertical space between characters or sets of characters, and the configuration of the text. However, it was clear throughout this individual analysis that, for good legibility, the various typographic features should be selected in relation to each other (as highlighted before by, for example, Lupton, 2004; Lonsdale *et al*, 2006; Lonsdale, 2007). Each typographic choice affects the other. For example, it does not seem sufficient to have text set in a moderate line length if at the same time a small type size with little or no interlinear space are used and paragraphs are not sufficiently distinguished. Therefore, the various features that define a typographic layout should be combined and manipulated as a group to make the layout legible.

Equally important is the fact that the present literature review took two fundamental and distinct approaches into account, i.e. legibility research and typographic practice. Although legibility research and typographic practice do not always reach the same conclusions, both contribute to the study of the typographic features of text. Typographic practice can usefully inform legibility research on which material is relevant to test, whilst legibility research can give us clear information regarding readers' performance, tolerance, and preferences.

To give a concrete example, the mutual relationship between research and practice is of most importance in those particular cases where 1) the reader has no power to decline reading a text that he/she does not find legible and 2) reading a text has a direct link on performance and achievement. This is certainly the case in examinations (as supported by Lonsdale *et al*, 2006 and Lonsdale's, 2007 studies – Section 5) which are used extensively every academic year and for every subject field. But, interestingly enough, it is also the case for essays that are submitted by the students for assessment. This is supported by Hartley's *et al*' (2006) study conducted to test the effects of typographic variables on essay grades. The results showed that essays using a combination of popular and more legible typographic features gained significantly higher marks than those using other combinations.

Just in these two particular cases, the combined effort between research and practice would benefit teaching and learning by designing well informed solutions, as well as making available clear guidance on how typographic features of text can be used to minimise unwanted effects on performance and consequently on students' grades.

This is true for examinations and essays but would also be true for many other graphic materials similar to examinations and essays that are used everyday to teach, learn, study (e.g. classroom material,

textbooks, virtual learning environments), to research (e.g. journals, primary sources, academic books), to write about one's work (e.g. dissertations, projects, reports, presentation material), to read for general information (e.g. newspapers, magazines, websites, apps), to read for pleasure (e.g. magazines, books), to advertise (e.g. direct mail, brochures), and so on.

This review is therefore valuable in providing guidance on the design and preparation of typographic materials. It will help designers, researchers, scholars, as well as students and anyone using typography to make informed and educated typographic choices. If the aim is to communicate objectively and to facilitate ease of reading, then typographic legibility is the answer.

ACKNOWLEDGMENTS

The author would like to thank Mary Dyson and Linda Reynolds from the Department of Typography and Graphic Communication at the University of Reading, who contributed to her research with their suggestions, knowledge and advice. The author also wishes to express her sincere gratitude to Mike Zender and the anonymous reviewers whose valuable comments helped strengthen this paper.

REFERENCES

- Becker, D., Heinrich, J., von Sichowsky, R. and Wendt, D. 1970. "Reader preferences for typeface and leading." *Journal of Typographic Research*, 4, 61-66.
- Beier, S. 2012. *Reading letters: designing for legibility*. Amsterdam: BIS.
- Beier, S. and Dyson, M. C. 2014. "The influence of serifs on 'h' and 'i': useful knowledge from design-led scientific research." *Visible Language* 47.3, 74-95.
- Black, A. 1990. *Typefaces for desktop publishing: a user guide*. London: Architecture Design and Technology Press.
- Bringhurst, R. 1992. *The elements of typographic style*. Vancouver: Hartley & Marks.
- Burt, C. S. 1959. *A psychological study of typography*. Cambridge: Cambridge University Press.
- Carter, R., Day, B. and Meggs, P. B. 1993. *Typographic design: form and communication* (2nd edn). New York: John Wiley & Sons.
- Chung, S. T. L. 2002. "The effect of letter spacing on reading speed in central and peripheral vision." *Investigative Ophthalmology & Visual Science*, 43, 1270-1276.

- Cornog, D. and Rose, F. 1967. *Legibility of alphanumeric characters and other symbols 2: a reference handbook*. Washington: National Bureau of Standards.
- Dyson, M. C. 2013. "Where theory meets practice: a critical comparison of research into identifying letters and craft knowledge of type design." *The Design Journal*, 16.3, 271-294.
- Fabrizio, R., Kaplan, I. and Teal, G. 1967. "Readability as a function of the straightness of right-hand margins." *Journal of Typographic Research*, 1, 90-95.
- Foster, J. J. 1970. "A study of the legibility of one-and two-column layouts for BPS publications." *Bulletin of the British Psychological Society*, 23, 113-114.
- Gilreath, C. T. 1993. "Graphic cueing of text: the typographic and diagraphic dimensions." *Visible Language*, 27.3, 336-361.
- Glynn, S., Britton, B. and Tillman, M. 1985. "Typographical cues in text: management of the reader's attention." In D. H. Jonassen (ed), *The technology of text: principles for structuring, designing and displaying text*, vol. 2. New Jersey: Educational Technology Publications, 192-209.
- Gregory, M. and Poulton, E. C. 1970. "Even versus uneven right-hand margins and the rate of comprehension in reading." *Ergonomics*, 13.4, 427-434.
- Hartley, J. 1980a. "Space and structure in instructional text." In J. Hartley (ed), *The psychology of written communication: selected readings*. London: Kogan Page, 127-143.
- Hartley, J. 1980b. "Spatial cues in text: some comments on the paper by Frase & Schwartz (1979)." *Visible Language*, 14.1, 62-79.
- Hartley, J. 1994. *Designing instructional text* (3rd edn). London: Kogan Page.
- Hartley, J. 2004. "Designing instructional and informational text." In D. H. Jonassen (ed), *Handbook of research on educational communications and technology* (2nd edn). Mahwah, New Jersey: Lawrence Erlbaum Associates, 917-947.
- Hartley, J. and Burnhill, P. 1971. "Experiments with unjustified text." *Visible Language*, 5, 265-278.
- Hartley, J. and Burnhill, P. 1976. "Explorations in space: a critique of the typography of BPS publications." *Bulletin of the British Psychological Society*, 29, 97-107.
- Hartley, J. and Burnhill, P. 1977a. "Fifty guide-lines for improving instructional text." *Programmed Learning and Educational Technology*, 14.1, 65-73.

- Hartley, J. and Burnhill, P. 1977b. "Understanding instructional text: typography, layout and design." In M. Howe (ed), *Adult learning: psychological research and applications*. London: John Wiley & Sons, 223-247.
- Hartley, J. and Mills, R. 1973. "Unjustified experiments in typographical research and instructional design." *British Journal of Educational Technology*, 2.4, 120-131.
- Hartley, J. and Rooum, D. 1983. "Sir Cyril Burt and typography: A reevaluation." *British Journal of Psychology*, 74, 203-212.
- Hartley, J. and Trueman, M. 1981. "The effects of changes in layout and changes in wording on preferences for instructional text." *Visible Language*, 15.1, 13-31.
- Hartley, J. and Trueman, M. 1983. "The effects of headings in text on recall, search and retrieval." *British Journal of Educational Psychology*, 53, 120-131.
- Hartley, J., Young, M. and Burnhill, P. 1975. "The effects of interline space on judgments of typesize." *Programmed Learning and Educational Technology*, 12.2, 115-119.
- Hartley, J., Trueman, M., Betts, L. and Brodie, L. 2006. "What price presentation? The effects of typographic variables on essay grades." *Assessment & Evaluation in Higher Education*, 31.5, 523-534.
- Hartley, J., Burnhill, P. and Davis, L. 1978. "The effects of line length and paragraph denotation on the retrieval of information from prose text." *Visible Language*, 12.2, 183-194.
- Humphreys, G. W. and Bruce, V. 1989. *Visual cognition: computational, experimental and neuropsychological perspectives*. East Sussex: Lawrence Erlbaum Associates.
- Jonassen, D. H. (ed). 1985. *The technology of text: principles for structuring, designing, and displaying text*, vol. 2. New Jersey: Educational Technology Publications.
- Legge, G. E. and Bigelow, C. A. 2011. "Does print size matter for reading? A review of findings from vision science and typography." *Journal of Vision*, 1.5:8, 1-22.
- Lewis, J. 1963. *Typography: basic principles. Influences and trends since the 19th century*. London: Studio Books.
- Lonsdale, M. dos S. 2007. "Does typographic design of examination materials affect performance?" *Information Design Journal* 15.22, 114-138.
- Lonsdale, M. dos S., Dyson, M. and Reynolds, L. 2006. "Reading in examination-type situations: the effects of the typographic layout on

- performance." *Journal of Research in Reading*, 29.4, 433-453.
- Lorch, R. F. 1989. "Text-signaling devices and their effects on reading and memory processes." *Educational Psychology Review*, 1.3, 209-234.
- Luckiesh M., Moss F. K. 1938. "Visibility and readability of print on white and tinted papers." *Sight-Saving Review*, 8, 123-134.
- Luckiesh M., Moss F. K. 1940. "Boldness as a factor in type-design and typography." *Journal of Applied Psychology*, 24.2, 170-183.
- Luna, P. 1992. *Understanding type for desktop publishing*. London: Blueprint.
- Lund, O. 1995. "Review of Kim Pederson and Anders Kidmose, In black & white: an r & d report on typography and legibility." *Information Design Journal*, 8.1, 91-95.
- Lund, O. 1999. *Knowledge construction in typography: the case of legibility research and the legibility of sans serif typefaces*. Unpublished Ph.D. Thesis. Department of Typography & Graphic Communication, The University of Reading, U.K.
- Lupton. 2004. *The science of typography*. https://www.typoshock.com/articles/the_science_of_typography (Accessed 28 May 2014).
- McLean, R. 1980. *The Thames and Hudson manual of typography*. London: Thames and Hudson.
- Michael, W. B. and Jones, R. A. 1955. "The influence of color of paper upon scores earned on objective achievement examination." *Journal of Applied Psychology*, 39.6, 447-450.
- Moriarty, S. E. and Scheiner, E. C. 1984. "A study of close-set text type." *Journal of Applied Psychology*, 69.4, 700-702.
- Paterson, D.G. and Tinker, M. A. 1929. "Studies of typographical factors influencing speed of reading: II. Size of type." *Journal of Applied Psychology*, 13.2, 120-130.
- Paterson, D.G. and Tinker, M. A. 1932. "Studies of typographical factors influencing speed of reading: X. Style of type face." *Journal of Applied Psychology*, 16.6, 605-613.
- Paterson, D.G. and Tinker, M. A. 1940. *How to make type readable*. Harpers, xix-209.
- Poulton, E. C. 1959. "Effects of printing types and formats on the comprehension of scientific journals." *Nature*, 184, 1824-1825.
- Poulton, E. C. 1965. "Letter differentiation and rate of comprehension in reading." *Journal of Applied Psychology*, 49.5, 358-362.
- Poulton, E. C. 1967. "Searching for newspaper headlines printed in capitals or lower-case letters." *Journal of Applied Psychology*, 51.5, 417-425.

- Poulton, E. C. 1969. "Skimming lists of food ingredients printed in different sizes." *Journal of Applied Psychology*, 53.1, 55-58.
- Poulton, E. C. 1972. "Size, style, and vertical spacing in the legibility of small typefaces." *Journal of Applied Psychology*, 56.2, 156-161.
- Pyke, R. L. 1926. *Report on the legibility of print*. London: Medical research Council.
- Rehe, R. F. 1979. *Typography: how to make it most legible*. Carmel: Design Research Publications.
- Reynolds, L. 1978. "The legibility of printed scientific and technical information." In R. Easterby and H. Zwaga (eds), *Information design: the design and evaluation of signs and printed material*. Chichester: John Wiley & Sons, 187-208.
- Schrivver, K. A. 1997. *Dynamics in document design: creating texts for readers*. New York: John Wiley & Sons.
- Schwarz, M. N. K. and Flammer, A. 1981. "Text structure and title: effects on comprehension and recall." *Journal of Verbal Learning and Verbal Behavior*, 20, 61-66.
- Simmonds, D. and Reynolds, L. 1994. "Data presentation and visual literacy in medicine and science." Oxford: Butterworth-Heinemann.
- Simon, O. 1945. *Introduction to typography*. London: Faber & Faber.
- Skottun, B. C. and Freeman, R. D. 1983. "Perceived size of letters depends on inter-letter spacing: a new visual illusion." *Vision Research*, 23, 111-112.
- Southall, R. 1984. "First principles of typographic design for document production." *TUGboat*, 5.2, 79-91.
- Spencer, H. 1969. *The visible word*. London: Lund Humphries.
- Spencer, H. and Shaw, A. 1971. "Letter spacing and legibility." *British Printer*, 84.2, 84-86.
- Strizver, I. 2014. *Type rules: The Designer's Guide to Professional Typography* (4th edn). New Jersey: John Wiley & Sons.
- Tinker, M. A. 1955. "Prolonged reading tasks in visual research." *Journal of Applied Psychology*, 39.6, 444-446.
- Tinker, M. A. 1963a. *Legibility of print*. Ames, Iowa: Iowa State University Press.
- Tinker, M. A. 1963b. "Influence of simultaneous variation in size of type, width of line, and leading for newspaper type." *Journal of Applied Psychology*, 47.6, 380-382.
- Tinker, M. A. and Paterson, D. G. 1928. "Influences of type form on speed of reading." *Journal of Applied Psychology*, 12.4, 359-368.

- Tinker, M. A. and Paterson, D. G. 1931. "Studies of typographical factors influencing speed of reading: VII. Variations in color of print and background." *Journal of Applied Psychology*, 15.5, 471-479.
- Tinker, M. A. and Paterson, D. G. 1942. "Reader preferences and typography." *Journal of Applied Psychology*, 26, 38-40.
- Tschichold, J. 1967. *Asymmetric typography* (trans. R. McLean). London: Faber & Faber Limited.
- Twyman, M. 1982. "The graphic presentation of language." *Information Design Journal*, 3.1, 2-22.
- Wendt, D. 1979. "An experimental approach to the improvement of the typographic design of textbooks." *Visible Language*, 13.2, 108-133.
- Wiggins, R. H. 1977. "Effects of three typographical variables on speed of reading." *Visible Language*, 1, 5-18.
- Wijnholds, A. D. B. 1997. *Using type: the typographer's craftsmanship and the ergonomist's research*. Available from: <http://www.plainlanguage-network.org/type/utboinst.htm> (Accessed 10 June 2014).
- Williams, T. R. and Spyridakis, J. H. 1992. "Visual discriminability of headings in text." *IEEE Transactions on Professional Communication*, 35.2, 64-70.
- Wright, P. and Barnard, P. 1975. "'Just fill in this form': a review for designers." *Applied Ergonomics*, 6.4, 213-220.
- Yu, D., Cheung, S., H., Legge, G. E., and Chung, S. T. L. 2007. "Effect of letter spacing on visual span and reading speed." *Journal of Vision*, 7.2:2, 1-10.
- Zachrisson, B. 1965. *Studies on the legibility of printed text*. Stockholm: Almqvist and Wiksell.

ABOUT THE AUTHOR

Maria dos Santos Lonsdale is a lecturer, researcher and graphic designer. She is Currently teaching at the University of Hull, Cottingham Road, HU6 7RX, UK. Having taught Graphic Design and Psychology of Perception in Portugal, she came to do a Ph.D at the Department of Typography and Graphic Communication, University of Reading, UK. Her research involves Typographic and Graphic Design, Psychology of Reading, and various research methods including experimental studies. Her research interests lie in typographic design of instructional and information materials and how they affect performance.

Book Review:

Design for information, an introduction to the histories, theories, and best practices behind effective information visualizations.

by

Isabel Meirelles

Beverly, MA: Rockport Publishers, 2013.

Jorge Frascara

Design for information is a thorough representation of both the field of information visualization and the research interests of the author, whose focus is on “the theoretical and experimental examination of the fundamentals underlying how information is structured, represented and communicated in different media.”

Beginning with the “big picture,” the book includes an amazing collection of examples, the most thorough I have seen to date in a volume. The author organizes the content according to several categories represented by the titles of the chapters: 1. Hierarchical structures: trees; 2. Relational structures: networks; 3. Temporal structures: timelines and flows; 4. Spatial structures: maps; 5. Spatio-temporal structures; and 6) Textual structures. An appendix, notes, a bibliography, a contributors list, and an index complete the content of the book.

Design for information is an extensive taxonomy of data visualization types and is “a must” for anybody interested in the work done in the area. Each one of the hundreds of examples is explained and discussed, forming a kind of encyclopedia on the subject. It seems that nothing escaped the exemplary collection that Meirelles assembled. The discussions and explanations normally focus on what information is represented and how it is represented.

It is interesting to see, as well, how many different professional fields today use diagrams to organize and represent information: basic science, applied science, education, engineering, medicine, and technologies, etc. The value of the book is centered on the inclusion of examples of how many different problems are now being addressed through data visualizations, how many historical efforts preceded whatsoever is

done today, and how the advent of the computers have allowed the field to explode by handling large data sets as well as dynamic representations.

At the end of the examination of the 224-page volume I became curious as to how these diagrams might have performed with the users they were intended for in terms of ease of comprehension; what conclusions I could arrive at from an evaluation of the examples from a perceptual and cognitive human factors perspective; or how a complementary book could contribute to the development of best practices. I would not expect that one volume could be so extensive as this one and also cover the field critically. However, I have to wonder how the super-complex visualizations permitted by computer programs today would perform regarding comprehension, memorization, and use of the information presented. The discussion on perception and cognition is very brief, and it might leave some readers wondering about the assertions made: they are proposed as principles without them being discussed. This topic, as well as Gestalt theory, are not considered during the description of examples. The size of some reproductions is too small to assess their quality as data visualizations. They appear as examples of problems addressed but not as information in themselves. To compensate for this, the book includes valuable URLs for people interested in seeing in better detail many of the diagrams shown.

While the above issues could be perceived as weaknesses, the strength of the book is its truly amazing array of examples and the rare historical diagrams it offers. It also displays an uncommon erudition and includes an extensive and useful bibliography. I do not know how long Meirelles took to complete the manuscript, but it feels like a lifetime project. These assets, coupled by excellent production, make this an indispensable publication for anyone interested in information visualization.

Book Review:

Isotype: Design and contexts 1925–1971

by

Burke, Christoher; Kindel, Eric; Walker, Sue (Eds.)

Hyphen Press, London, 2013

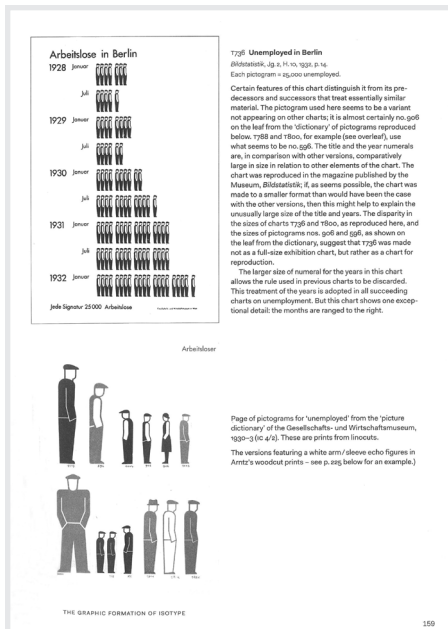
Per Molleup

Isotype, why not?

The term Isotype, an acronym for International System Of Typographic Picture Education, is a technique of data visualization introduced by sociologist, economist, and philosopher Otto Neurath. Originally called “The Vienna

School of Pictorial Statistics” and developed and practiced at the Gesellschafts- und Wirtschafts-museum in Wien (Social and Economic Museum of Vienna), 1925–34, Isotype’s purpose was to communicate societal information to visitors. In 1935, Neurath’s technique was renamed, and Isotype began its own life and was used for other purposes in other places.

Isotype builds on the idea expressed in Neurath’s often-repeated adage, “To remember simplified pictures is better than to forget accurate numbers” (p. 85). Therefore, Isotype is best known for Picture tables—graphic displays with rows of repeated pictograms each standing for a number of real world units. The picture tables embody the proposition that it is easier to compare quantities by comparing numbers of well-presented symbols, than to compare symbols of different size. Pictograms in the Isotype picture tables are scaled: in a display showing unemployment, each pictogram would stand for 1,000; 100,000; or 1 million – or another round number of unemployed persons. In picture tables, the reader must count the pictograms in different groups and multiply with the scaling factor to get the total amounts. The number of the repeated pictograms in a picture table is most often rounded off. Some Isotype picture tables feature half, quarter, or smaller fractions of pictograms. Even then, Isotype displays are typically not as precise as the numbers they represent.



Page 158

Males with flat cap and hands in pocket stereotype unemployed persons. Striking workers have crossed arms.

Isotype: Design and contexts 1925-1971 describes Isotype in a period delimited by 1925 when the Gesellschafts-und Wirtschaftsmuseum in Wien was founded and 1971 when the Isotype Institute in London closed. The book comprises 12 chapters dealing with the genesis and further development and design of Isotype. The book includes two kinds of information; it describes Isotype design principles, and it describes the process by which Isotype was developed and disseminated. To this reviewer the former part is the most interesting, while the latter part serves as a useful historical backdrop.

TEACHING MUSEUM

In the first of two central chapters, Christopher Burke covers the ten-year lifetime of The Gesellschafts-und Wirtschaftsmuseum in Wien including the formative years of Isotype. The idea behind Isotype predated the museum. Otto Neurath, sociologist, economist, and philosopher, had already applied charts with pictorial descriptions of quantities for the Museum für Siedlung und Städtebau, Museum for Settlement and Town Planning. Eager to educate by means of these didactic tools, Otto Neurath suggested a new museum to expand the ordinary population's understanding of national and world relations. The social democrat regime in Vienna understood the importance of education and provided the necessary financial support.

Otto Neurath invented Isotype, but more than that, he promoted it. Philosophically and organisationally trained in addition to being well connected academically and politically he spread the word and established the connections that were vital to the incubation of a new idea like Isotype. Neurath partnered his strong interest in education of ordinary people with his equally strong social commitment resulting in his belief that progress depends on knowledge, and knowledge should be delivered in ways that are both attractive and memorable – essential qualities of Isotype.

The Gesellschafts und Wirtschaftsmuseum in Wien was not a museum in the traditional sense of that word; and therefore consistent with Neurath's view that "The modern museum should be a teaching museum, a means of education, a schoolbook on a grand scale..." (p. 30). The Gesellschafts und Wirtschaftsmuseum in Wien consisted primarily of graphic charts explaining societal matters, first and foremost quantities. The museum introduced a number of advanced ideas to meet its audience. To accommodate prospective visitors the museum was open evenings and Sunday mornings. Also, the museum branched out at several places where visitors would be. At a certain time, the museum would exhibit at several different locations in Vienna including the town hall. A central corner shop museum open in the lunch hours had as many as two thousand visitors a day. At the corner shop special interactive knowledge machines were placed where visitors could test their knowledge – anticipating a distant, digital future. Exhibition material was reused and exchanged between permanent

and time limited exhibitions in several places. Along with its own exhibitions, the museum took part in fairs and exhibitions in Austria and abroad.

The museum also published books, pamphlets, and journals to reach its audience in time and space. *Gesellschaft und Wirtschaft*, Society and Economy, was a collection of 100 Isotype charts. *Fernunterricht*, distant teaching/learning, later renamed *Bildstatistik*, Pictorial Statistics, prefigured modern distance learning.

Three persons led the development of Isotype: Otto Neurath, a sociologist, economist, and philosopher; Marie Reidemeister, a German academic; Georg Arntz, a German graphic designer.

Austrian Otto Neurath's past career included his initiative to, and directorship of, the German museum of war economy in Leipzig during WWI. After the war, his presidency of the Central Office of Economics, in the Bavarian Soviet Republic, was followed by a conviction of assisting high treason and an eighteen-month, later suspended, prison sentence. In 1920, Neurath was back in Vienna to become the director of the *Forschungsinstitut für Gemeindewirtschaft*, Research Institute for Co-operative Economy. In this capacity Neurath initiated a Museum for Settlement and Town Planning, which within a year – also on Neurath's initiative – was replaced by The *Gesellschafts- und Wirtschaftsmuseum* in Wien.

Marie Reidemeister (after 1940 Marie Neurath) met Otto Neurath before the start of the *Gesellschafts- und Wirtschaftsmuseum* in Wien, became his right hand, and continued working with Isotype after Otto Neurath's death in 1945. Most importantly, Marie Reidemeister played and developed the role of 'transformer'. Otto Neurath and Marie Reidemeister considered the 'transformation' of a message into a principle for a graphic chart the crucial part of the work with Isotype. Transformation was the link between science and graphic design. According to Marie Reidemeister: "We think out which is the point that has to be brought home, and then we try to do so in such a way that everybody will grasp it. We avoid distracting the attention from the more important issues." (p. 15). Also according to Marie Reidemeister, other designers impressed by Isotype would emulate the form but hardly master the transformation (p. 14). Today, the term 'transforming' is not used, but the substance is a natural part of the work of information designers engaged in data visualisation in news media and elsewhere.

Georg Arntz was a German artist working with woodcuts in precise graphic shapes, which caught the attention of Otto Neurath. Georg Arntz began working for the museum in 1928 and in 1929 moved to Vienna where he developed the schematic graphic form that became a signature quality of Isotype. In the process he also changed the technical production from paper cuts to printing from linocuts.

Three conditions for launching Isotype were present. First, a strong-minded initiator with a firm social and educational commitment who was well connected politically; second, highly qualified principal collaborators; and third, a friendly political market.

Partly inspired by the political winds and the following possible need for a foothold outside Austria, Otto Neurath established in 1932 the affiliate Mundaneum to take care of international relations. In 1932 and 1933, Mundaneum established branches in Amsterdam and London respectively. In 1934, the International Foundation for the Promotion of the Vienna Method of Visual Education was established in The Hague. Later in 1934, when the political situation in Austria and Vienna as envisioned by Neurath became dangerous, he, his wife Marie Reidemeister, Georg Arntz, and two other collaborators moved to the Netherlands. The Gesellschafts- und Wirtschaftsmuseum was closed. Part of its material was already transferred to Mundaneum. The rest was seized by the new regime, not the first time a design initiative has been subject to political change. In 1940 the Neuraths moved on to England.

THE NETHERLANDS

Two chapters of the book deal with the continuous work in the Netherlands and England. In Vienna, Isotype had been a means to inform the visitors of the Gesellschafts- und Wirtschaftsmuseum. In the Netherlands the Neurath team had to earn their way from projects. Otto Neurath wrote two books in Basic English: *International Picture Language* and *Basic by Isotype*. Other jobs included production of a children's theatre puppet show and an art exhibition, *Rondon Rembrandt*. Also, commissions resulted from Otto Neurath's frequent travels to the USA.

ENGLAND

When Germany occupied the Netherlands the Neuraths moved on to England, where Otto Neurath had been promised a teaching position at Oxford. The Isotype Institute was then established in 1942. The Isotype work in England followed two lines. The Neuraths wrote and designed a number of books for Adprint, a book packager who also published, and they worked on informative films together with British film producer John Rotha. The books dealt with the war effort and social policy. Apart from a couple of booklets this work included a three book series: *America and Britain*, *The Soviets and ourselves*, and *New Democracy*. Two chapters in *Isotype: Design and contexts 1925-1971* deal with film work and children's books respectively.

FILM

Documentary filmmaker John Rotha approached the Neuraths soon after their arrival in England to initiate a collaboration concerning films for the Ministry of Information. The first film, *A few ounces a day* about saving waste to be used in the war effort, was based exclusively on animated Isotype graphics. The Neuraths acted as de facto directors and Maria Neurath made a complete storyboard as well as the graphics to be animated. Later followed several films, where Isotype animations were combined with live action. A series of films that had significant results included, *Worker and*

warfront, which was shown for workers in factory canteens, *World of Plenty* and *Land of promise* which dealt with food and with planning respectively.

In 1945 Rotha established a special company, Unifilm, with himself and Otto Neurath as directors. After Otto Neurath's death Marie Neurath would continue the cooperation with John Rotha until 1948, when Unifilm closed down. In 1954 Marie Neurath contributed to a TV series, *The World is ours*, and in 1965 to a film *The physics and chemistry of water*.

The film work was not without problems. Some critics found that serious matters should not be treated through the genre of animation. The Neuraths complained when they did not have full control of the work, and Paul Rotha did not always find the necessary support for Isotype work from the Ministry. Professional designers recognise these kinds of problems. Otto Neurath also had some didactic reservations. Isotype on paper lets the viewer see and compare several displays concurrently in space, while film – working in time – doesn't provide that possibility. Also paper media, in contrast to film, gives viewers as much time as they want. Today video technology has solved this problem.

CHILDREN'S BOOKS

In her chapter about children's books Sue Walker rightly states that "The children's books produced by the Isotype Institute provide an excellent insight into Marie Neurath's work as a transformer and show that she had a particular skill in making charts and illustrations that were accessible to children of all ages." (p. 391). This chapter reaches beyond children's books: The account of Marie Neurath's approach is relevant to all designers concerned with data visualisation.

The children's book production took place from the 1940s into the 1970s. Otto Neurath took the initiative, but after his death Marie Neurath edited, wrote, and designed a large number of children's educational books, some of which were schoolbooks. Children's book series included *If you could see inside, I'll show you how it happens*, *Visual history of mankind*, *Visual science*, *Wonders of the Modern world*, and *Wonder world of nature*. The Isotype institute delivered both the text and design for these books. Illustrations would include pictograms and all kinds of explanatory drawings. In another series, *They lived like this*, the majority of the illustrations were drawings of contemporary artefacts. This series was co-written by external artists.

Marie Neurath's thoughts about the work with children's books are interesting to everyone working with data visualisation:

I had to ask myself: what are the essential things we want to show, how can we use comparison, direct the attention, through the arrangement and use of colour, to bring out the most important things at the first glance, and additional features on closer scrutiny. Details had to be meaningful, everything in the picture had to be useful for information. (p.395)

From a note addressed to the readers of the second book in the Visual history series:

Everything which would not help you understand the meaning, or which would confuse you, is left out. Colours are used only to help make the meaning clearer, never simply as decoration. This means that every line and every colour in these pictures has something to tell you. (p. 403)

U S A

Three factors obstructed Isotype's introduction into the USA. The timing was not good. It was the middle of the depression, there were several imitators (just competitors?) around, and there was Rudolf Modley, a former part-time employee in the administration of the Gesellschafts- und Wirtschaftsmuseum in Wien. Rudolf Modley would cooperate and compete with the Isotype team in Den Hague and Oxford, and challenge Otto Neurath's views.

A group of influential supporters worked together to get Otto Neurath and Isotype to the USA. When in 1930 there was an opportunity to use Isotype at the Museum of Science and Industry in Chicago, Otto Neurath recommended the employment of Rudolf Modley. Here and later Modley acted more independently than envisaged by Otto Neurath.

In 1934 the supporters founded the Organizing Committee for the Institute for Visual Education "to establish in the United States an organization which can develop and promote the graphic methods of presenting social and economic facts, which have been characterised by the Vienna Method as exemplified in the work of the Gesellschafts- und Wirtschaftsmuseum in Wien under the direction of Dr. Otto Neurath" (p. 307). When the organisation did not follow Modley's advice, he created his own company, Pictorial Statistics Inc. Otto Neurath and Rudolf Modley held differing views. Neurath wanted standardised pictograms designed centrally while Modley had a more relaxed view. Neurath explained:

That is to say, for our picture language one general list of a limited number of signs is needed for international use, and this has to be worked out by or under the control of one chief organization (This organization is now the ISOTYPE work-room at the Hague). (p. 332).

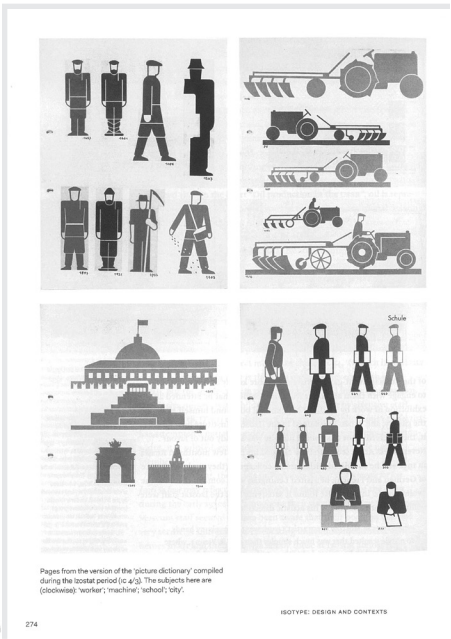
Also, Modley saw the pictograms as elements that could have their own life while Neurath saw pictograms as parts of visual arguments enabled by transformation. Modley was not interested in transformation. In line with this view he published symbols sheets with pictograms to be used by everyone and a book entitled, *1000 Pictorial Symbols* (1942).

Otto Neurath travelled to the USA several times and secured important commissions, primarily in the health sector. Isotype also delivered illustrations to *Compton's pictured encyclopedia* (1939) and Otto Neurath wrote *Modern man in the making* (1939) for Knopff publishers. After Neurath's death Marie Neurath wrote an essay on Isotype for Henry Dryfuss's *Symbol Source Book* (1972).

RUSSIA

The Isotype team's efforts in Russia took place from 1931-1934. Russia did not want to commission Isotype work from Vienna. Instead, they wanted Isotype staff to help establish a Soviet institute. A special organisation named Izostat was established with Otto Neurath as one of two directors, and several Isotype staff would join them for shorter or longer periods. The total staff at times would be as high as 75. A number of problems hindered

cooperation. The work primarily dealt with visualising the established success of the first five-year plan 1928-1932 and the predicted success of second five-year plan 1933-1937. While The Vienna Method as practiced in Vienna was based on empirical facts, the Russians wanted forecasts to play an essential role. The estimates were often exaggerated. Another problem was that the Russians wanted naturalistic pictograms aligned with wanted Soviet realism. Also, the Russians wanted more, sometimes propagandistic, illustration. The cooperation resulted in some publications with more or less Viennese influence. Georg Arntz made a series of charts for Izvestia, charts for exhibitions, and a number of publications more or less influenced by the Isotype team. One Isotype idea was used with a new meaning. In the Vienna Method black was sometimes used to illustrate worse, while red would stand for better. In Russian charts red would stand for Russia while black would stand for other nations.



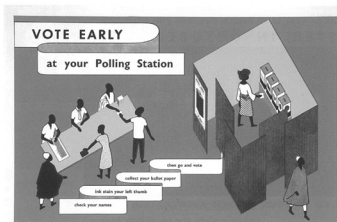
Page 174
Isotype work for Izostat in Moscow characterised by Russian realism.
(original in color)

In 1934 the Russians wrote to Otto Neurath that the contract did not comply with Russian law and the amount due at the end of the contract would not be paid. The latter incident was a major blow to the Isotype organisation, which in Den Hague depended on paid work. Izostat continued without Isotype help until 1940.

AFRICA

Some Isotype work in Africa took place from 1952-1958. Otto Neurath reportedly said that Isotype was not for the Viennese, but for the Africans (p. 449). In 1943 he worked on a proposal for an exhibition for the British Colonial Office entitled, *Human life in Africa*. This project did not materialize.

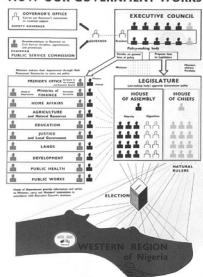
In 1953 a partnership between Buffalo Books, a subsidiary of Adprint, the Isotype Institute, and Purnell and Sons, a printing firm, planned and published the magazine *Forward* addressing the three British colonies Gold Coast (Ghana), Sierra Leone, and the Western Region of Nigeria soon to become independent. A trial issue and an issue number 1, dealing with culture, adventure, sports, and practical advice were published before the magazine was determined to be economically impossible in 1953.



"Vote early at your polling station", 1955-6, 300 x 250 mm.

"How our government works", 1955-7, 700 x 950 mm.

HOW OUR GOVERNMENT WORKS



ISOTYPE: DESIGN AND CONTEXTS

480

Page 480

Isotype work with limited abstraction for Western Region, Nigeria, promoted participation in an upcoming election. (original in color)

In 1954 Marie Neurath wrote a memorandum sketching what Isotype could do in the Western Region of Nigeria. It included a visual explanation of the aims of the government and the establishment of a local workshop for Isotype run by trained Nigerians. Marie Neurath visited Africa three times and a series of booklets and poster-leaflets were produced, while the workshop remained a plan.

For the Western Region a series of 16-page White Paper Booklets were published including *Education for all in the Western region*, *Better farming for better living in the Western Region*, *Health for all in the Western Region*, and *Paying for Progress in the Western Region*. Also a series of poster-leaflets dealing with health issues was produced. As indicated by the name, the poster-leaflets worked both as wall charts and as folded leaflets to take away. A following visit to the Western Region resulted in commissions for a new series of booklets.

Compared with the Western Region in Nigeria the Gold Coast and Sierra Leone had little work for Isotype. In 1956 Isotype made one leaflet for The Gold Coast, *The Volta River Project: what it means to you*, and in 1957 one for Sierra Leone *Voting, general election*.

In the late fifties the Isotype work in Africa came to an end. The chapter author, Eric Kindel, offers a number of probable explanations, one being the distance, another being the failure to establish a local workshop with trained local people. To the Isotype Institute the African experience meant realising the need for locally adapted symbols for man, woman, house, and more. The pictograms should 'speak'. In the same vein, charts were given familiar backgrounds. According to Marie Neurath: "[A]dherence to the method cannot go as far as imposing an alien background on those unable to share one's experience of it." (p. 495). This did not, according to Marie Neurath "imply that the system had to be radically changed" (p.495).

DESIGN

In the second central chapter of the book, Robin Kinross presents the design of Isotype. This chapter was originally a part of Kinross's MPhil thesis from 1979. (Robin Kinross is the owner of Hyphen Press, the publisher of this book as well as Otto Neurath's 'visual biography': *From hieroglyphics to Isotype* (2010) and a string of well presented books on typography.) The provenance of the chapter may explain the order in which it deals with the subject. The description begins with the formats of the wall charts, and moves through

colour, male and female, qualifying symbols, and guide pictures, down to pictograms and configuration. In the latter part Kinross codifies six types of displays dealt with by Isotype. This would have been a natural start of the chapter to be followed by pictograms. Apart from this peculiar arrangement the chapter gives a robust description of the elements used in Isotype. Kinross calls Isotype "a coherent approach to ordering material in graphic form" (p.107). It covers what we today call 'data visualisation'. In contrast to the remaining part of the book, Kinross offers a few critical remarks on Isotype.

Considering Neurath's interest in education it is remarkable that there exists no manual, no single, document explaining the Isotype design principles thoroughly. One reason could be that Isotype remained a work in progress. Another reason could be that Neurath did not want everyone to design visual displays, but rather to commission the displays from the initiators. So-called notes, single sheets each describing a design subject, were descriptive rather than prescriptive. They described current practice more than recommending what should be done. Also, Neurath's publication, *International Picture Language*, 1936, written in Basic English doesn't serve as a manual either.

Kinross's description of Isotype design gives a clear impression of Isotype being a work in progress. Pictograms, qualification, grouping of pictograms, use of colour, use of typography, and configuration would change considerably between 1925 and 1934, especially after Georg Arntz joined the team. However, this development did not always follow a straight line. Different principles were sometimes used concurrently; old design features were sometimes used after new design features were introduced. The development involved standardization, modularization, and simplification. Pictures would be reused and be combined; the use of colours would be restricted.

Kinross refers to the common misunderstanding that "quantified rows and columns" "might be typical of the work as a whole" (p. 142). Well, these picture tables and their pictograms are what most of us think about first when we think about Isotype. The picture tables and their pictograms are featured on the covers of publications and wherever Isotype is discussed. Kinross shows the width of Isotype by the following classification (p. 139).

Charts showing quantified material:

1. rows and columns [picture tables],
2. division of a whole (usually a checker-board),
3. geographically ordered pictograms and more diagrammatic charts,
4. quantities related to area (usually showing densities),
5. flows.

Charts showing non-quantified material:

Neurath broke down the picture table category into six sub-categories (p. 140):

- 1.1 comparison of total quantities,
- 1.2 where sizes of constituent parts are interesting, as well as total quantities,
- 1.3 where relative sizes of constituent parts are most important,
- 1.4 to make a shift particularly clear; alignment left and right to form an axis,
- 1.5 where the sizes of parts and of wholes are equally important; one compares both horizontally and vertically,
- 1.6 to allow comparison of parts and wholes, and to make a shift clear; especially important in showing changes over time.

A schematic drawing and an Isotype picture table illustrate each of these sub-categories.

While the fact that a large part of the text of this chapter is devoted to picture tables and pictograms may support the idea that Isotype first and foremost is picture tables, the book’s numerous illustrations establish some balance. Isotype is both picture tables and a general approach to data visualisation.

In a chapter about pictograms, Christopher Burke confirms that a direct line from the Isotype pictograms to the pictograms used in transport and communication today hardly exists. However, qualities such as standardization, modularity, and schematization are parts of the Isotype heritage. Isotype pictograms worked in lines in picture tables to compare something, while modern pictograms in transport and communication simply point to the existence or condition of something. Otto Neurath, however, suggested that the Isotype pictograms could possibly also be used for public information signs. This application was not realised.

WHY NOT?

Isotype: Design and contexts 1925–1971 is a comprehensive introduction to the Isotype idea. The book’s 12 chapters written by nine authors are well planned with a minimum of overlaps. While the main text goes into considerable historical detail, the illustrations present the elements and charts by which Isotype should be known and appreciated. The numerous illustrations – more than 400 – and their elaborate captions turn the book into a portable archive, which for everybody unable to access the Isotype collection at University of Reading will remain the most important Isotype resource.

Implicitly the book relays a well-known phenomenon: how a design idea born to solve one problem if successful becomes a

solution that looks for other problems. From informing the Viennese citizens the problem changed into finding potential outlets for the newfound method.

In the beginning of *Isotype: Design and contexts 1925–1971* Christopher Burke states, “The best way to bring these [the qualities of Isotype] to the fore is to examine it as a historical phenomenon in all the complexities of its contexts.” (p. 14). This is questionable. To compare is the basic function of Isotype. Isotype should itself be compared with competing data visualizing formats. How can we evaluate the virtues of airships without comparing airships with other airborne vessels?

We still need a balanced discussion of the qualities of Isotype. What exactly is the Isotype approach? How does it survive today? How does Isotype compare with the display formats that news media and others prefer today? What are the pros and the cons of Isotype compared with other more frequently used data visualising formats such as bar charts, bubble charts, and line charts? Understandability, accuracy, attraction, and memorability are factors that should be discussed. The discussion should also include the intended target groups of Isotype and the contemporary audiences of news media and professional literature. Is Isotype only for uneducated people?

One probable finding is that most contemporary audiences prefer exact information to the visual explanation offered by Isotype picture tables. Today bar charts, pie charts, and bubble charts, which in principle present *visual* messages, are as a rule supplied with exact figures. Such displays are hybrids. They are half visual display, half table. The visual part lets the reader get a fast idea, while the figures deliver accuracy. In a short period Isotype’s picture tables were also supplied with exact figures. In later displays the figures were abandoned. The big, undisputable advantage of isotype displays is that they are attention grabbing and attractive to look at. The visual attraction may be accompanied by good memorability.

.....
P S

Design and contexts 1925-1971 is well crafted with a pleasing design. However, there are two minor flaws. First, the key to source abbreviations is located on page 18, while readers expect to find it in the beginning of the book where it would be easy to retrieve for later reference. Second, tiny, alphanumeric caption designations of up to four characters are written with lowercase numerals (6 and 8 with ascenders and 3, 4, 5, 7, and 9 with descenders), which are difficult to read, especially when presented in the very small type used for marginalia.

Per Møllerup
14 August 2014

The Case for Mental Imagery

by
Stephen M. Kosslyn, William L. Thompson,
and Giorgio Ganis

Mike Zender

date: 2035 CE

location: a design office

The designer looked at the screen and watched the child's memory of being sick. "I'm sorry to ask you this, but think of diarrhea again please," she said. The toilet shimmered into view briefly followed by transparent wavy lines. The designer noted the lines, then replayed the other children's memory and noted that 67% of them included shimmering, wavy lines to represent smell. "Thank you, that's all I needed. You've really helped me design this icon," she said.

Paul Rand once said that communication design is about "saying the commonplace in an uncommonplace way." (Rand, 1970, p. 36) This suggests that effective communication is essentially enhancing the familiar. For visual communication design, this means creating unique images that will connect in predictable ways with the images people already hold in their minds. From this perspective, the whole user-centered design movement is a cultivation of means for designers knowing, not just assuming, the mental images people have. Stephen Kosslyn, William L. Thompson, and Giorgio Ganis' book *The Case for Mental Imagery* (Kosslyn, Thompson, & Ganis, 2006, p. 4) gives designers an accurate glimpse into how mental images work.

MENTAL IMAGES

The plausibility of the fictional design office above hinges on the answer to a debate that has raged for at least decades, perhaps centuries: do we see mental images or not? According to Kosslyn, Thompson, and Ganis, "A mental image occurs when a representation of the type created during the initial stages of perception is present but the stimulus is not actually being perceived." Mental imagery is seeing what is not there, not an illusion or a mirage, but seeing in our mind something familiar and then perhaps using that mental image to think with or solve a problem. We might experience this by answering this question: how many windows face the street in your house or apartment? Given this task most people gaze blankly for a second

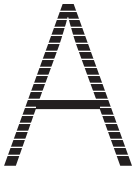
or two as they push into memory an image of their house and then briefly count the windows in the image. Kosslyn et. al. cite similar questions such as “Do you know which is darker green, a frozen pea or a pine tree? Or the hand in which the Statue of Liberty holds the torch” as examples where people use mental imagery.

Belief that this phenomena exists are not new. The authors briefly note that thinkers from the classic Greeks to Einstein claimed to use mental images “in memory, problem solving, creativity, emotion, and language comprehension.” However, introspective experiences are notoriously difficult to study, easy to refute, and thus ripe territory for endless debate. Kosslyn, Thompson, and Ganis use Chapters 2 and 3 to detail the debate, Chapter 4 to marshal empirical findings from a broad range of cognitive psychologists and neuroscientists in order to settle the debate, and Chapter 5 to articulate a well-founded theory of mental imagery.

The theory articulated in the book is based on the process of visual perception which it describes. The eye is just the start of a process that occupies much of the brain. In fact, approximately 50% of the cerebral cortex is devoted to visual processing. The brain is not like a general-purpose computer with generic processing capacity to which are downloaded different problems for analysis. Rather, the brain is like a special purpose device with different neurons in different regions hard-wired to accomplish specific tasks. Vision is one of the brain's largest tasks. In visual perception a huge volume of sensations are processed and reduced to simpler more organized forms. It's as if individual camera pixels are processed for simple features then structured into units that correspond to distinct objects and key properties that define and distinguish those objects from each other. Kosslyn and his colleagues propose that we can reverse this process and push the abstracted memory of a visual object backward onto the brain's early visual processing areas and there mentally re-construct a representation of something. Representation is a key idea here. The authors point out that stored depictive representations are not like photographic pictures. They are simplified forms that can be re-presented and then examined and to which detail can be added. It may help communication designers to think of these abstracted representations as “brain icons” because they, like drawn icons, are simplified and focus on key features of an object or idea rather than inessential details. We can use these mental images to reason about problems, like whether a jar could squeeze into a crowded pantry shelf, or to communicate with people by creating images that connect with their visual imagery. It is important to note that understood this way, there is a deep and complex relationship between seeing and thinking that deserves attention.

COMPETING THEORIES

Kosslyn et. al. identify the core of the debate as two competing conceptions of the format we use to store internal visual representations: depictive



Depictive format above

FIGURE 1

FIGURE 2

Propositional format below

**“two diagonal lines
that meet at the top,
joined halfway down
by a short horizontal
segment.”**

(Kosslyn et al., 2006, p. 12)

or propositional. The depictive approach suggests that our brain encodes images in a visual format using points, similar to the way a computer screen uses pixels. The blocks forming the triangle in Figure 1 illustrate a depictive format. The propositional approach suggests that we format images using abstract concepts like words in language or computer software. The words “two diagonal lines that meet at the top, joined halfway down by a short horizontal segment.” in Figure 2 illustrate a propositional format for the same image.

The format used may seem like an academic debate, but it matters because the format of representation makes possible, or at least preferences, different kinds of thinking and from this the creation of different knowledge.

To settle the debate the authors call upon findings that add significant detail to the outline of the perceptual process noted above. Very early in this process the image from our retina is topographically mapped point-for-point on our brain. Objects close to each other on our retina are also close to each other on the cortical area called V1. There are, in fact, several topographically organized layers in V1 with each layer providing different kinds of processing. Cutting down through layers are columns that distinguish different line orientation, curve, value, and hue. These topographic layers are part of what Kosslyn labels the “visual buffer.” The “visual buffer” then “reports” the results to other areas of the brain where patterns and shapes are assembled, where objects are formed and subsequently identified. Kosslyn asserts that through these successive stages a “population code” is assigned containing in abstracted form the key visual features that define an object. Kosslyn posits a “hybrid representation” that combines information for each point about its role in the depiction of the object, as well as additional abstracted information. “In spite of their coding nondepictive information, these hybrid representations cannot be reduced to propositional representations. Crucially, they use space (literally, on the cortex) to represent space in the world. The fact that each point codes additional information does not obviate its role in depicting the shape.”

The highlight of Kosslyn’s argument is that these encoded representations can be recalled and when they are, an image is reconstructed from memory using the same topographic neural space in the “visual buffer” that was used to “see” the initial image from the eye. In Kosslyn’s words, the “stored shape representation is primed so strongly that activation is propagated backwards, including a representation of a part or characteristic in the visual buffer (which corresponds to the depictive image itself).” Kosslyn theorizes that we literally re-construct the object from memory and create a representation of it. These are mental images.

VALIDATION

When Kosslyn and his colleagues wrote this book some years ago the viability of their theory was still open to debate. But much has happen since then to support its basic premises.

In 1988 Tootell et. al. provided a foundation for how we see when they showed a topographically represented visual image mapped on the surface of a primate brain. Over the years various scientists have developed techniques that enable them to dye a primate brain and see there on the cortex - in real time - the images from the eye. A 2012 NIH presentation by Dr. Eyal Seidemann is one example of video showing this. ("Decision Related Activity and Top-down Attentional Modulations in Primate V1" <http://videocast.nih.gov/summary.asp?Live=11769&bhcp=1>) More recently researchers used fMRI to produce an image of a person's recalled memory (mental image) of a simple object. In 2014 Dr's. Cowen, Chun and Kuhl presented findings that through observing brain activity they were able to reconstruct recognizable individual faces from people's mental images of faces they were seeing ("Neural portraits of perception: Reconstructing face images from evoked brain activity" in *Neuroimage*). The title of the March 28, 2014 Fox news article reporting this paper was "*We know what you're thinking: Scientists find a way to read minds.*" by Maxim Lott. While the face reconstruction study may be as much about the inventiveness of the computer processes employed as it is about the biological ones, its findings dramatically support the foundation of Kosslyn's hypothesis: mental images are seen reconstructed in the visual buffer. These studies can "see" them.

SO WHAT?

The Case for Mental Imagery may sound interesting to some readers, but to others the question "So what?" may have been lingering for some time now.

So what? How is the information in this book relevant to the designer? One answer is "A theoretical foundation for communication design." Communication design has entertained competing theories to guide practice. Some, such as semiotics, are based in linguistics. Theories of visual perception such as the one articulated by Kosslyn, Thompson, and Ganis may help provide more appropriate visual ground for a theory of visual communication. Knowing how people process, store, and use images is at the heart of visual communication. It's true that communication designers create objects that use both textual and visual forms to communicate and much has been written recently about the role of designer as author and the need for more writing in design education. Without dismissing the positive role designers can play in crafting the written content of the communication they create (designer as author), or diminishing the role writing can play for organizing and expressing thought in design classes (writing in design education), Kosslyn's theory suggests that there is a good reason that college "communication" programs focus on writing while "visual communication" programs focus on image making. Visual images are the essence of visual communication. Communication designers employ forms of communication that largely bypass language. Kosslyn reminds us that people think with images. One benefit of

Kosslyn's theory as it applies to design is that it is founded on hard-wired neurobiological perceptual processes common to all people, suggesting that design principles founded on this approach may be universal, applying to people of every age, language, literacy level, and culture. With limited research resources to invest, design might do well to focus on universal visual processes that can apply to nearly everyone before building upon theories focused on individual differences.

In addition to providing a theoretical foundation for visual communication, "Visual thinking" is another defense of the book's relevance. Kosslyn's theory, based as it is on depictive representations, means that visual designers use a visual language that is inherently more flexible and less inhibited by arbitrary encoding structures than language. Depictive reasoning can be more ambiguous and less structured than propositional reasoning. Images are more direct, less categorical, less overtly defined, and thus better suited for creative thinking and problem solving than language-based propositional representations that seem plodding by comparison. "I see" is a common visual-based metaphor for sudden understanding and an apt metaphor for visually-empowered design thinking.

"User centered" is yet another response. Kosslyn's theory means that communication designers now and in the future can reliably identify the mental images that people have, thus gaining direct insight into how to communicate with them more accurately. Designers who know their subjects' mental images can more reliably produce images that evoke the correct meaning. Knowing people's mental images moves user-centeredness into the user's head, literally. The point of view for designers might be transformative.

"Evidence-based" is another reply. Kosslyn's theory doesn't just apply to the front end of design creation, but also to the back end of design evaluation. Using people's mental images to evaluate communication objects could give not only very accurate measurement of communication but insight to corrective action. A loop of creation and evaluation based on reliable measurement of mental image may provide communication design with some solid principles for practice.

Another Paul Rand quote suggests a final answer when he states, "...the designer must steer clear of visual clichés by some unexpected interpretation of the commonplace." "Innovation" is the final answer. Design has been said to be the process of converting existing states to preferred ones. Designers don't just create what already exists; they create something new. So how can knowing the images people already have in their heads help create something new? To a designer the question is the answer. Knowing what people think enables us to take liberties, to explore novel variations and "unexpected interpretations", to both connect and expand what is in people's minds. Apart from knowing the people's mental images designers innovate in the dark, ignorant of whether their novel approaches support or hinder communication.

Kosslyn, Thompson, and Ganis' theory means several things to communication design. It means that seeing and thinking are complementary, helping to explain the effectiveness of information visualization. It means that visual communication designers who create images are directly connecting to the one of the most significant means people have for processing information, for thinking. It means that emphasis on visual thinking is one key to why design is good at creative problem solving.

If design theories should be founded on research findings in visual perception and cognition, then they will in some measure be founded on work by Kosslyn and his colleagues. It's a book that most designers should read.

Cowen, Chun, & Kuhl. (2014). "Neural portraits of perception: Reconstructing face images from evoked brain activity." *Neuroimage*

Kosslyn, Stephen M., Thompson, William L., & Ganis, Giorgio. (2006). *The Case for Mental Imagery*. New York, NY: Oxford.

Rand, Paul. (1970). *Thoughts on Design* (Third ed.). New York: Wittenborn Schultz.

Advisory Board

W E L C O M E

Visible Language wishes to welcome new advisory Board member Keith Crutcher. Keith reflects our interest in connecting to disciplines whose research is well-advanced and whose knowledge is related to visual communication.

.....
Keith Crutcher

Keith A. Crutcher, Ph.D., has over 30 years of experience in biomedical research and technology including prior tenured faculty appointments at the University of Utah (7 years) and the University of Cincinnati (22 years), a founding role in an early stage drug discovery company (ApoLogic, Inc.), and four years serving as a Scientific Review Officer at the Center for Scientific Review at the National Institutes for Health. In the latter role, he managed the peer review of hundreds of grant applications. His academic research program, funded by the NIH, NSF, and other agencies, included studies of brain injury and Alzheimer's disease resulting in over 100 peer-reviewed publications, two issued patents, and numerous presentations. He has also served as an ad hoc reviewer for several federal agencies and private foundations as well as serving on the editorial boards of several journals including *Experimental Neurology*, *Aging Cell*, and *Neurobiology of Aging*, where he participated in the peer review of numerous manuscript submissions. He currently does consulting work for applicants seeking research funding and provides assistance in preparing proposals and navigating the peer review system at various federal agencies.

JOURNAL INFORMATION

Visible Language is an academic journal focused on research in visual communication. We invite articles from all disciplines that concern visual communication and would be of interest to designers.

READERSHIP

Visible Language, an academic journal, seeks to advance research and scholarship for two types of readers: academics and professionals. The academic is motivated to consume knowledge in order to advance knowledge thorough research and teaching. The professional is motivated to consume and apply knowledge to improve practice. *Visible Language* seeks to be highly academic without being inaccessible. To the extent possible given your topic, *Visible Language* seeks articles written to be accessible to both our reader types. Anyone interested may request a copy of our editorial guidelines for authors.

EDITORIAL CORRESPONDENCE

Article concepts, manuscripts, inquiries about research and other contributions to the journal should be addressed to the editor. We encourage article concepts written as an extended abstract of 1 to 2 pages single-spaced. We will offer prompt feedback on article concepts with our initial opinion on their suitability for the journal. Manuscripts accepted for peer review will receive a summary response of questions or comments within three weeks. Letters to the editor are welcome. Your response — and the author's reply — will not be published without your permission and your approval of any editing. If you are interested in submitting an article to the journal and would like a copy of our Notes on the Preparation of a Manuscript, please obtain it from the journal's website at <http://visiblelanguagejournal.com>

Editorial correspondence should be addressed to:

Mike Zender
Editor, *Visible Language*
College of Design, Architecture, Art, and Planning
School of Design
University of Cincinnati
PO Box 210016
Cincinnati, OH 45221-0016
email: mike.zender@uc.edu

If you are interested in serving as guest editor for a special issue devoted to your specific research interest, write to the editor, outlining the general ideas you have in mind and listing a half dozen or so topics and possible authors. If you would rather discuss the idea first, call the editor at: phone number

BUSINESS CORRESPONDENCE

Subscriptions, advertising and related matters should be addressed to:

Visible Language
Sheri Cottingim
Office of Business Affairs
College of Design, Architecture, Art, and Planning
University of Cincinnati
PO Box 210016
Cincinnati, OH 45221-0016
telephone 513 556-4377
email: sheri.cottingim@uc.edu

Before there was reading there was seeing. *Visible Language* has been concerned with ideas that help define the unique role and properties of visual communication. A basic premise of the journal has been that created visual form is an autonomous system of expression that must be defined and explored on its own terms. Today more than ever people navigate the world and probe life's meaning through visual language. This journal is devoted to enhancing people's experience through the advancement of research and practice of visual communication.

If you are involved in creating or understanding visual communication in any field, we invite your participation in *Visible Language*. While our scope is broad, our disciplinary application is primarily design. Because sensory experience is foundational in design, research in design is often research in the experience of visual form: how it is made, why it is beautiful, how it functions to help people form meaning. Research from many disciplines sheds light on this experience: neuroscience, cognition, perception, psychology, education, communication, informatics, computer science, library science, linguistics. We welcome articles from these disciplines and more.

Published continuously since 1967, *Visible Language* maintains its policy of having no formal editorial affiliation with any professional organization — this requires the continuing, active cooperation of key investigators and practitioners in all of the disciplines that impinge on the journal's mission as stated above.

Website

<http://visiblelanguagejournal.com>

Postmaster:

send address changes to:

circulation manager name

Office of Business Affairs

College of Design, Architecture, Art, and Planning

University of Cincinnati

PO Box 210016

Cincinnati, OH 45221-0016

Published tri-annually in January, May and October

Mike Zender, *Editor*

University of Cincinnati, School of Design, *Publisher*

Sheri Cottingim, *Publication Manager*

Merald Wrolstad, *Founder*

Sharon Poggenpohl, *Editor Emeritus*

SUBSCRIPTION RATES

| United States | Individual | Institutional |
|---------------|------------|---------------|
| 1 year | \$35.00 | \$65.00 |
| 2 year | \$65.00 | \$124.00 |
| 3 year | \$90.00 | \$183.00 |

.....

| Canadian* | Individual | Institutional |
|-----------|------------|---------------|
| 1 year | \$44.00 | \$ 74.00 |
| 2 year | \$83.00 | \$142.00 |
| 3 year | \$117.00 | \$210.00 |

.....

| Foreign** | Individual | Institutional |
|-----------|------------|---------------|
| 1 year | \$ 56.00 | \$ 86.00 |
| 2 year | \$107.00 | \$166.00 |
| 3 year | \$153.00 | \$246.00 |

Prepayment is required. Make checks payable to University of Cincinnati
Visible Language in U.S. currency only, foreign banks need a U.S.
correspondent bank.

* Canadian subscriptions include additional postage (\$9.00 per year).

**Foreign subscriptions include additional postage (\$21.00 per year).

ISSN 0022-2224

Published continuously since 1967.

Index included in last issue of volume year.

BACK COPIES

A limited number of nearly all back numbers is available. The journal website
at <http://visiblelanguagejournal.com> is searchable and lists all issues,
contents and abstracts.

COPYRIGHT INFORMATION

Authorization to photocopy items for internal or personal use, or for libraries
and other users registered with the Copyright Clearance Center (CCC) Trans-
actional Reporting Service, provided that the base fee of \$1.00 per article,
plus .10 per page is paid directly to:

CCC

21 Congress Street

Salem, Massachusetts 01970

Telephone 508.744.3350

0022-2224/86 \$1.00 plus .10